Appendix 5.1.2.6C
Fisheries Mitigation and Offsetting Plan

Blackwater Gold Project

Fisheries Mitigation and Offsetting Plan

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ACRONYMS

Abbreviations and Units of Measure	Definition
ALR	Agricultural Land Reserve
AMEC	AMEC Environmental & Infrastructure
ANFO	Ammonium nitrate-fuel oil
Application (the)	Application for an Environmental Assessment Certificate
ARMP	Aquatic Resources Management Plan
Avison	Avison Management Services Ltd.
BACI	Before-After-Control-Impact
BC	British Columbia
BC CDC	BC Conservation Data Centre
BC EAO	BC Environmental Assessment Agency
BC ILMB	BC Integrated Land Management Bureau
BC MEM	BC Ministry of Energy and Mines
BC MFLNRO	BC Ministry of Forests, Lands, and Natural Resource Operations
BC MOE	BC Ministry of Environment
BC MOF	BC Ministry of Forests
BC MOT	BC Ministry of Transportation
BC MWLAP	BC Ministry of Water, Land and Air Protection
BMI	Benthic Macroinvertebrates
BMP	Best Management Practices
CABIN	Canadian Aquatic Biomonitoring Network
CEAA	Canadian Environmental Assessment Agency
CL	Confidence limit
cm	Centimetre
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
DFO	Fisheries and Oceans Canada
DO	Dissolved oxygen
EA	Environmental Assessment
EC	Environment Canada
ECD	Environmental Control Dam
Ecofor	Ecofor Consulting Ltd.
EMP	Environmental Management Plan
FHAP	Fish Habitat Assessment Procedures
FISS	Fisheries Inventory Summary System

Abbreviations and Units of Measure	Definition
FMOP	Fisheries Mitigation and Offsetting Plan
FRISP	Farmland-Riparian Interface Stewardship Program
FSR	Forest Service Road
FSS	Freshwater Supply System
GIS	Geographic Information System
>	greater than
ha	hectare
HADD	harmful alteration, disruption, or destruction
HEP	Habitat Evaluation Procedures
HGI	Habitat Gained Index
HSI	Habitat Suitability Index
HU	Habitat unit
IR	Indian Reserve
km	kilometre
km^2	square kilometres
kv	Kilovolt
kW	Kilowatt
<	less than
LiDAR	Light Detection and Ranging
LSA	Local Study Area
LWD	large woody debris
m	metre
m^2	square metres
m^3	cubic metres
masl	metres above sea level
MCRP	Murray Creek Rehabilitation Project
mg/L	milligrams per litre
Mm^3	million cubic metres
MMER	Metal Mining Effluent Regulations
µS	Micro-Siemens
Mt	Million tonnes
NAG	Non Acid Generating
NCD	Non Classified Drainage
NEWSS	Nechako Environment and Water Stewardship Society
NFCP	Nechako Fisheries Conservation Program

Abbreviations and Units of Measure	Definition
NSRI	Nechako White Sturgeon Recovery Initiative
NTS	National Topographic System
NVC	No visible channel
oz	ounces
PAG	Potential Acid-Generating
PECG	Palmer Environmental Consulting Group Inc.
%	percent
Proponent (the)	New Gold Inc.
Project (the)	Proposed Blackwater Gold Project
ROW	Right-of-Way
RSA	Regional Study Area
SFN	Saik'uz First Nation
TIA	Tailings Impoundment Area
Triton	Triton Environmental Consultants Ltd.
TSF	Tailings Storage Facility
TSS	Total Suspended Solids
UNBC	University of Northern British Columbia
US	United States
US FWS	US Fish and Wildlife Service
DFO	Fisheries and Oceans Canada

EXECUTIVE SUMMARY

Introduction and Regulatory Context

Construction and operation of the Blackwater Project will result in "serious harm to fish." This "serious harm" includes the permanent alteration or destruction of fish habitat in the Davidson Creek and Creek 661 watersheds, including some streams used by rainbow trout for different parts of their life history. Because rainbow trout are part of recreational and Aboriginal fisheries near the Project, the Proponent requires a Section 35(2) *Fisheries Act* authorization from Fisheries and Oceans Canada (DFO) before it can proceed with the Blackwater Project.

The Project will also result in the deposit of deleterious mine tailings in waters "frequented by fish." These waters include the upper reaches of Davidson Creek within the Blackwater Project's Tailings Storage Facility (TSF). These reaches are used exclusively by rainbow trout. As a result of their use by fish, the Proponent requires the Government of Canada to amend Schedule 2 of the Metal Mine Effluent Regulation (MMER) so that these reaches of Davidson Creek are designated as a Tailings Impoundment Area (TIA). This designation is required before the Proponent can begin to deposit mine tailings in Davidson Creek or waste rock in the headwaters of Davidson Creek and Creek 661.

The Section 35(2) authorization and the Schedule 2 amendment of the MMER require "offsetting" plans that show how the Proponent intends to counterbalance all unavoidable "serious harm to fish" and the corresponding loss of fisheries productivity. This document outlines the Proponent's plan to avoid and mitigate potential "serious harm to fish" upstream and downstream of the Project and to offset all residual "serious harm to fish" including habitat permanently altered or destroyed under various Project infrastructure or affected by the deposit of deleterious mine tailings. Separate offsetting plans will be submitted to DFO for the Section 35(2) authorization and the Schedule 2 amendment of the MMER during the permitting phase, if required.

Mitigation Plan

Consistent with DFO's "Hierarchy of Measures for Fisheries Protection," avoidance of potential "serious harm to fish" was the Proponent's first priority when planning and designing the Blackwater Project. Environmental design criteria to avoid "serious harm to fish" included: 1) clustering the TSF, waste rock dumps, stockpiles, and all other mine site facilities as closely to the open pit as possible to minimize the spatial extent of potentially affected fish habitat; 2) locating the TSF, waste rock dumps, stockpiles, and all other mine site facilities in the headwaters of the Davidson Creek and Creek 661 watersheds to avoid higher quality habitat downstream and to minimize the number of watersheds potentially affected; 3) maintaining a "zero discharge" facility during mine operations and closure; and 4) optimizing the use of the existing roads and transmission line corridors to minimize the number of new stream crossings required. These environmental design criteria resulted in the avoidance of impacts to fisheries in the Blackwater River Watershed, a Heritage River designated by the Province of British Columbia due to its unique combination of natural, cultural, and recreation values, avoidance of kokanee spawning habitat in the lower reaches of Davidson Creek and Creek 661, and

avoidance of potentially acute and chronic toxicity effects to fish and other aquatic biota downstream.

Mitigation measures were incorporated into all phases of the Project to further eliminate or reduce potential "serious harm to fish." During the construction phase, mitigation measures at the mine site will focus on reducing the amount of sediment mobilized and deposited in local streams. Mitigation measures implemented at the mine site during construction will include:

- Implementation of erosion and sediment control plans;
- Implementation of emergency spill response plans;
- Implementation of a construction water management plan which includes construction of sediment control ponds downstream prior to construction of mine infrastructure, diversion of water around construction areas, and construction of diversion ditching, water collection ponds, and pumping systems; and
- Salvaging of fish from isolated construction areas and relocation of captured fish downstream.

During construction of the various linear developments required for the Blackwater Project (e.g., mine access road, transmission line), mitigation measures will be focused on reducing downstream sedimentation and eliminating barriers to upstream and downstream passage of fish. Mitigation measures at all existing or new stream crossings will include:

- Implementation of erosion and sediment control plans;
- Construction of stream crossings during relevant "Reduced Risk Timing Windows" when possible;
- Construction of clear-span, open-bottom structures at all fish-bearing stream crossings; and
- Isolation of construction areas and completion of fish salvages prior to construction.

Mitigation measures during operation of the Blackwater Project will be focused on minimizing changes in downstream water quantity and quality, eliminating isolation of upstream habitat that cannot support fish on its own, and minimizing direct mortality of fish under and upstream of, and by, various mine components. The two principle mitigation measures for eliminating potential "serious harm to fish" during the mine operations phase will be the operation of the Freshwater Supply System and diversion of the Davidson Creek headwater lake, Lake 01628LNRS, to Lake 01538UEUT, the headwater lake in the adjacent watershed of Creek 705.

The Freshwater Supply System (FSS) will pump water from Tatelkuz Lake up to a freshwater reservoir built in Davidson Creek downstream of the TSF. Water in this reservoir will be used to meet the mill freshwater demand and to meet instream flow requirements in lower Davidson Creek. These instream flow requirements are designed to provide kokanee and rainbow trout in lower Davidson Creek with flows sufficient to maintain their current level of productivity during all months of all years of mine operations. Operation of the FSS to meet these instream flow requirements will mitigate the potential loss of approximately 31,020 m^2, or 45% of the total fish

habitat in lower Davidson Creek. Operation of the FSS will also maintain access to approximately 189,106 m^2, or 88% of the total fish habitat in Davidson Creek tributaries.

Diversion of Lake 01628LNRS outflow to Lake 01538UEUT is required to avoid the potential isolation, and subsequent extirpation, of its resident rainbow trout population. This lake is located upstream of the Blackwater TSF and construction of the Blackwater TSF would affect spawning habitat located in Davidson Creek immediately downstream of the lake. Without this spawning habitat, it is unlikely that the resident population would persist in perpetuity.

Diversion of Lake 01628LNRS to Lake 01538UEUT will be accomplished in three ways. First, a new dam will be constructed in Davidson Creek upstream of the TSF. This dam will back-flood the upper 917 m of Davidson Creek and raise the water level in the creek to the existing water level of the lake. This dam will increase the area of Lake 01682LNRS by approximately 125,500 m^2 and will cause water that previously flowed out of the lake through Davidson Creek to flow towards Lake 01538UEUT instead. Second, a connector channel approximately 650 m long will be constructed between Lake 01682LNRS and Lake 01538UEUT. The channel will convey water from Lake 01682LNRS to Lake 01538UEUT and allow fish to move between both lakes. Lastly, new spawning habitat will be created in a new channel connecting the existing headwater tributary of Lake 01538UTEUT to Lake 01628LNRS. This new spawning habitat will replace the spawning habitat flooded by the TSF and, when fully functional, will provide for the long-term sustainability of the lake's rainbow trout population.

Diversion of Lake 01628LNRS will mitigate the loss of all 91,860 m^2 of fish habitat in Lake 01628LNRS. Construction of the new spawning channel will mitigate the loss of the 9 m^2 of rainbow trout spawning habitat in Davidson Creek downstream of the lake.

Other mitigation measures that will be implemented during mine operation to eliminate or reduce potential "serious harm to fish" at the mine site and along the linear development components of the Project include:

- Recycling of water from the TSF in the mill process;
- Incorporation of a cyanide destruction circuit in the mill effluent treatment process;
- Operation and maintenance of seepage collection trenching and an Environmental Control Dam (ECD) immediately downstream of the TSF, and upstream of the freshwater reservoir. These components, combined with a seepage pump-back system to return seepage to the TSF, will ensure a "zero discharge" facility during mine operations and closure;
- Operation and maintenance of diversion ditching and sediment control ponds downstream of mine infrastructure and waste rock dumps;
- Appropriately-sized fish screens on the intake pipes of the FSS in Tatelkuz Lake;
- Maintenance of access roads according to Provincial road maintenance guidelines; and
- Following "Approved Work Practices for Riparian Vegetation Management" at all stream crossings.

All mitigation measures used during mine operations will continue during the mine closure phase. This will include the continued operation of the FSS to maintain flows in lower Davidson Creek. The only new mitigation measures during the closure phase will be pumping water from Tatelkuz Lake to the open pit to speed its filling and construction of treatment wetlands in the TSF and in the seepage pond upstream of the ECD. These wetlands will further reduce dissolved metal and nutrient concentrations in the TSF supernatant before it enters Davidson Creek.

Mitigation measures during the post-closure phase will include construction of a treatment wetland in the freshwater reservoir used for the FSS, release of water from the TSF to Davidson Creek only when it meets site-specific water quality objectives in Davidson Creek, and re-establishment of natural drainage patterns in Davidson Creek and Creek 661.

Residual "Serious Harm to Fish"

Despite these avoidance and mitigation measures, potential "serious harm to fish", including the permanent alteration and destruction of fish habitat, will occur due to construction, operation, and closure of the Blackwater Project. In total, 158,339 m^2 of fish habitat will be permanently altered or destroyed by the mine site infrastructure. This includes 104,649 m^2 of fish habitat under or isolated upstream of the mine footprint (i.e., requiring a Section 35(2) *Fisheries Act* authorization) and 53,689 m^2 of fish habitat subject to the deleterious deposit of waste rock and mine tailings (i.e., requiring amendment of Schedule 2 of the MMER). Most of this habitat (84%) is located in the upper reaches of Davidson Creek and its headwater tributaries. The remaining habitat (16%) is located in the upper reaches of Creek 661 and its headwater tributaries. No "serious harm to fish" will occur to do construction, operation, and closure of any of the linear developments (e.g., mine access road, transmission line) because of the high likelihood of success of the various mitigation measures employed.

Rainbow trout is the only fish species that will be affected by the permanent loss of habitat at the mine site. This is because all potentially affected habitat is located in the headwaters of the Davidson Creek and Creek 661 watersheds, areas no other fish species are known to use.

Habitat units for rainbow trout were calculated to account for the differences in habitat quality between the different habitat types affected and the different rainbow trout life stages using these different habitat types. In total, 218,078 rainbow trout habitat units would be permanently lost under, upstream or downstream of the mine site footprint. This includes 83,673 rainbow trout habitat units within the TIA and waste rock dumps (i.e., requiring amendment of Schedule 2 of the MMER) and 134,404 rainbow trout habitat units under, upstream and downstream of the other mine site infrastructure (i.e., requiring a Section 35(2) *Fisheries Act* authorization).

By rainbow trout life stage, these habitat units include 29,172 habitat units (13% of total) for spawning/egg incubation, 41,417 habitat units (19%) for fry summer rearing, 48,374 habitat units (22%) for juvenile summer rearing, 21,041 habitat units (10%) for overwintering, and 78,074 habitat units (36%) for food and nutrient production. The largest number of habitat units is for food and nutrient production because of the location of the tailings facility, waste rock dumps, and other mine infrastructure in the headwaters of the Davidson Creek and Creek 661

watersheds. Here, the majority of streams are non-fish-bearing, first- or second-order tributaries that produce nutrients and food for trout but do not directly provide trout habitat. It is also because all streams, regardless of size or fish-bearing status, provide at least some value to fish in terms of food and nutrient production. The number of habitat units for overwintering was low because of the paucity of pools with sufficient size and depth to hold rainbow trout in winter. No habitat units for adult foraging will be affected because the upper reaches of Davidson Creek and Creek 661 do not support resident trout populations and are instead only used by adults for spawning and by fry and juvenile trout for rearing and overwintering.

Offsetting Plan

Five separate projects are proposed by the Proponent to offset the residual "serious harm to fish" caused by the Blackwater Project. These include three "on-site" projects within the Davdison and Creek 661 watersheds (enlargement of Lake 01682LNRS; construction of two overwintering and summer rearing ponds near the middle reaches of Davidson Creek; and construction of an overwintering and summer rearing pond near the middle of Creek 661) and two "off-site" projects (restoration of fish habitat in the Mathews Creek watershed and restoration of fish passage at existing road crossings in the Vanderhoof Forest District). Both "off-site" projects target the creation, restoration, or enhancement of fish habitat, promote the recovery of sensitive fish species, and are recognized by the community, local First Nations, and/or government agencies as regionally important initiatives.

These projects were selected after review and evaluation of 31 separate projects (19 "on-site" and 12 "off-site" options) compiled from field studies conducted as part of baseline investigations by AMEC and by desktop reviews or previous experience working with non-governmental organizations, provincial regulators, and First Nations groups by local sub-consultants (Avison and Ecofor) charged with compiling a list of potential offsetting projects. Once compiled, all 31 potential projects were evaluated in a two-step process: a preliminary screening involving a desktop review and fatal flaw analysis, against regulatory, biological, engineering, construction and socio-economic screening criteria; and a detailed assessment, based on field studies and analysis of site-specific groundwater, hydrology, and biological data. The purpose of these steps was to identify, from the 31 available options, those that were most closely aligned with federal, provincial, and First Nations fisheries management objectives, were technically feasible and biologically relevant, and provided the greatest likelihood of success and acceptance by regulatory agencies, First Nations, and other stakeholders.

Enlargement of Lake 01682LNRS

Enlargement of Lake 01682LNRS will be accomplished by constructing a dam in Davidson Creek near the outlet of the lake. This dam will back-flood approximately 1,872 m^2 of stream habitat in Davidson Creek downstream of the lake and create 125,500 m^2 of additional lacustrine habitat in Lake 01682LNRS. This new habitat will provide additional littoral and deep water habitats for the rainbow trout and longnose sucker populations that will reside in the newly connected Lake 01682LNRS/Lake 01538UEUT complex. Using the same habitat suitability model used to quantify habitat losses, this enlarged lake is predicted to provide 331,440 habitat units for rainbow trout. This will include 87,296 habitat units (26% of total) for juvenile summer

rearing, 78,437 habitat units (24%) for adult summer foraging, 109,807 habitat units for overwintering (33%), and 55,901 habitat units of food and nutrient production (17%). The new lake habitat is not expected to provide any new spawning habitat.

Both populations will be supported by the 18 m^2 of spawning habitat present in the one tributary currently entering Lake 01682LNRS on its southern shore, by the new spawning habitat built in the new channel diverting the existing inlet tributary of Lake 01538UEUT to Lake 01682LNRS, and by the existing spawning habitat in the inlet tributary to Lake 01538UEUT that would be made accessible by this new channel. Fish populations that currently occupy Lake 01538UEUT will be able to access this spawning habitat through the new connector channel built to convey water from Lake 01682LNRS to Lake 01538UEUT.

Off-Channel Ponds

Two off-channel ponds will be created in the Davidson Creek watershed. One pond will be built adjacent to the Davidson Creek mainstem while the other pond will be built adjacent to the lower reaches of Creek 428073, a Davidson Creek tributary. Together, these two ponds will provide approximately 13,530 m^2 of low velocity pool habitat that will increase the amount of summer rearing and, particularly, overwintering habitat for juvenile rainbow trout. This is because the ponds will partially alleviate the paucity of suitably deep pools in the Davidson Creek mainstem by providing deep (>2 m), low velocity (<0.005 m/s) off-channel habitats preferred by juvenile rainbow trout in winter. Availability of pools deep enough to support overwintering juvenile trout was identified as a factor likely limiting rainbow trout production in Davidson Creek.

A third off-channel pond will be created in the Creek 661 watershed. This pond will be located adjacent to Creek 505569, a tributary of Creek 661. This pond will provide 8,030 m^2 of low velocity pool habitat for juvenile rainbow trout summer rearing and overwintering.

All three ponds have been located in areas of high groundwater seepage. This groundwater will be the primary source of water to the ponds during low flow periods in the summer and winter. Additional design features to maximize suitability for juvenile rainbow trout rearing and overwintering include:

- Close proximity (typically 10 m to 20 m) to the local stream within the floodplain or natural low-lying wetland area;
- Groundwater source that provides sufficient water quantity to eliminate the need for an inlet channel;
- Depths >2 m to prevent freezing to bottom during exceptionally cold winters and to maximize refuge volumes for overwintering fish beneath the ice;
- Double layers of cobbles on the bottom to provide interstitial spaces for juvenile fish in winter;
- Shallow water benches around the perimeter to allow opportunities for colonization by aquatic macrophytes and to increase habitat complexity and cover for fish;
- Shallow banks with 2:1 slopes to avoid slumping and sedimentation and minimize requirements for hard bank erosion protection;

- Constructed outlet channels that allow fish passage during all seasons; and
- Abundant instream and overhead cover (i.e., LWD, cobble/boulder substrates, depth, riparian vegetation).

Together, these three ponds will provide 47,411 habitat units for rainbow trout. Seventy-eight percent of these habitat units are for juvenile trout summer rearing and overwintering.

Mathews Creek Restoration

The Mathews Creek Watershed is situated adjacent to, but west of, the Davidson Creek Watershed. Streams in this watershed have been degraded by past and current agricultural activity, primarily cattle grazing, as well as by past logging and mineral exploration activities.

Five separate, but complementary, restoration projects will be completed in Mathews Creek as part of the Proponent's offsetting plan for the Blackwater Project. All projects are located in Reach 5 of Mathews Creek, the reach where most of the previous habitat degradation has occurred. These projects are intended to restore and enhance instream, riparian and wetland habitat that has previously been degraded by cattle grazing and trampling of riparian vegetation with the end goal of increasing the production of rainbow trout. The Proponent recently purchased the private land along Reach 5 of Mathews Creek, thus removing any land tenure impediments to completing these projects. The five projects include:

- Restoration and enhancement of a 1,393 m of section of Mathews Creek with additions of large woody debris, root wads, and boulder clusters to increase habitat complexity and instream cover, additions of brush layers, willow whips, and shrubs to a 15 m riparian buffer zone along both banks, and removal of man-made obstructions to fish passage;
- Restoration and enhancement of a 2,341 m long section of Mathews Creek using similar techniques as above (one bank only);
- Restoration and enhancement of a 468 m long groundwater-fed tributary to Reach 5 of Mathews Creek. This would be done by reshaping the channel to make it deeper and narrower and, thus, less prone to choking by instream vegetation, and by re-sculpted and replanting the banks with willows, shrubs and trees to reduce erosion and sedimentation and to increase overhanging cover, shade and allochthonous inputs for fish;
- Creation of a 295 m long, meandering tributary to Reach 5 of Mathews Creek to replace a straight drainage ditch. The meander pattern will mimic a nearby natural tributary and will include pools at outside bends and gravel riffles or runs at the meander cross-over points. Banks will be stabilized with willow, shrubs and trees where appropriate; and
- Restoration of previously drained wetlands on the north side of Mathews Creek. This will be accomplished by filling in drainage ditches and excavating a shallow (<2 m) basin, with approximately 48,000 m^2 of open-water habitat, on the north side of Mathews Creek. Once filled with natural run-off, colonized by native wetland vegetation, and connected to Mathews Creek, this wetland will improve water quality in Mathews Creek, help attenuate natural flood-events, and will provide a food-source for rainbow trout.

Together, these five projects are predicted to provide ~65,000 m^2 of new, restored or enhanced fish habitat for rainbow trout in the Mathews Creek watershed. Because of the diversity of habitats that would be restored, enhanced or created, these projects are predicted to provide additional rainbow trout habitat, including summer rearing habitat for fry (29% of total) and juveniles (13%), foraging habitat for adults (12%), overwintering habitat for all life stages (1%), and additional nutrient and food production (39%), particularly from the restored wetland. No new or enhanced spawning habitat for rainbow trout is anticipated. However, spawning habitat is not currently limiting trout production in the creek. Together, these projects are predicted to provide ~42,000 habitat units for rainbow trout in the Mathews Creek Watershed.

Culvert Restoration in the Vanderhoof Forest District

Three closed-bottom culverts currently creating barriers to upstream fish passage in the Vanderhoof Forest District will be replaced with clear-span bridges or open-bottom culverts. These open-bottom structures combined with new channels underneath, will restore fish passage and access to upstream habitat.

Three culverts were selected from a candidate pool of 78 problem culverts identified by local consultants (Avision and Ecofor) and by the BC Ministry of Forest, Lands, and Natural Resource Operations (BC MFLNRO) in Vanderhoof. These culverts include one culvert on Cutoff Creek, one culvert on Suscha Creek, and one culvert on Big Bend Creek. All three of these creeks are tributaries to the Nechako River.

These culverts were selected because: 1) they were identified as “high priority” stream crossings due to the composition and distribution of fish species upstream and downstream, the linear length and size of streams upstream, and the number and distribution of other man-made or natural barriers; 2) they were positively identified as barriers to upstream fish passage during site visits; 3) they were installed prior to implementation of the Forest Practice Code for Stream Crossings in 1995; 4) they have no identifiable legal owner and are therefore the responsibility of the Province of BC; 5) they have high quality habitat upstream which is likely to produce fish for recreational or Aboriginal fisheries; and 6) their replacement was unlikely to create potential ancillary effects to sensitive vegetation or wildlife.

Replacement of the culvert on Cutoff Creek will provide fish access to approximately 59 km of upstream habitat. These fish include Chinook salmon, sockeye salmon, mountain whitefish and potentially white sturgeon. Removal of this culvert will also eliminate the upstream isolation of populations of rainbow trout and blue-listed bull trout.

Replacement of the culvert on Suscha Creek will provide fish access to approximately 45 km of upstream habitat. These fish include Chinook salmon and mountain whitefish. Removal of this culvert will also eliminate the upstream isolation of rainbow trout and blue-listed bull trout populations.

Removal of the culvert on Big Bend Creek will provide access to approximately 22 km of upstream habitat. At a minimum, removal of this culvert will benefit kokanee and rainbow trout populations currently using Big Bend Creek for spawning and rearing downstream and upstream of the culvert, respectively.

Approximately 125,700 linear metres of stream habitat will be made accessible to fish with the removal of these three culverts. Using stream width data, by stream order, for surveyed streams in the Davidson Creek Watershed, a total of about 406,800 m^2 of fish-bearing stream habitat will be made accessible to fish. Although habitat units and the likely increase in fish production provided by this newly accessible habitat cannot be calculated, it is conservatively assumed that 10% of the total upstream area will contribute to offsetting "serious harm to fish" caused by the Blackwater Project. Given the length of large, higher order streams above these three culverts and that the fish species potentially using this habitat are valued by recreational and Aboriginal fisheries (e.g.,Chinook salmon, sockeye salmon, bull trout, rainbow trout, and kokanee), the benefit of these culvert removals is likely much higher than has been consservatively estimated.

Contingency Plan

Several other rehabilitation projects have been identified in the Vanderhoof region that could be included in the Blackwater Project Fisheries Mitigation and Offsetting Plan should any of the offsetting projects described above prove to be unfeasible during detailed design, to be unsatisfactory to regulators or First Nations, or fail to meet their success criteria. These contingency projects include:

- Participation in and/or funding of the Murray Creek Rehabilitation Project;
- Participation in and/or funding of various Nechako Environment Water Stewardship Society (NEWSS) projects;
- Rehabilitation of Swanson Creek; and/or
- Replacement of additional "high priority" culverts in the Vanderhoof Forest District.

Murray Creek is a tributary of the Nechako River northwest of Vanderhoof, BC. It supports Chinook, sockeye and coho salmon and a resident rainbow trout population. Endangered white sturgeon also use the lower reaches of Murray Creek at different times of the year. Similar to Mathews Creek, habitat in Murray Creek has been impacted by past and current agricultural practices, particularly cattle grazing. Rehabilitation of Murray Creek would benefit many recreational, commercial, and Aboriginal fisheries.

The Murray Creek Rehabilitation Project (MCRP) was established to improve land and agriculture management practices and to restore riparian and fish habitat in the watershed. The over-arching goals are to improve production of rainbow trout, Chinook, sockeye, and coho salmon and to promote watershed stewardship values to land-owners and land-users. The Proponent has explored opportunities for partnering with MCRP on further habitat restoration activities in Murray Creek. Several habitat restoration opportunities have been identified including:

- Habitat complexing with boulder clusters and large woody debris installations;
- Riparian planting and bank stabilization prescriptions;
- Cattle exclusion fencing;
- Replacement of impassable culverts at road crossings; and

- Projects to increase and maintain adequate water supply, rebuild degraded streambeds and establish wetlands in lower sections of Murray Creek.

The NEWSS was created in 2013 following the success of the Murray Creek rehabilitation work. To date, established partners include the BC Cattlemen's Association, the Nechako Valley Regional Cattlemen's Association, Fisheries and Oceans Canada, the Fraser River Action Plan, the BC MFLNRO, the Nechako White Sturgeon Recovery Initiative, and the Nechako Fisheries Conservation Program (NFCP). The objectives of the society include rehabilitation of streams that flow through the Nechako Agricultural Belt, promotion of best land management practices with water stewardship as an objective, facilitation and participation in environmental stewardship education, and mapping of the aquifer under the Nechako Agricultural Belt.

One of the main initiatives of NEWSS is to take the successes achieved by the MCRP and apply the same principles and practices to 30 other small to medium-sized watersheds on the Nechako Plateau. The majority of these creeks have at least some of their watersheds within the Agricultural Land Reserve (ALR) and all have experienced at least some impact due to past agricultural activities. The Proponent has explored opportunities for partnering with NEWSS on habitat restoration in these watersheds. Although existing information on the condition of streams in the NEWSS operating area is more limited than in Murray Creek, there appear to be at least 11 watersheds in the NEWSS area with at least as much degraded stream and riparian habitat in the ALR as Murray Creek.

Swanson Creek has been identified as a historically important stream for production of Chinook salmon by the Sai'kuz First Nation. It is also know to support recreationally important populations of mountain whitefish and rainbow trout. Swanson Creek has experienced natural and anthropogenic disturbances that now limit its capacity to produce Chinook salmon, whitefish, and trout. These disturbances have included frequent flooding and beaver dam breaching and cattle grazing in riparian areas. As a result, gravels suitable for salmon and trout spawning have been lost or covered, side-channels important for rearing have been cut-off, mainstem channels are shallow, and the services provided by riparian vegetation have been reduced.

Four opportunities for restoration of Swanson Creek have been identified. All opportunities would improve spawning habitat for Chinook salmon as well as spawning and rearing habitat for rainbow trout and mountain whitefish. These four opportunities include:

- Enhancement of groundwater-fed side-channels;
- Maintenance of previously installed large woody debris structures;
- Stabilizing of lateral bars; and
- Restoration of stream banks and riparian vegetation.

Finally, there are a minimum of eight other high-priority, "pre-code" culverts in the Vanderhoof Forest District that could be replaced with clear-span structures to restore fish passage. These include culverts on Finger Creek, Angly Creek, an unnamed creek crossed by the Holy Cross FSR, a tributary to Chedakuz Creek, Duncan Creek, a tributary to Corkscrew Creek, an unnamed creek crossed by the Bobtail-Tatuk FSR, and a tributary to Nulki Lake. Another eight

"high priority" culverts also exist but the date of their installation, and therefore, their responsible authority are currently unknown.

Summary of Losses and Gains

A total of 104,650 m^2 of habitat, or 134,400 rainbow trout habitat units, will be permanently and unavoidably altered or lost in Davidson Creek and Creek 661 watersheds under or upstream of mine site facilities. These losses will require a Section 35(2) *Fisheries Act* authorization. To offset these losses, a total of 153,700 m^2 of habitat, providing approximately 386,800 rainbow trout habitat units, would be created, enhanced, or restored in the Davidson Creek watershed. This amounts to a spatial offset ratio of approximately 1.5:1 and a habitat unit based ratio of approximately 2.9:1. Offsets for the Section 35(2) authorization will be provided largely by enlargement of Lake 01692LNRS in the upper Davidson Creek watershed but also by the creation of off-channel overwintering ponds in the middle reaches of Davidson Creek and Creek 661.

A total of 53,700 m^2 of habitat, or 83,700 rainbow trout habitat units, will be affected by the deposit of deleterious mine tailings and waste rock. These losses will require amendment of Schedule 2 of the Metal Mine Effluent Regulation. To offset these losses, a total of 105,600 m^2 of habitat would be created, enhanced, or restored. This amounts to a spatial offset ratio of approximately 2:1. Offsets for the Schedule 2 amendment will be provided by habitat rehabilitation in the Mathews Creek watershed and by replacement of three pre-Forest Practices Code, fish-barrier culverts in the Vanderhoof Forest District. The net gain in rainbow trout habitat units from these projects cannot be comprehensively estimated due to the uncertain quantity and quality of habitat upstream of the three culverts. However, the length of large, higher order streams above each culvert is high, and it is highly likely that newly accessible habitat will be used by fish species important to recreational and Aboriginal fisheries (Chinook salmon, sockeye salmon, kokanee, rainbow trout, mountain whitefish, bull trout, and possibly endangered Nechako River white sturgeon) for spawning, rearing, foraging and overwintering. Therefore, a habitat unit based offsetting ratio higher than 2:1 would be expected.

1.0 INTRODUCTION

1.1 Background

New Gold Inc. (the Proponent) is proposing to construct and operate the proposed Blackwater Gold Project (the Project), an open pit gold/silver mine located approximately 110 kilometres (km) south of Vanderhoof on the Nechako Plateau in north-central British Columbia (**Figure 1-1**). The mine site is located primarily within the Davidson Creek Watershed, a tributary of Chedakuz Creek within the larger Nechako River Watershed (**Figure 1-2**). However, mine components also extend into the adjacent Creek 661 and Turtle Creek watersheds, two other tributaries of Chedakuz Creek. The mine site borders the Creek 705 watershed, a tributary of Fawnie Creek. Both Chedakuz Creek and Fawnie Creek drain to the Nechako Reservoir. The Project is located within the Omineca Region of BC Ministry of Forests, Lands, and Natural Resource Operations (BC MFLNRO) and the Pacific Region of Fisheries and Oceans Canada (DFO).

The mine site consists of an open pit, east and west waste rock dumps, low-grade ore stockpile, a central plant site where the processing mill will be located, construction and operations lay-down areas, construction and operations camps, and a Tailings Storage Facility (TSF) (**Figure 1-3**). The Project also includes:

- A 133 km-long 230 kV transmission line connecting with BC Hydro's 230 kV system at the Glenannan Substation near Endako;
- A 15 km access road connecting the mine site with the Kluskus-Ootsa Forest Service Road (FSR);
- Minor upgrades to and re-alignment of the existing Kluskus-Ootsa FSR;
- An airstrip and 6 km airstrip access road; and
- A 20 km freshwater supply pipeline from Tatelkuz Lake to a freshwater reservoir in upper Davidson Creek.

Construction and operation of the Project has the potential to cause "serious harm to fish", including permanent alteration or destruction of fish habitat in streams and lakes in the Chedakuz Creek Watershed. These losses will include unavoidable losses of fish habitat in the Davidson Creek and Creek 661 headwaters under and upstream of the mine site footprint. As such, the Project will require DFO to authorize these unavoidable losses of fish habitat under Section 35(2)(b) of the *Fisheries Act* before construction can commence.

The Project will also result in the deposit of deleterious substances (i.e., mine tailings and waste rock) into fish-bearing portions of Davidson Creek and Creek 661. This will require the federal government to amend Schedule 2 of the Metal Mining Effluent Regulations (MMER) (Government of Canada, 2002) to designate the portions of Davidson Creek within the TSF and

the portions of Davidson Creek and Creek 661 under the West and East Waste Rock Dumps[1] as Tailings Impoundment Areas (TIA). Both the Section 35(2) *Fisheries Act* authorization and the Schedule 2 amendment of the MMER require the Proponent to develop plans to mitigate and offset the unavoidable losses of fish habitat such that there is no residual "serious harm to fish". This report documents the Proponent's plan to do both and, by doing so, supports the Proponent's contention that the Project will not result in significant adverse effects to fish and fish habitat.

In support of these project permit applications, two separate Fisheries *Mitigation and Offsetting Plans* (FMOP) are required: 1) a plan for Section 27.1 of the MMER that describes the avoidance, mitigation and offsetting measures for the deposition of deleterious substances in waters "frequented by fish" within the TIAs; and 2) a plan for the Section 35(2)(b) *Fisheries Act* authorization that describes the avoidance, mitigation and offsetting measures for all other mine components or activities that result in "serious harm to fish", including all other unavoidable permanent alteration or destruction of fish habitat, that are part of commercial, recreational, or Aboriginal fisheries or to fish that support such a fishery as required by the recently amended *Fisheries Act* (Government of Canada, 2013).

However, separate plans will be developed for submission only if the Project receives its Environmental Certificate and enters the permit phase of the Project. Until then, this FMOP presents the anticipated habitat losses and gains within the TSF and waste rock dumps as well as those under and downstream of other Project infrastructure to show how the Proponent anticipates balancing habitat losses and gains between these two separate permit applications.

[1] Habitat under East and West waste rock dumps included as part of Schedule 2 amendment of MMER until proven that waste rock in these dumps will not be "deleterious". If proven to be "not deleterious", waste rock dumps will be included as part of the Section 35(2) Fisheries Authorization application.

320000 360000 400000 440000

5960000 5920000 5880000

François Lake
Southbank
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
Knapp Creek
BAPTISTE LOUIS 8
Cheslatta River
Cheslatta Lake
ALEXIS THOMAS 1A
TARGE CREEK 15
Targe Creek
HOLY CROSS LAKE 3
Cheslatta
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
Blackwater River
Kluskus
CHIEF MORRIS 13
BISHOP BLUFFS 5
BISHOP BLUFFS 6
BISHOP BLUFFS 10
KLUSKUS 14
SUNDAYMAN'S MEADOW 3
KLUSKUS 1
UPPER KLUSKUS LAKE 9
KLOYADINGLI 2
YALADELASSLA 4
Kuyakuz Lake
Chedakuz Creek
Top Lake
Tatelkuz Lake
TATELKUS LAKE 28
Kluskus-Ootsa FSR
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Exploration Road
Kluskus-Blue FSR
Kluskus FSR
Nechako Canyon Protected Area
Finger Lake
TATUK LAKE 7
Tatuk Lake
Finger Tatuk Park
Chilako River Ecological Reserve
Chilako River
Taiuk 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 Lakes
Euchiniko
Baezaeko
REDWATER CREEK 30
Nazko
Meridian Road (Vanderhoof) Ecological Reserve
Hallett Lake
Greer Creek
Tahultzu Lake
Nechako River
Nechako River
Engen
Endako
Stellako
Fraser Lake
Fraser Lake
FRASER LAKE 2
Nadleh Whuten
YENSISCHUCK 3
Fort Fraser
NAUTLEY 1
STELLAQUO 1
SEASPUNKUT 4
Engen
NOONLA 6
Vanderhoof
Weneez
Sinkut River
Stuart River Park
Stuart River
STONY CREEK 1
Tachick Lake
Saik'uz
CLUSTALACH 5
SINKUT LAKE 8
OLD COUNTRY MEADOW 4
Nulki
Nulki Lake
LAKETOWN 3
SACKANITECLA 2
Mapes
CORKSCREW CREEK 10
CORKSCREW CREEK 9
Corkscrew
Sinkut River
Cluculz Lake
Cluculz Creek
Khai
Smith Creek
Stellako
16

Legend

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

Project Components

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

KEY MAP



Scale: 1:500,000

0 5 10 20
Kilometres

Reference
BC Government GeoBC Data Distribution

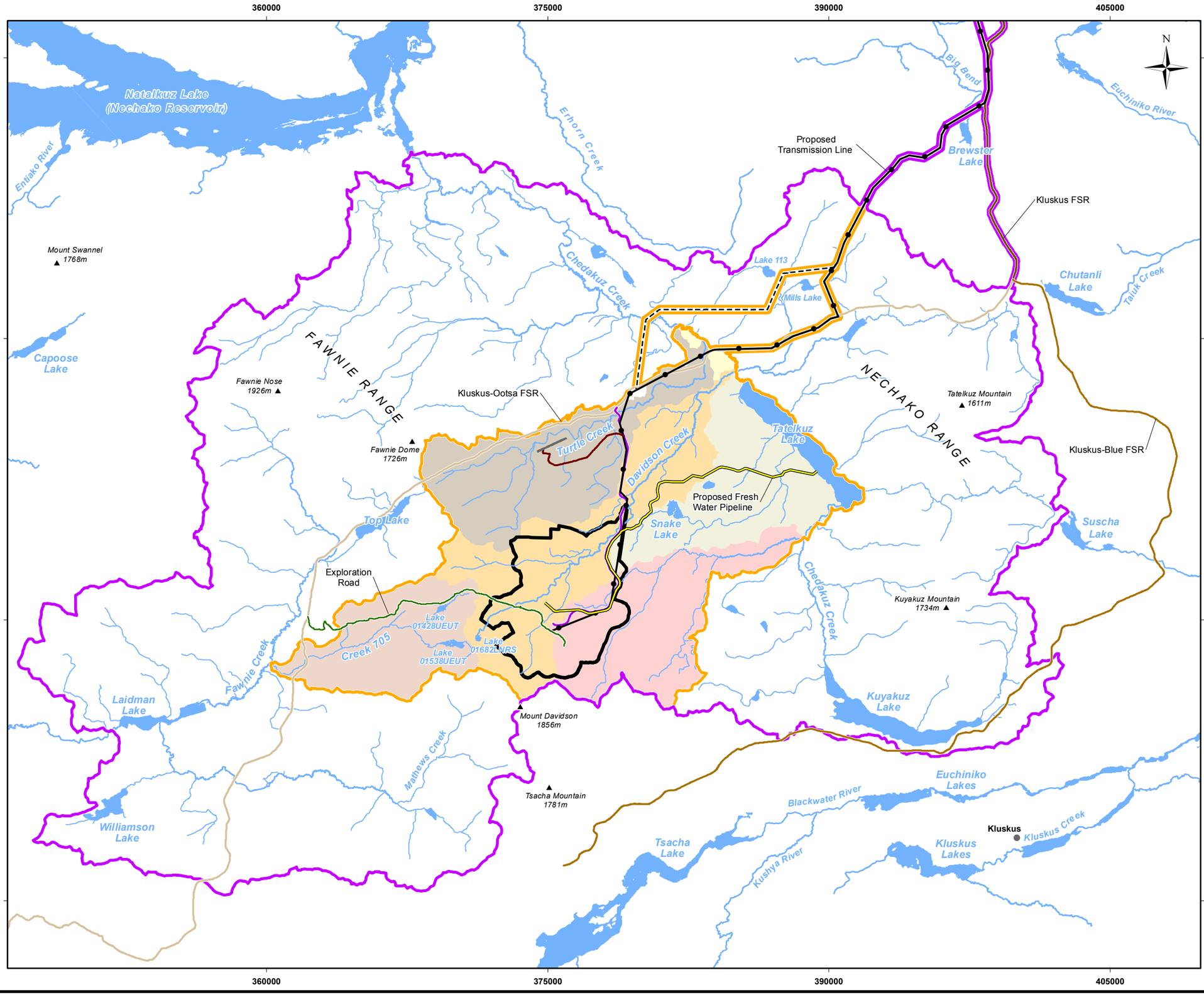
CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of the Blackwater Project South of Vanderhoof, BC

DATE:	ANALYST:	**Figure** 1-1
April, 2014	WR	
JOB No: VE52277	QA/QC: AP	PDF FILE: Other-100-028_v10_TL_mine_parks.pdf
GIS FILE: Other-100-028_v10_TL_mine_parks.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

\\bby-fs2\BBY-EE-GIS\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\Other\Other-100-028_v10_TL_mine_parks.mxd



Legend

- Populated Place
- Spotheights
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream
- Waterbody

Project Components

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

Watersheds

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

Fish and Aquatic Resources

- Local Study Area
- Regional Study Area

Scale:1:200,000

0 2.5 5 10

Kilometres

Reference

BC Government GeoBC Data Distribution
AMEC 2013 Baseline Report - Fish and Aquatic Resources

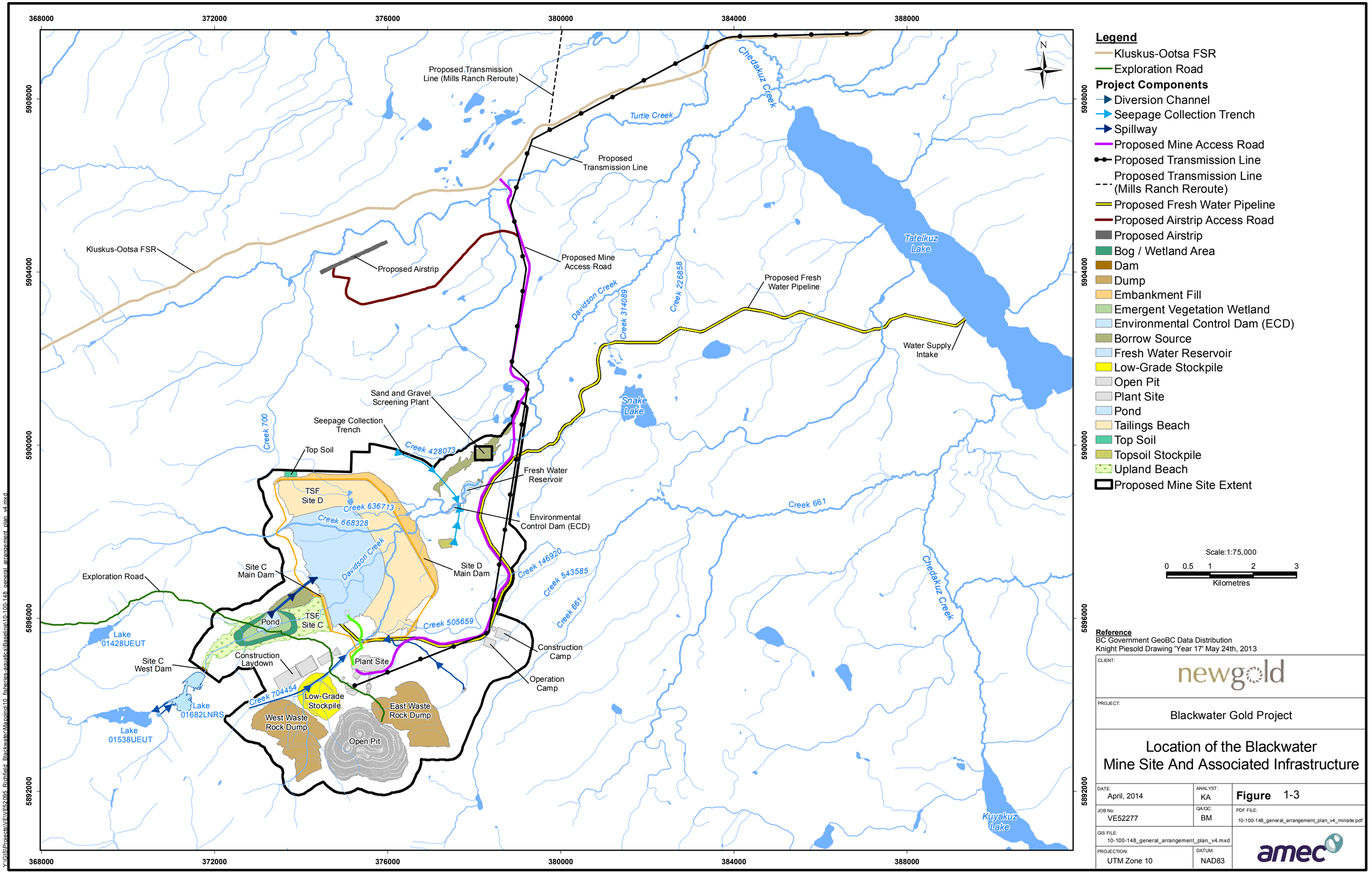
CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of the Blackwater Mine Site in the Davidson and Creek 661 Watersheds

DATE: April, 2014	ANALYST: WR	**Figure** 1-2
JOB No: VE52095	QA/QC: BM	PDF FILE: 10-100-002_v13_aquatic_FMOP.pdf
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PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Reference
BC Government GeoBC Data Distribution
Knight Piesold Drawing 'Year 17' May 24th, 2013

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of the Blackwater Mine Site And Associated Infrastructure

DATE:	ANALYST:	Figure 1-3
April, 2014	KA	
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This FMOP includes descriptions of the avoidance, mitigation, and offsetting measures the Proponent intends to implement to minimize and offset unavoidable "serious harm to fish," including the permanent alteration or destruction of fish habitat, resulting from the construction, operation, and closure of the Project. Avoidance measures are those designed to completely prevent *serious harm to fish* (DFO, 2013a). For this FMOP, these included measures that were incorporated into the mine planning process, compared in the Multiple Accounts Analysis (i.e., various TSF alternatives), and ultimately, were included in the Project Description. Mitigation measures are those designed to reduce the spatial scale, duration, or intensity of *serious harm to fish* (DFO, 2013a). For this FMOP, these included measures included in the mine plan, associated environmental management plans, and commitments made by the Proponent in the Environmental Assessment Application, including those in the effects assessment sections for the Fish VC (**Section 5.3.8**) and the Fish Habitat VC (**Section 5.3.9**) and in this FMOP. Offsetting measures are those that counterbalance unavoidable *serious harm to fish* resulting from a project, after avoidance and mitigation measures are implemented, with the goal of "sustaining the ongoing productivity of commercial, recreational, or Aboriginal fisheries" (DFO, 2013a). For this FMOP, these include all "in-kind"[2] and "out-of-kind"[3] habitat restoration, enhancement, or creation projects that will be implemented should the Project be approved for construction. By looking to avoid first and offset last, this plan is consistent with DFO's hierarchy of habitat conservation and protection guidelines (DFO, 1998a) and DFO's recently issued *Fisheries Protection Policy Statement* (DFO, 2013a).

1.2 Purpose and Objectives

The purpose of this FMOP is to provide federal and provincial regulators, First Nations, and other stakeholders with the information they need to: 1) assess whether the Proponent has done all it can to avoid or minimize "serious harm to fish", including the permanent alteration or destruction of fish habitat, while still allowing the mine to be constructed, operated, and closed; 2) assess whether sufficient low risk, highly effective offsetting options exist to mitigate all unavoidable "serious harm to fish", including all permanent alteration and destruction of fish habitat such that no significant adverse effects to fish and fish habitat are likely to occur due to construction, operation, and closure of the Project; and 3) assess whether sufficient low risk, highly effective offsetting options exist to ensure that the goal of the Fisheries Protection Policy (i.e., the "sustainability and ongoing productivity of commercial, recreational, and Aboriginal fisheries") can be achieved.

To achieve this purpose, this FMOP has been organized to meet the following objectives:

- Describe the existing fisheries, the fish habitat that supports them, and the factors that currently limit their productivity, in the vicinity of the Project;
- Describe the components and activities required for the construction, operation, and closure of the Project that could potentially affect fish and fish habitat;

[2] Same kind of habitat and fisheries that are lost are replaced (DFO, 2013b)
[3] Measures that target the limiting factors of productivity in a given area rather than replacing exactly what was lost (DFO, 2013b)

- Describe steps taken during mine planning to avoid "serious harm to fish";
- Describe steps taken during mine planning, the environmental assessment, and offset planning to minimize effects to fish and fish habitat;
- Describe the compilation and evaluation process used to identify "in-kind" and "out-of-kind" offsetting measures included in this FMOP;
- Describe all mitigation and offsetting measures, the rationale for their selection, and their engineering details and drawings;
- Describe how the selected offsetting measures will maintain or improve productivity of commercial, recreational, or Aboriginal fisheries and/or align with available fisheries management objectives and/or local restoration priorities;
- Describe the approach and methods used to assess whether the "sustainability and ongoing productivity of commercial, recreational, and Aboriginal fisheries" can be achieved by this offsetting plan;
- Describe a monitoring plan that will be implemented to assess the effectiveness of mitigation and offsetting measures to minimize and counterbalance unavoidable "serious harm to fish"; and
- Describe a contingency plan of other mitigation and offsetting measures that are available and could be implemented should monitoring show that mitigation and offsetting measures committed to by the Proponent are less effective or insufficient to achieve DFO's "sustainability and ongoing productivity of commercial, recreational, and Aboriginal fisheries" goal.

1.3 Regulatory Framework

As indicated above, the FMOP is a necessary regulatory requirement for the Proponent's Environmental Application and, ultimately, for its permit applications for a Section 35(2)(b) *Fisheries Act* authorization and a Schedule 2 amendment of the MMER. Each of these regulatory requirements is described briefly below.

1.3.1 Fisheries Act

Changes were made to the *Fisheries Act* by the federal government in June 2012. The intent of these changes was to refocus how the federal government manages potential impacts to fish and fish habitat from development in Canada. It did so by switching the focus from the protection of fish habitat[4] to the protection of commercial[5], recreational[6], and Aboriginal[7] fisheries[8].

[4] Spawning grounds and nursery, rearing, food supply, and migration areas on which fish depend directly or indirectly to carry out their life processes (*Fisheries Act*)
[5] Fish harvested under the authority of a license for the purpose of sale, trade, or barter
[6] Fish harvested under the authority of a license for personal use of the fish or for sport
[7] Fish harvested by an Aboriginal organization or any of its members for the purpose of using the fish as food, for social or ceremonial purposes or for purposes set out in a land claims agreement entered into with the Aboriginal organization

Two principle amendments were made to facilitate this switch. First, Section 35(1) was amended from:

35. (1) "*No person shall carry on any work or undertaking that results in the harmful alteration, disruption, or destruction of fish habitat*"

To:

35. (1) "no person shall carry on any work, undertaking, or activity that results in serious harm to fish that are part of a commercial, recreational, or Aboriginal fishery, or to fish that support such a fishery"

Under the new Act, "serious harm to fish" is defined as "*the death of fish or any permanent alteration to, or destruction of, fish habitat*." Thus, the amended *Act* still requires protection of fish habitat in as long as it supports fish that are directly utilized by a fishery or by fish that support such a fishery. The amended Section 35(1) now merges the previous Section 32 (prohibition of killing fish) and Section 35 (prohibition of harming fish habitat) into a single prohibition.

Like the previous *Act*, the amended *Fisheries Act* requires Proponents wishing to develop a Project that will result in the alteration or destruction of fish habitat, to apply for an authorization from DFO before any fish are killed or any fish habitat is permanently altered or destroyed. Before this Section 35(2) *Fisheries Act* authorization is issued however, the Proponent must submit an "offsetting" plan (formerly compensation plan) that describes, in detail, how the Proponent will avoid and mitigate potential "serious harm to fish", and how the Proponent will "offset" any unavoidable "serious harm to fish", including any and all permanent alterations or destructions of fish habitat.

The second change to the *Fisheries Act* was addition of Section 6. This section sets out the purpose of the new fisheries protection provisions, that being "to provide for the sustainability and ongoing productivity[9] of commercial, recreational, and Aboriginal fisheries", and identifies four factors that the Minister must consider before making a decision on issuance of new regulations under the *Act* or issuance of Section 35(2) authorizations. These are:

- The contribution of the relevant fish to the ongoing productivity of commercial, recreational, or Aboriginal fisheries;
- Fisheries management objectives;
- Whether there are measures or standards to avoid, mitigate or offset serious harm to fish that are part of a commercial, recreational, or Aboriginal fishery; and
- The public interest.

[8] The area, locality, place, or station in or on which a pound, seine, net, weir or other fishing appliance is used, set, placed or located, and the area, tract, or stretch of water in or from which fish may be taken by the said pound, seine, net, weir or other fishing appliance, and also the pound, seine, net, weir, or other fishing appliance used in connection therewith (*Fisheries Act*)
[9] Potential sustained yield of all fish populations and their habitat that are part of or support commercial, recreational, or Aboriginal fisheries

The *Fisheries Protection Policy Statement* (DFO, 2013a) provides guidance on how DFO expects proponents to provide information for each of these factors in their project design, mitigation plan, and offsetting plan. Specifically, this includes:

- Confirmation that habitat area and quality continues to be one of the appropriate surrogates for qualifying and quantifying the potential losses and gains of productivity of fisheries
- Confirmation that federal, provincial, territorial, or co-management board fisheries management objectives and the potential negative effects of the Project on these objectives will be considered when making decisions about the acceptability of a proponent's Project, their mitigation plan, and their offsetting plan;
- A hierarchy of habitat protection measures including, in order of preference: 1) avoidance; 2) mitigation; and 3) offsetting; and
- Confirmation that restoration of previous degraded habitat, replacement of the same type of habitat, in the same place, that is affected (i.e., "in-kind"), and restoration, replacement or creation of different habitat in water bodies or for fish species other than those affected by the Project (i.e., "out-of-kind") are acceptable offsetting measures as long as they provide "tangible conservation outcomes for fish and fish habitat that may be reasonably be expected to counterbalance the loss of fish habitat and fisheries productivity as a result of negative project impacts."

Changes to the *Fisheries Act* came into force June 2013.

1.3.2 Metal Mining Effluent Regulations

Section 36 of the *Fisheries Act* prohibits the deposit of deleterious substances to waters "frequented by fish." However, the MMER of the *Fisheries Act* may authorize Proponents to deposit deleterious substances (i.e., mine tailings, waste rock, and mine effluent) into waters frequented by fish if EC, the administrator of the MMER, recommends to the Minister of Environment that Schedule 2 of the MMER should be amended to designate these waters as a TIA.

Section 27.1 of the MMER requires proponents to develop and submit a fish habitat compensation plan (now an "offsetting" plan) to DFO that shows, to DFO's satisfaction, that habitat alterations and losses can be offset such that the "productive capacity of fish habitat" is undiminished. DFO is responsible for approval of the fish offsetting plan, ensuring monitoring is sufficiently to determine effectiveness, and that contingency options are available should monitoring show that the plan is not meeting its success criteria or objectives. When satisfied, DFO notifies E C, who then recommends to the Minister of Environment that the affected waters should be designated as a TIA.

DFO, Environment Canada, and Natural Resources Canada are responsible for completing an analysis of tailings management options to ensure that the selected TIA option considers environmental and socio-economic benefits and costs.

1.4 Document Organization

This plan has been organized in alignment with the information requirements outlined in DFO's *Guidelines to Submitting an Application for Authorization under Paragraph 35(2)(b) of the Fisheries Act* (DFO, 2013c). As such, the report has been structured as follows:

- Section 2.0: Description of Proposed Work, Undertaking, or Activity;
- Section 3.0: Description of Fish and Fish Habitat;
- Section 4.0: Description of Effects on Fish and Fish Habitat;
- Section 5.0: Measures and Standards to Avoid or Mitigation Serious Harm to Fish;
- Section 6.0: Residual Serious Harm to Fish After Implementation of Avoidance and Mitigation Measures and Standards;
- Section 7.0: Offsetting Plan; and
- Section 8.0: Monitoring Plan.

2.0 DESCRIPTION OF PROPOSED WORKS, UNDERTAKINGS, AND ACTIVITIES

2.1 Project Purpose

The Proponent intends to develop and operate the Project to provide shareholders with a reasonable rate of return on their investment. This will be accomplished by economically extracting gold and silver resources from the Blackwater deposit to help meet the worldwide demand for these resources.

In addition to meeting resource demands, the Project will provide economic benefit to the local and regional areas by providing employment opportunities for 1,000 to 1,500 construction workers and approximately 500 operations workers and by contributing royalties and taxes to the Province of British Columbia. This will help to compensate for the recent downturns in the BC forestry and tourism sectors that have negatively affected the local, regional, and provincial economies.

2.2 Location

The Project is located approximately 20 km from the Kluskus Village, approximately 110 km southwest of Vanderhoof, approximately 100 km south of Fraser Lake, and approximately 160 km west-southwest of Prince George in central British Columbia (**Figure 1-1**). The mine site is centred at 5893000 N and 375400 E and is located in National Topographic System (NTS) sheet 93F/02.

Mine site facilities will be located in the headwaters of Davidson Creek and Creek 661, two tributaries of Chedakuz Creek in the Nechako River Watershed (**Figure 1-2** and **Figure 1-3**). The Project also borders Creek 705 in the adjacent Fawnie Creek Watershed. Some offsetting projects included in this FMOP will be located in the Creek 705 Watershed. Both Chedakuz Creek and Fawnie Creek drain to the Nechako Reservoir. The Project is adjacent to the Blackwater River Watershed to the south. However, no part of the mine site or any other mine infrastructure is located in or passes through the Blackwater River Watershed.

Linear components of the Project will extend beyond the Davidson Creek, Creek 661 and Creek 705 watersheds. The new mine access road will traverse the Turtle Creek, Davidson Creek, and Creek 661 watersheds (all Chedakuz Creek tributaries), and will extend approximately 15 km from the existing Kluskus-Ootsa FSR to the mine site (**Figure 1-3**). The section of the Kluskus-Ootsa FSR requiring re-gravelling and realignment will cross two unnamed tributaries in the Creek 522107 Watershed, a tributary to Chedakuz Creek entering from the north, opposite of Davidson Creek. The airstrip and its access road will be located in the Turtle Creek Watershed, the Chedakuz Creek tributary immediate north-west of the Davidson Creek Watershed (**Figure 1-2**).

The transmission line right-of-way (ROW) will extend from the Glenannan sub-station near Endako, BC, to the mine site (**Figure 1-1** and **Figure 1-2**) and will cross the following named streams and rivers, from the north to south (**Figure 1-1**):

- Mudhole Creek;
- Robertson Creek;
- Smith Creek;
- Fifteen Creek;
- Tahuttzu Creek;
- Nechako River;
- Greer Creek;
- Swanson Creek;
- Big Bend Creek;
- Chedakuz Creek;
- Turtle Creek; and
- Davidson Creek.

2.3 Timeline

The Project includes construction, operations, closure/decommissioning, and post-closure phases. The anticipated durations of each of these phases are as follows:

- Construction: approximately two years before start of Operations (i.e., year -2);
- Operations: approximately 17 years (i.e., from year 0 to year +17);
- Closure and decommissioning: approximately 18 years from year +17 to year +35; and
- Post closure: a period of post-closure maintenance and monitoring starting in year +35 (year +37 for aquatics disciplines because full discharge from the TSF will take 2 years to be reached). Post-closure monitoring and maintenance will continue until the long-term environmental objectives are achieved.

2.4 Project Description Summary

A detailed Project Description is provided in **Section 2** of the Application. A summary of the Project Description is provided here that focuses on project components and activities that have the potential to affect fish and fish habitat.

The Project will be a conventional truck-and-shovel open pit mine. In total, 361 million tonnes (Mt) of ore, 735 Mt of waste rock, and 99 Mt of overburden for a total production of 1,195 Mt of material will be mined, processed, or relocated over the 17-year mine life. The Project is

anticipated to have an average annual production of 507,000 ounces (oz) of gold and 2,039,000 oz of silver over these 17 years.

The Project has six main components: the mine site, a Freshwater Supply System (FSS), a new mine access road, a transmission line, an airstrip and access road, and an upgrade to the existing Kluskus-Ootsa FSR. Each of these components is described below.

2.4.1 Mine Site

The mine site is the largest component of the Project. The mine site includes (**Figure 1-3**):

- Open pit;
- Two TSFs (Site C and Site D) and associated dams and spillways;
- Two waste rock dumps (East and West);
- Low-grade ore stockpile;
- Plant site, which includes the processing mill;
- Construction lay-down area;
- Construction and operations camps;
- Sand and gravel screening plant;
- An Environmental Control Dam (ECD);
- Seepage collection ditches and ponds; and
- Other on-site infrastructure including haul roads, truck shop, explosives storage facilities and warehouses, and administrative buildings.

As stated in **Section 2.2**, all mine site components will be located in the Davidson Creek and Creek 661 watersheds.

2.4.2 Freshwater Supply System

The FSS is required for three reasons: 1) to provide any additional freshwater required by the mill that cannot otherwise be met by recycled water from the TSF or upstream run-off captured by the TSF; 2) to saturate potentially acid-generating (PAG) waste rock within the TSF if required; and 3) to supplement flows in Davidson Creek downstream of the mine site such that minimum instream flow requirements for fish and other aquatic biota are met during operations and closure phases. The FSS includes the following components (**Figure 1-2** and **Figure 1-3**):

- An intake facility on Tatelkuz Lake, including two screened pipes, a pump station, a laydown area, and any required bank protection;

- A 14 km long pipeline and associated pump booster stations, maintenance access roads, and transmission line extending from Tatelkuz Lake to a freshwater reservoir constructed in Davidson Creek immediately downstream of the ECD; and
- A freshwater reservoir in Davidson Creek.

The intake structure on the shore of Tatelkuz Lake includes a wet-well chamber fed by two 610 mm diameter high density polyethylene pipes, each approximately 50 m long and equipped with appropriately sized fish screens (refer to **Chapter 5.0** for specifics). Pipe intakes will be positioned between 8 and 12 m below the Tatelkuz Lake surface elevation. The pump house floor will house four 525 kW vertical turbine pumps (three operating, one installed spare) that will draw a continuous supply of water from the wet-well chamber.

A 14 m high, water-retaining dam will be constructed in Davidson Creek to create the freshwater reservoir. When finished, the area occupied by the freshwater reservoir will be about 11 ha. The freshwater reservoir will store approximately 700,000 m^3 of water, enough to provide a minimum of 10 days water supply for Davidson Creek and the mill should any other part of the FSS system fail. Specifications for the FSS were designed to ensure the system has additional pumping and storage capacity to provide an additional 3 Mm^3 of water per year as a contingency in dry years. A spillway will be built to carry storm flows, up to and including the 1 in 200 year, 24-hour storm, around the dam.

Water will be discharged from the reservoir to Davidson Creek through two pipelines near the downstream toe of the dam: a 150 mm diameter pipe for instream flows and a concrete-enclosed, 610 mm diameter, steel pipe for flushing and channel maintenance flows. The pipe-ends will discharge to a rip-rap-lined outfall channel to dissipate energy and to aerate the water with dissolved oxygen.

At closure, the freshwater reservoir will be converted to a wetland for passive treatment of water discharged from the TSF (refer to Chapter 5.0).

2.4.3 Transmission Line

The 230 kV transmission line will extend approximately 133 km from BC Hydro's Glenannan Substation near Endako to the mine site (**Figure 1-1**). The transmission line will be supported by wooden H-frame or steel monopole structures placed approximately every 250 m along the route. A right-of-way (ROW) ranging from 30 m to 50 m in width, depending on the presence of hazard trees, will be cleared. The transmission line route has been aligned to make use of existing access and to cross recently logged areas as much as possible. Major stream crossings along the proposed transmission line are described in **Section 2.2**.

2.4.4 Airstrip

The proposed airstrip will be located on the site of a previously logged forestry cut-block in the Turtle Creek Watershed (**Figure 1-3**). The runway will be approximately 1,706 m long and 30 m wide. An 18 m long taxiway will connect the runway to the terminal buildings. Overall, the airstrip

site will be approximately 1.7 km long and 90 m wide, with a total area of approximately 15.5 ha. An existing forestry cut-block road will be upgraded to serve as the airstrip access road. This road extends approximately 5.6 km from the proposed mine access road to the airstrip site.

2.4.5 Mine Access Road

Access to the mine site will be provided by a new mine access road. This new road will be approximately 15 km long and will connect the mine site to the existing Kluskus-Ootsa FSR at 123+973 km (**Figure 1-2**). Current access to the Project site via the existing mine exploration road will be closed and decommissioned.

The FSS corridor parallels the mine access road ROW approximately 7.2 km from the mine site while the transmission line ROW parallels the mine access road all the way from the Kluskus-Ootsa FSR to the mine site. The mine access road ROW in these sections will be made wide enough to accommodate all three linear developments.

The road will be used for heavy machinery traffic during mine construction and has been designed for year-round all-weather access. The running width of the road will be 10 m. It will have two lanes, a design speed of 60 km/h, and will incorporate five bridges. The road design includes ditching to control erosion as well as culverts and cross drains as required.

2.4.6 Kluskus-Ootsa FSR Upgrade

The Proponent plans to use the existing Kluskus and Kluskus-Ootsa FSRs for year-round operations. Portions of the Kluskus-Ootsa FSR will be upgraded and realigned to allow safe travel of B-trains and other mine vehicle traffic to and from the mine site. The proposed road upgrades will involve:

- Re-gravelling a 22 km section of road from 101+650 km to 123+973 km;
- Realigning approximately 1.8 km of the road from 104+900 km to 106+738 km;
- Improving existing ditch lines or constructing new ditch lines where required; and
- Replacing damaged culverts or establishing new culverts where required.

2.5 Project Schedule

Descriptions of the project components and activities that will be completed during the construction, operations, closure/decommissioning, and post-closure phases of the Project are described in the sections below.

2.5.1 Construction

Construction at the mine site will begin with the clearing of top-soil and over-burden from the open pit, waste rock dumps, TSF dam and mine effluent storage areas, the construction lay-down area, and the ore-processing area where the plant site, mill, core-logging buildings, fuel

site, warehouses, truck shop, maintenance buildings, the explosives facility, and construction camp will be built (**Table 2-1**).

Table 2-1: Project Activities during Construction Phase

Project Component	Project Component	Activities
Mine Site	Site Infrastructure and Site Roads	Clearing, grading and topsoil salvage, construction and lay-down areas, surface drainage controls, construction of site infrastructure (fuel site, warehousing and materials storage, construction lay-down area, truck stop, camp and maintenance buildings, explosives facility), camp waste management system (site landfill and domestic sewage system)
	Mine Pit	Clearing topsoil and overburden
	Ore Processing Area	Clearing and construction of ore processing area (plant site, mill and processing area, core logging area) foundations and building construction, crusher and conveyor and low-grade ore stockpile
	Waste Rock Areas	Mine waste rock dumps construction
	TSF	Clearing, grading and topsoil salvage, construction of TSF (tailings and return water lines), construct dams and collect water, Site C west dam, Site C main dam, Site D main dam and embankment
	Wetland and Water Management System, Freshwater Reservoir	Construction of water management system (site surface drainage management, erosion and sediment control, water recovery and recycle system from TSF)
	Borrow areas	Development of borrow sites (Site C main dam, esker borrow source and sand and gravel screening plant)
Linear developments	Mine Access Road	Site clearing, grading and topsoil salvage, road and lay-down area construction including transfer and placement of granular materials and stream crossings. Transportation of workforce and materials
	Kluskus-Ootsa FSR	Road upgrades. Transportation of workforce and materials
	FSS	ROW clearing and grading, timber salvage and soil management, facilities construction (pump-house, water intake, electrical hook-up), road construction, installation of water pipeline and fresh water reservoir. Transportation of workforce and materials
	Airstrip	Site clearing and grading, timber and soil salvage, construction of runway and construction of airstrip ancillary facilities (service road installation and site infrastructure). Transportation of workforce and materials
	Transmission Line	ROW clearing and preparation, vegetation clearing, construction of access roads, installation of power line (pole foundations, poles and cable stringing). Transportation of workforce and materials

Two separate ore stockpiles will be established immediately west of the plant site for high- and low grade ore.

Once the land is cleared, buildings will be built, surface drainage ditching around ore-stockpiles and waste rock dumps will be installed, and the camp waste management system, including the site land-fill, incinerator, and domestic sewage system will be built. Non-acid-generating (NAG)

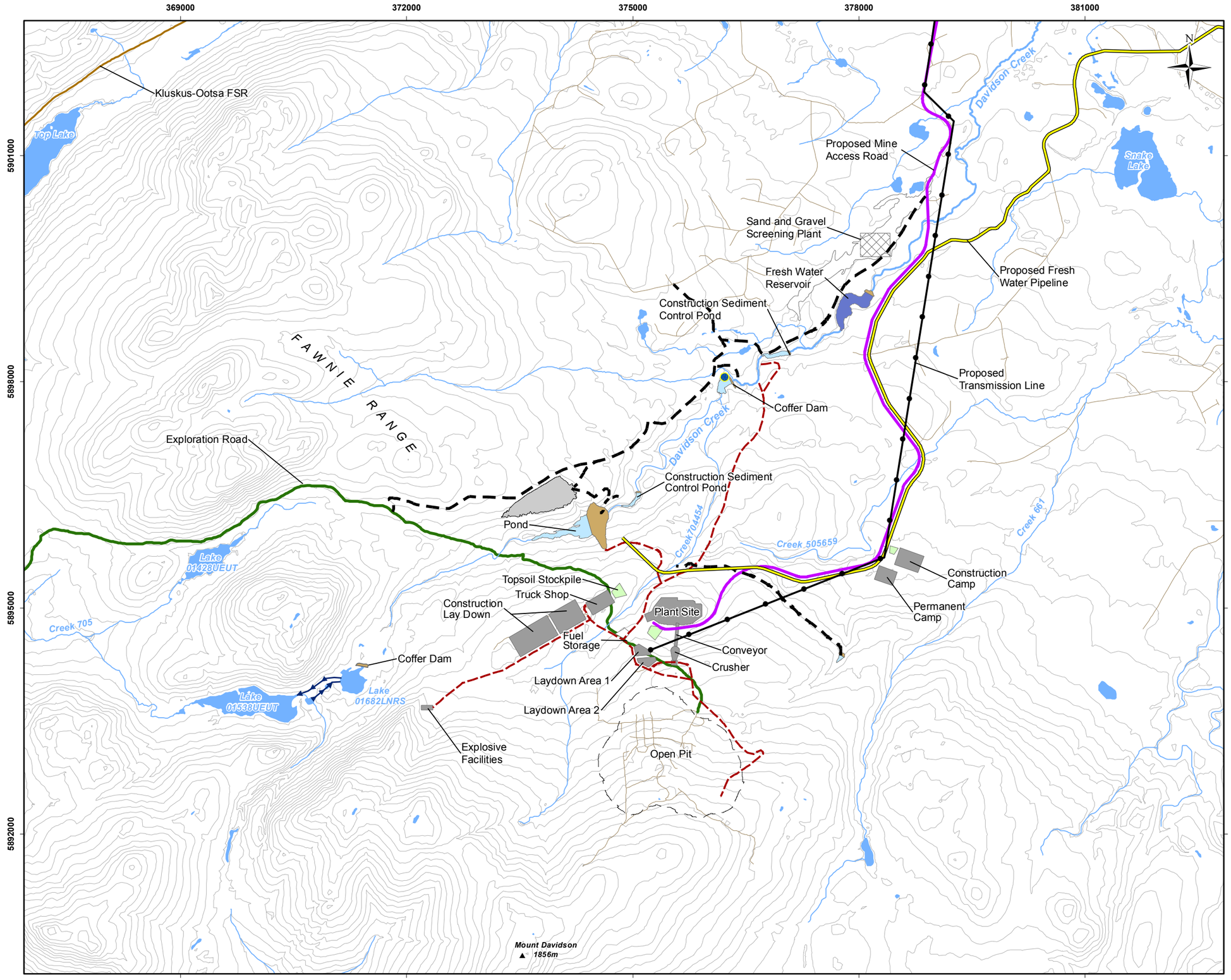
rock removed from the pit will be used to construct site roads. **Figure 2-1** and **Figure 2-2** show the development of the mine site facilities at the end of the first year of construction (i.e., Year -2) and the second year (i.e., Year -1), respectively.

The Site C West TSF dam, the Site C TSF dam, and the Site D TSF dam will be constructed using NAG material removed from the pit. Each of these dams will be built in lifts until the engineered heights and widths required for initial operations are achieved. At the same time, pipelines for the mine effluent and for the water recovery and recycling systems will be installed in the TSFs. Once built, these dams will begin to collect run-off from the upper Davidson and Creek 661 watersheds. Initially, NAG and PAG waste rock will be placed in the Site C TSF.

Borrow areas required for construction materials will be developed at the beginning of the construction phase. These include the esker borrow source, and the Site C dam area. The sand and gravel screening plant will be built in the esker borrow source area.

The construction phase Sediment and Erosion Control Plan (SECP) will be implemented to manage water associated with site grading and clearing, building construction, and pit, lay-down area, waste rock areas, and TSF area developments. This plan includes:

- Constructing surface water drainage ditching and temporary sediment ponds around all mine site facilities to collect and capture site contact water during construction;
- Using sump pits, wells, or removable pump stations to draw down the natural water table to provide dry, stable construction areas. Groundwater will collected in the excavation sump pits and pumped to holding ponds, sediment basins, or sediment filter bags where required;
- Using Best Management Practices (BMPs) and an adaptive management approach to minimise the volume of contact water and the amount of sediment in this water. BMPs will include: revegetation of disturbed areas; mulching; erosion control products such as silt fencing, coco-matting, filter fabrics, and other geo-textiles, surface roughening and re-contouring, filter bags and/or hay-bales, engineered diversion ditching and sediment traps, properly sized and installed culverts or open-bottom structures (i.e., clear-span bridges and/or open-bottom arch culverts), and exfiltration areas;
- Building sediment control ponds for each major area of disturbance. These areas include:
    - Construction lay-down, truck shop, and contractor lay-downs and offices;
    - Plant site and crusher;
    - Construction camp;
    - Aggregate screening area;
    - Waste Rock Dumps;
    - TSF;
    - Open pit; and
- Phasing sediment control to match the main construction activities: land clearing and grading, TSF construction, and open pit development.



Legend

- Kluskus-Ootsa FSR
- Existing Road
- Exploration Road
- Contour (20 m)
- Stream
- Waterbody

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Pumpstation
- Construction Haul Road
- Flow Diversion
- Mine Haul Road
- Proposed Fresh Water Pipeline
- Borrow Area (Zones S, C, and Rockfill)
- Embankment Fill
- Construction Site
- Fresh Water Reservoir
- Open Pit
- Pond
- Sand and Gravel Screening Plant
- Topsoil

Scale:1:50,000

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Kilometres

Reference

BC Government GeoBC Data Distribution
Knight Piésold Consulting Engineers

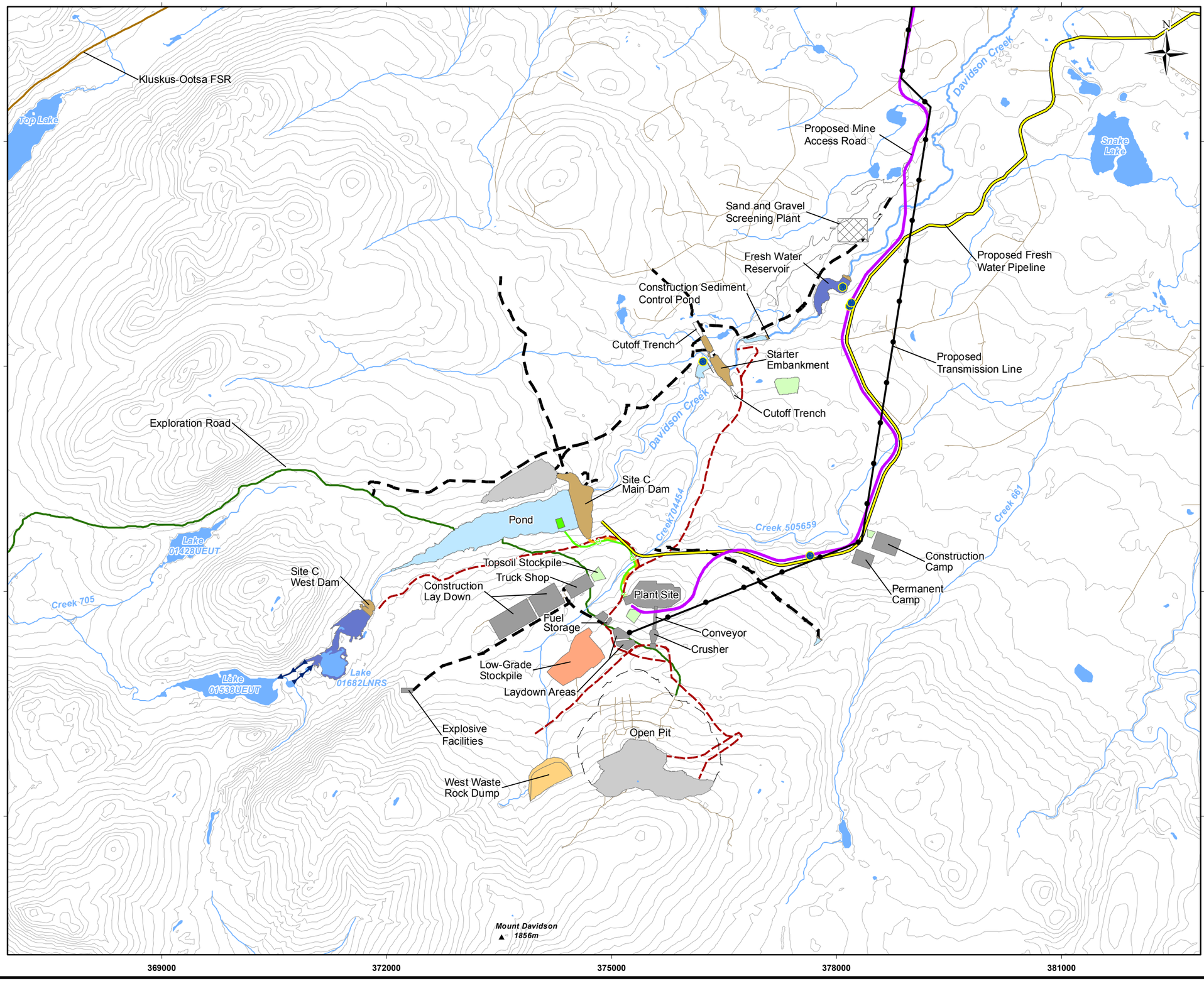
CLIENT: newgold

PROJECT: Blackwater Gold Project

General Arrangement End of year -2 Plan

DATE: April, 2014	ANALYST: WR	**Figure** 2-1
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Legend

- Kluskus-Ootsa FSR
- Exploration Road
- Existing Road
- Contour (20 m)

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Fresh Water Pipeline
- Pumpstation
- Construction Haul Road
- Mine Haul Road
- Flow Diversion
- Tailings Pipeline
- Water Reclaim Pipeline
- Borrow Area (Zones S, C, and Rockfill)
- Construction Site
- Embankment Fill
- Fresh Water Reservoir
- Low-Grade Ore
- NAG Waste Rock / Overburden
- Open Pit
- Pond
- Reclaim System
- Topsoil

Scale:1:50,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution
Knight Piésold Consulting Engineers

CLIENT: newgold

PROJECT: Blackwater Gold Project

General Arrangement End of year -1 Plan

DATE:	ANALYST:	**Figure** 2-2
April, 2014	WR	
JOB No: VE52277	QA/QC: MY	PDF FILE: Other-100-082_year_minus_1_v2.pdf
GIS FILE: Other-100-082_year_minus_1_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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The seven sediment control ponds, and their operating periods and discharge points, are listed in **Table 2-2** and shown in **Figure 2-3**.

Table 2-2: Sediment Control Ponds Locations and Discharge Strategies

Sediment Control Pond	General Area	Start of Construction	Discharge Strategy	Date of Decommissioning	Post Decommissioning Runoff Routing
#1	Construction laydown and truck shop	Beginning of Year -2	Permeable glaciofluvial deposits	End of Year -2	To TSF Site C basin via West Ditch
#2	Plant site	Beginning of Year -2	Permeable glaciofluvial deposits	End of Year -2	To TSF Site C basin via West Ditch
#3	Camp	Beginning of Year -2	Permeable glaciofluvial deposits	N/A	N/A
#4	Aggregate screening area	Beginning of Year -2	Permeable glaciofluvial deposits	N/A	N/A
#5	East waste dump area	Late Year -2	Creek 661	End of Year -1	To TSF Site C basin via collection ditch
#6	Downstream of Site C cofferdam	Late Year -2	Davidson Creek	End of Year -1	SECP is in TSF basin footprint, water stays in TSF basin
#7	Downstream of Site D cofferdam	Late Year -2	Davidson Creek	End of Year -1	SECP becomes obsolete, structure is in place and can be used if needed

Four of the seven ponds may discharge to Davidson Creek or Creek 661 during spring freshet depending on severity of the run-off. All seven ponds were designed to accommodate a live storage equal to the 1 in 10 year, 24 hour storm event with 0.5 m of freeboard and to settle out sediment particles sized 0.01 mm (and larger), while providing a retention time of at least 24 hours. All but two of the ponds will be removed by the end of construction.

Construction activities associated with the linear development components of the Project will include (**Table 2-1**):

- Tree-removal, clearing, grading, topsoil storage, and placement of materials for mine access road, airstrip construction, transmission line access road, and re-alignment of the Kluskus-Ootsa FSR;
- Installation of culverts and open-bottom structures at stream crossings along all roads;
- Tree-removal, clearing, grading, top-soil storage, and placement of materials for the FSS access road, pump-house, and pipeline;
- Construction of the FSS pipeline and stream crossings;
- Construction of the water intake pump house and intake pipe in Tatelkuz Lake;
- Construction of the freshwater reservoir in Davidson Creek;
- Tree and vegetation removal along the transmission line ROW; and
- Installation of transmission line poles including pole foundations, poles, and cable stringing.

370000 372500 375000 377500 380000 382500

5902500 5900000 5897500 5895000 5892500

Kluskus-Ootsa FSR
Creek 700
FAWNIE RANGE
Proposed Mine Access Road
SCP #4
Snake Lake
Seepage Collection Trench
Sand and Gravel Screening Plant
Creek 428073
Top Soil
Fresh Water Reservoir
SCP #7
Environmental Control Dam (ECD)
Pond
TSF Site D
Site D Main Dam
Creek 146920
Creek 543585
Creek 661
Exploration Road
SCP #6
Site C Main Dam
TSF Site C
Pond
SCP #3
Construction Camp
Lake 01428UEUT
Creek 505659
SCP #1
SCP #2
Operation Camp
Plant Site
Site C West Dam
SCP #5
Creek 704454
Low-Grade Stockpile
Lake 01682LNRS
West Waste Rock Dump
Lake 01538UEUT
Open Pit

N

Legend

- Sediment Control Ponds
- Kluskus-Ootsa FSR
- Exploration Road
- Stream
- Waterbody

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Fresh Water Pipeline
- Flow Direction
- Seepage Collection Trench
- Spillway
- Bog / Wetland Area
- Dump
- Embankment Fill
- Emergent Vegetation Wetland
- Environmental Control Dam (ECD)
- Borrow Source
- Fresh Water Reservoir
- Low-Grade Stockpile
- Open Pit
- Plant Site
- Pond
- Sand and Gravel
- Tailings Beach
- Top Soil
- Topsoil Stockpile
- Upland Beach
- Proposed Mine Site Extent

Scale:1:45,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of Sediment Control Ponds

DATE:	ANALYST:	
April, 2014	MY	**Figure** 2-3
JOB No: VE52277	QA/QC: BM	PDF FILE: 10-200-182_sediment_control_ponds_minsite.pdf
GIS FILE: 10-200-182_sediment_control_ponds.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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2.5.2 Operations

During operations, ore will be blasted from the open pit with ammonium nitrate-fuel/oil (ANFO) explosives placed in drill holes (**Table 2-3**). Ore will be loaded into 290 tonne haul trucks by electric/diesel shovels and delivered to a primary crusher. Crushed ore will then be fed into a whole-ore cyanide leach gold-silver recovery mill. Tailings from the mill will be treated by a SO_2/air treatment plant to destroy cyanide used in the extraction process before disposal into the TSF. Gold and silver will be recovered into a gold-silver ore product and shipped by air or road.

Ore will be stockpiled during operations. High-grade ore stockpiling will end in Year 1 once the mill starts up. Low-grade ore will continue to be stockpiled throughout operations while the high-grade stockpile will be reclaimed. After the high-grade stockpile is reclaimed, plant feed will be maintained by ore delivered directly from the pit. Ore from the low-grade ore will be fed to the plant after Year 10.

Initially, PAG waste rock will be placed in the Site C TSF. PAG waste rock will be placed in the Site D TSF beginning in Year 2. This will continue throughout operations. NAG waste rock will be used to continue building the Site D TSF dam as required.

Table 2-3: Project Activities during the Operations Phase

Project Component	Project Component	Activities
Mine Site	Site Infrastructure and Roads	Worker accommodations operation, hazardous materials management (waste, explosives, and spills), camp and offices waste management
	Mine Pit	Drill, blast, excavate, transport ore and waste rock
	Ore Processing Area	Process area operations
	Waste Rock Area	Mine waste rock dump placement
	TSF	TSF ongoing development and operations
	Wetland and Water Management System, Freshwater Reservoir	Water management system operation and maintenance
	Borrow areas	Operate sand and gravel screening equipment. Excavate and transport material
Linear Developments	Mine Access Road	Transportation of workforce and materials and maintenance
	Kluskus-Ootsa FSR	Maintenance and transportation of workforce and material
	FSS	Pumping of water and maintenance of system
	Airstrip	Maintenance only. No regular scheduled flights
	Transmission Line	Maintenance

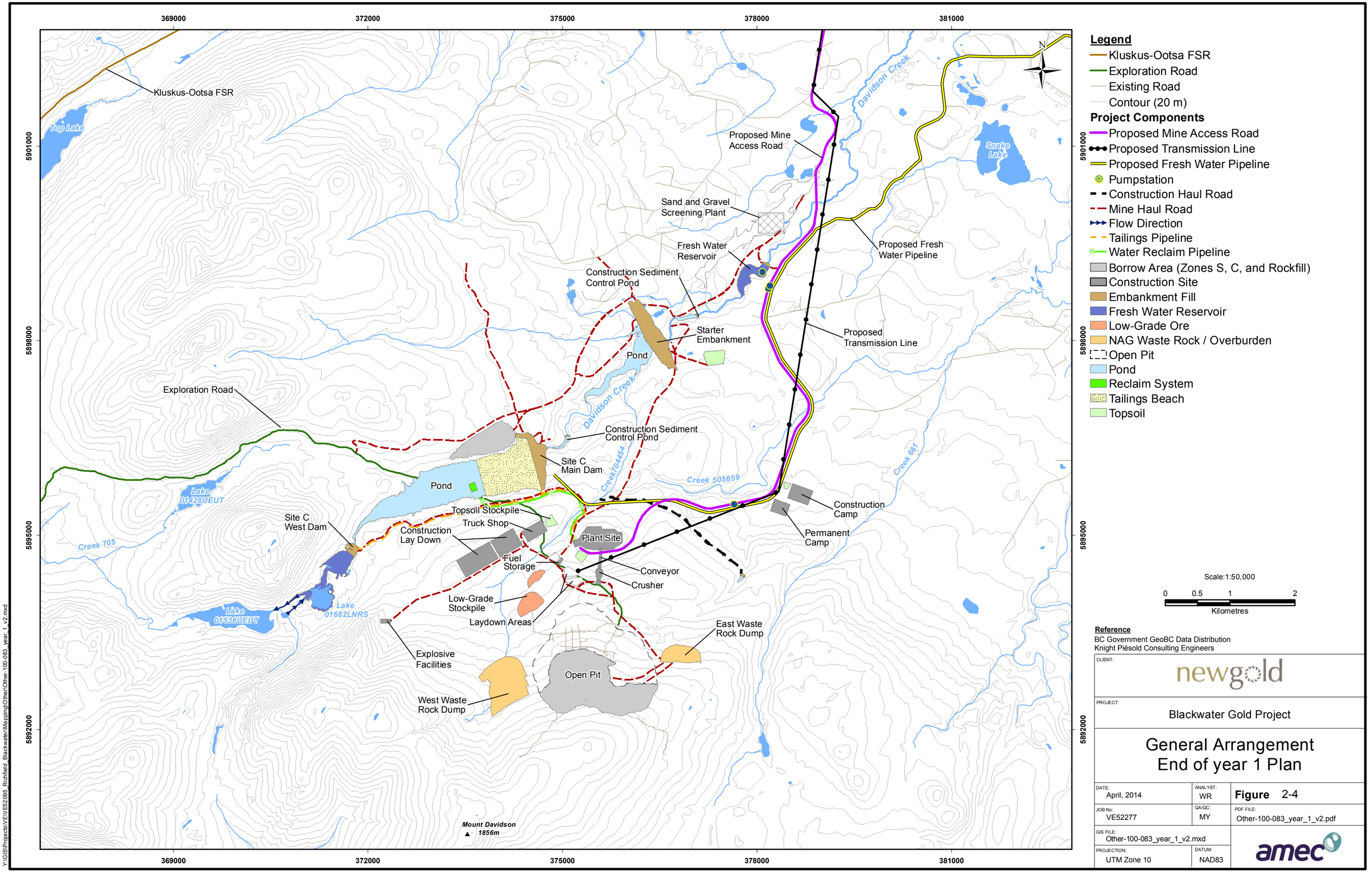
Waste rock and overburden will continue to be extracted from the pit and stored in the East and West waste rock dumps and overburden storage areas during operations. An overburden stockpile will be established at the south end of the Site D TSF dam to provide an overburden supply for the final years of dam construction. Overburden will also be stored near the Site C TSF for use during site reclamation. By Year +9, the pit will be mined to the final wall configuration and all overburden will have been mined out and stored. Progressive reclamation of the overburden storage areas and waste rock dumps will begin in Year +1 and continue throughout operations.

Water stored in the Site C TSF pond will serve as the primary process water during the initial two years of mill operations. After that, water stored in the Site D pond will be the primary source of process water. This will continue until the end of mining operations in Year 17. Any additional freshwater required by the plant that cannot be supplied by the TSF ponds will be provided by operation of the FSS. The water will be pumped from Tatelkuz Lake to the freshwater reservoir and then pumped to the mill.

The ECD will be constructed in Year +1 to capture seepage and surface runoff from the Site D TSF dam. The dam will include a spillway designed to pass the 1 in 200–year, 24-hour storm. Two main interceptions trenches, one on other side of the Site D TSF dam will collect seepage and divert it to the ECD pond. Seepage collected in the pond behind this dam will be pumped back to the TSF. Besides any unrecoverable seepage that cannot be collected and pumped back to the TSF (predicted to be no more than 2 L/sec), there will be no mine discharge released to Davidson Creek or Creek 661 during mine operations.

Regular maintenance of the access roads, stream crossings, airstrip, and FSS will be conducted throughout the operations phase. This will include management of vegetation posing a danger to power line along the transmission line ROW.

The build-out of the mine site facilities during the operations phase is shown in **Figure 2-4** to **Figure 2-6** for Years 1, 8, and 17 of mine life, respectively. Year 17 shows the maximum mine site facilities footprint.



Legend

- Kluskus-Ootsa FSR
- Exploration Road
- Existing Road
- Contour (20 m)

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Fresh Water Pipeline
- Pumpstation
- Construction Haul Road
- Mine Haul Road
- Flow Direction
- Tailings Pipeline
- Water Reclaim Pipeline
- Borrow Area (Zones S, C, and Rockfill)
- Construction Site
- Embankment Fill
- Fresh Water Reservoir
- Low-Grade Ore
- NAG Waste Rock / Overburden
- Open Pit
- Pond
- Reclaim System
- Tailings Beach
- Topsoil

Scale:1:50,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution
Knight Piésold Consulting Engineers

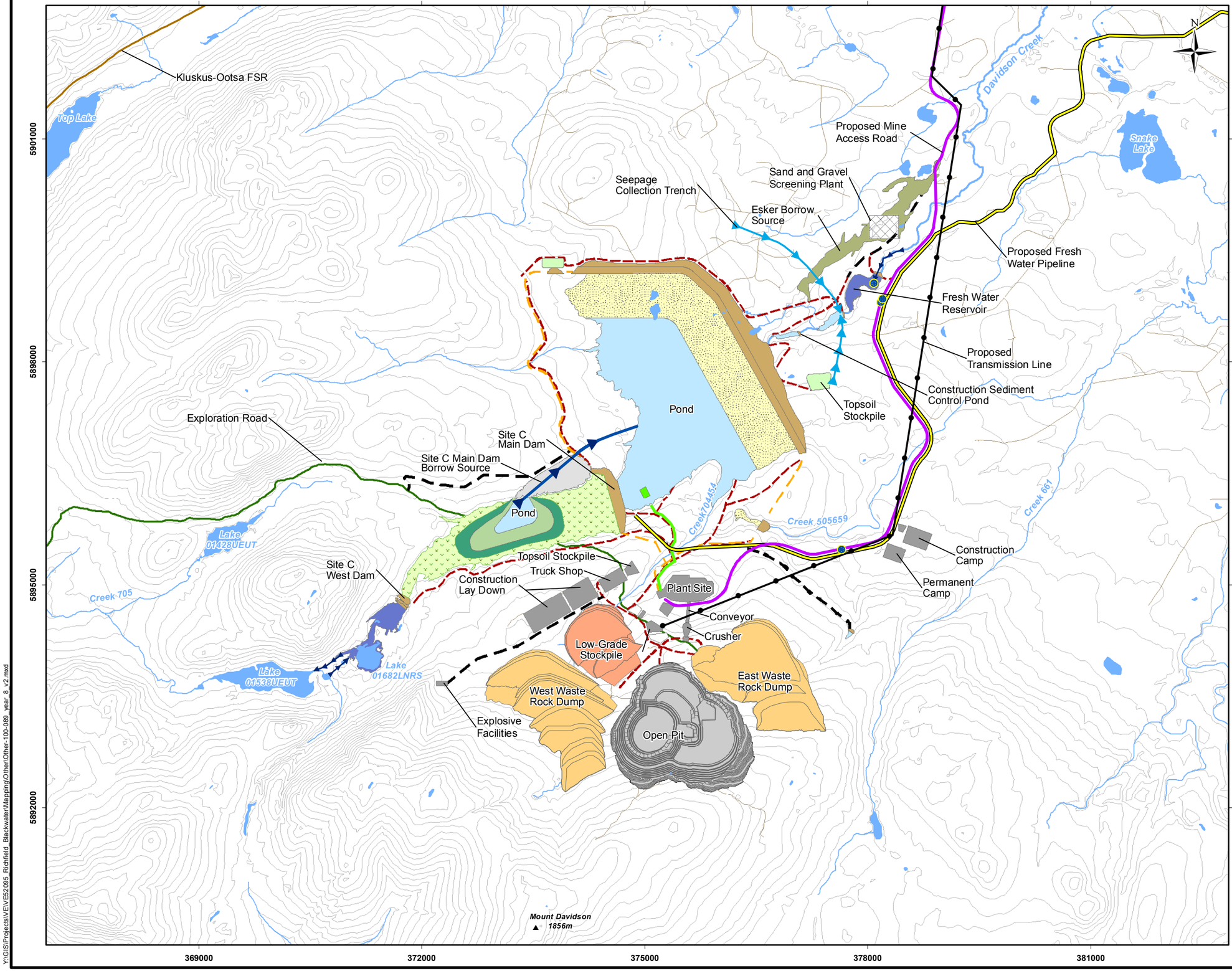
CLIENT: newgold

PROJECT: Blackwater Gold Project

General Arrangement End of year 1 Plan

DATE:	ANALYST:	
April, 2014	WR	**Figure** 2-4
JOB No: VE52277	QA/QC: MY	PDF FILE: Other-100-083_year_1_v2.pdf
GIS FILE: Other-100-083_year_1_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Legend

- Kluskus-Ootsa FSR
- Exploration Road
- Existing Road
- Contour (20 m)

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Proposed Fresh Water Pipeline
- Pumpstation
- Construction Haul Road
- Mine Haul Road
- Flow Diversion
- Seepage Collection Trench
- Spillway
- Tailings Pipeline
- Water Reclaim Pipeline
- Bog / Wetland Area
- Borrow Area (Zones S, C, and Rockfill)
- Construction Site
- Embankment Fill
- Emergent Vegetation Wetland
- Esker Borrow Source
- Fresh Water Reservoir
- Low-Grade Ore
- NAG Waste Rock / Overburden
- Open Pit
- Pond
- Reclaim System
- Tailings Beach
- Topsoil
- Upland Beach

Scale:1:50,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution
Knight Piésold Consulting Engineers

CLIENT: newgold

PROJECT: Blackwater Gold Project

General Arrangement End of year 8 Plan

DATE:	ANALYST:	**Figure** 2-5
April, 2014	WR	
JOB No: VE52277	QA/QC: MY	PDF FILE: Other-100-089_year_8_v2.pdf
GIS FILE: Other-100-089_year_8_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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372000 376000 380000 384000 388000

5908000 5904000 5900000 5896000 5892000

Proposed Transmission Line
Mills Ranch Reroute
Proposed
Transmission Line
Turtle Creek
Davidson Creek
Tatelkuz
Lake
Proposed Mine
Access Road
Proposed Fresh
Water Pipeline
Kluskus-Ootsa FSR
Freshwater
Pumpstation
Sand and Gravel
Screening Plant
Seepage
Collection Trench
Esker Borrow
Source
Snake
Lake
Topsoil
Diversion Ditches
Freshwater
Reservoir
Environmental
Control Dam (ECD)
Site C Main Dam
Borrow Source
Pond
Topsoil
Stockpile
Emergent
Vegetation Wetland
Upland
Beach
Bog/Wetland Area
Pond
Construction Camp
Lake
01428UEUT
Truck Shop
Plant Site
Site C West Dam
Construction
Laydown 1
Operation Camp
Diversion Ditches
Low-Grade
Stockpile
East Waste
Rock Dump
Lake
01538UEUT
Lake
01682LNRS
West Waste
Rock Dump
Explosive Facilities
Open Pit
Chedakuz Creek
Kuyakuz
Lake

N

Legend

- Kluskus-Ootsa FSR
- Exploration Road
- Existing Road
- Contour (20 m)

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Construction Haul Road
- Mine Haul Road
- Flow Direction
- Seepage Collection Trench
- Spillway
- Tailings Pipeline
- Water Reclaim Pipeline
- Proposed Airstrip Extent
- Proposed Mine Footprint
- Proposed Mine Site
- Bog / Wetland Area
- Borrow Source
- Construction Site
- Embankment fill
- Emergent Vegetation Wetland
- Esker Borrow Source
- Fresh Water Reservoir
- Low-Grade Stockpile
- NAG Waste Rock / Overburden
- Open Pit
- Pond
- Reclaim System
- Pumpstation
- Tailings Beach
- Top Soil
- Upland Beach

Scale:1:70,000

0 0.5 1 2 3

Kilometres

Reference

BC Government GeoBC Data Distribution
Knight Piésold Consulting Engineers

CLIENT: newgold

PROJECT: Blackwater Gold Project

Proposed Mine Site Facilities and Access Road Year 17

DATE:	ANALYST:	**Figure** 2-6
April, 2014	WR	
JOB No: VE52095	QA/QC: AP	PDF FILE: Other-100-115_SiteFacilities_year17_v3_minsite.pdf
GIS FILE: Other-100-115_SiteFacilities_year17_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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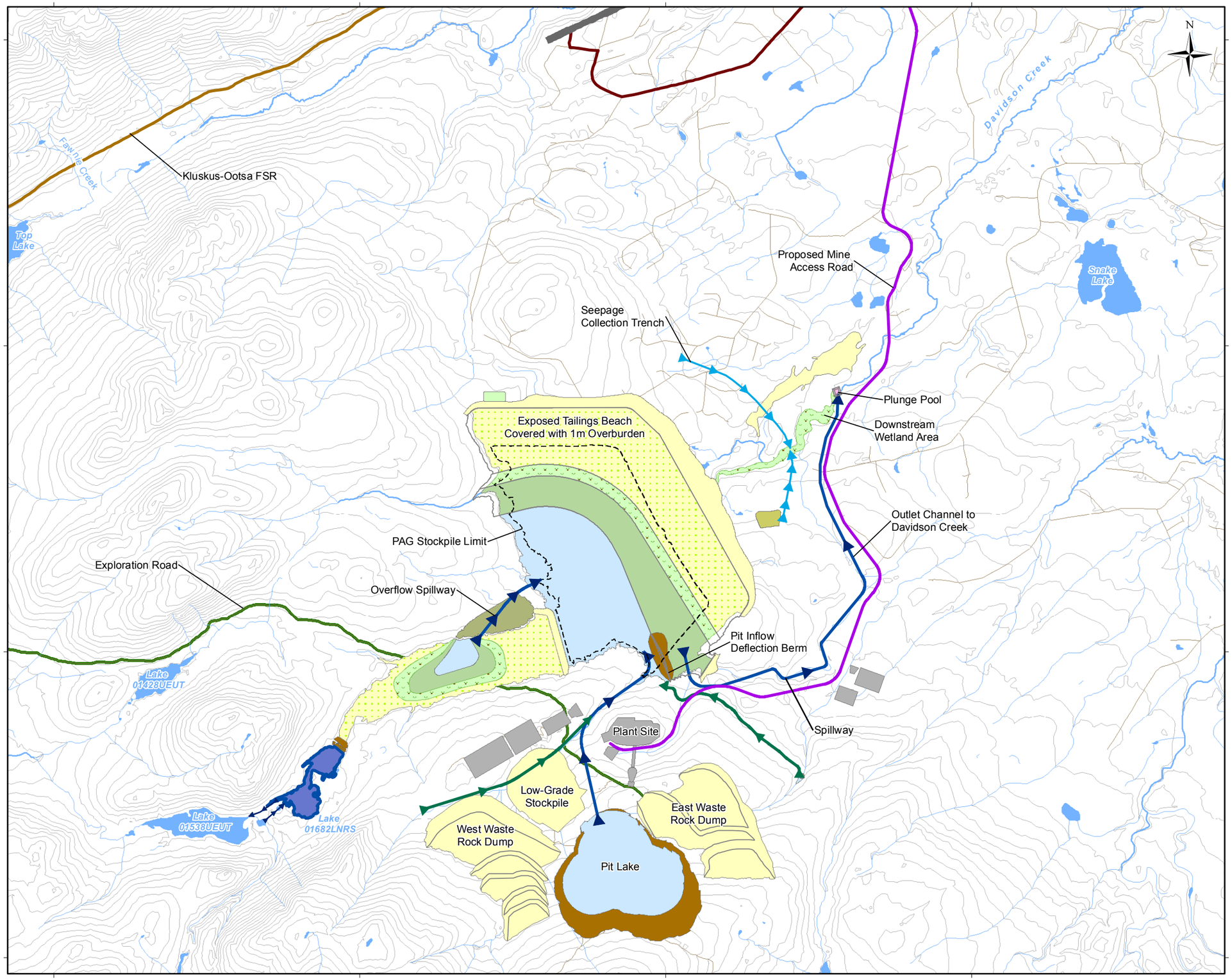
2.5.3 Closure/Decommissioning

After operations are complete, the Project will be decommissioned and reclaimed (**Table 2-4**). The overall reclamation approach includes the incorporation of mine-related landforms into the landscape, flooding the mined-out pit with water to create an end-pit lake, progressive covering of waste-rock dumps with over-burden and re-vegetating, and re-establishing the pre-existing drainage network to the maximum extent possible.

Table 2-4: Project Activities during the Closure/Decommissioning Phase

Project Phase	Project Component	Activities
Mine Site	Site Infrastructure and Roads	Decommission, dismantle and remove equipment (conveyors, crusher, warehousing, fuel storage, truck stop), reclaim areas of soil contamination, implement reclamation plan (grade and level site, implement erosion and sediment control features and spread overburden and topsoil)
	Mine Pit	Construct rock safety berm, spillways, and channel to TSF, overburden in bench flats, fertilize pit water while filling if required
	Ore Processing Area	Decommission, dismantle and remove equipment
	Waste Rock Areas	Re-grade, construct drainage control swales, cover, and re-vegetate
	TSF	Area C: Remove pumps/pipelines, cover, wetland and upland beach revegetation, outlet connection, reseed downstream slope, and decommission seepage sump Area D: Pump supernatant and Tatelkuz Lake water to pit, construct spillways, cover, deflector berm, outlet connection,
	Wetland and Water Management System, Freshwater Reservoir	Monitor water quality
	Borrow areas	Re-grade, cover, and re-vegetate
Linear Developments	Mine Access Road	Maintenance
	Kluskus-Ootsa FSR	Maintenance
	FSS	Pumping of water and maintenance of system, decommissioning of fresh water reservoir
	Airstrip	Maintenance; No regular scheduled flights
	Transmission Line	Decommissioning and removal of cables and poles, implement reclamation plan (re-contouring and revegetation)

The Closure/decommissioning phase will begin immediately after the cessation of mining activities and will continue until the pit is filled with water and the water quality in the TSF is sufficient to release to Davidson Creek (**Figure 2-7**). Closure/decommissioning activities for each of the main mine components are described in the sections below.



Legend

- Kluskus-Ootsa FSR
- Existing Road
- Contour (20 m)
- Stream
- Waterbody

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Airstrip Access Road
- Proposed Airstrip Extent
- Diversion Channel
- Flow Diversion
- Seepage Collection Trench
- Spillway
- Bog / Wetland Area
- Emergent Vegetation Wetland
- Flooded Lake
- Plunge Pool
- Pond
- Rock Slope
- Upland Beach
- Upland Slope

Scale:1:50,000

0 0.5 1 2

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

General Arrangement Closure End of Year 35 Plan

DATE: April, 2014	ANALYST: MY	**Figure** 2-7
JOB No: VE52095	QA/QC: AP	PDF FILE: Other-100-049_year32_v3.pdf
GIS FILE: Other-100-049_year32_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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2.5.3.1 Mine Pit

Once mining is complete, the pit will be filled with water by: 1) pumping supernatant from the TSF; 2) ceasing pumping of groundwater entering the pit; 3) diverting all upstream run-off to the pit; and 4) pumping water from Tatelkuz Lake via the FSS. Pit filling is expected to last about 18 years. A rock safety berm and spillway will be constructed during closure to carry water from the filled pit to the Site D TSF pond. Overflow from the pit will flow by gravity to the TSF through this spillway channel.

2.5.3.2 Tailings Storage Facilities

A spillway will be constructed in the Site D TSF dam at the end of mine operations to carry TSF over-flow to Davidson Creek. This spillway will connect to a discharge channel exiting at the wetlands constructed in the ECD and water reservoir basins downstream. The discharge channel will terminate in a constructed plunge pool in Davidson Creek to prevent erosion of the stream bed. The spillway elevation will be above the oxide/transition tailings interface elevation to ensure that the PAG tailings are kept saturated. Over-flow down this spillway will not occur until the post-closure period when water quality monitoring showed that the TSF supernatant met site-specific water quality objectives[10] for Davidson Creek.

To assist in achieving these objectives, a final cover of NAG tailings will be placed, a wetland will be established in the saturated areas of the Site D TSF impoundment, the exposed beaches in the TSF will be covered with overburden, and the ECD pump-back pipeline will be extended to discharge at the inlet of the wetland to maximize polishing treatment volume and duration. These wetlands will be used to polish water transferred to the pit lake from the TSF pond during the closure period and to polish water in the TSF prior to its release to Davidson Creek during the post-closure phase. The shape of the wetland will ensure that the pit lake inflow fully mixes with the TSF supernatant prior to discharge through TSF Dam D spillway to Davidson Creek.

Permanent open-water areas in the Site C and Site D TSF ponds will be planted with submerged and floating vegetation. The purpose of these plants will be to further improve the quality of the water above the tailings and to reduce the re-suspension of sediments and particles.

Wetlands will be constructed in the former ECD and freshwater reservoir basins to polish discharge from the TSF. These wetlands will have a total combined area of about 26 ha. A 4 ha test wetland in the former sediment control pond below the TSF D dam will be established during the mine life (about year +8) to demonstrate the effectiveness of wetland treatment and to confirm design parameters. Like the wetlands created in the TSF, the purpose of these wetlands will be to remove loads of nitrate, cadmium, and zinc that could be present in TSF seepage. Cadmium and zinc removed by the wetlands will be retained within sediments. Ammonia and nitrate will be taken up by the wetland plants. The treatment wetlands will protect both the aquatic and terrestrial ecosystems downstream from the TSF from metals present in seepage

[10] Site-specific water quality objectives have not yet been developed but would be in consultation with federal and provincial regulators prior to construction

(**Section 2.6.6.2.4.1** and **Appendix 2.6C** of the Application). Additional wetlands will be constructed, if required, as a contingency downstream of the water reservoir wetland but upstream of the mine access road crossing of Davidson Creek.

A literature and case studies review supports the use of wetlands to treat mine drainage at closure for the predicted flows and metal concentrations (**Section 2.6.6.2.4.1** and **Appendix 2.6C** of the Application). The surface area required for year-round treatment of the predicted flows of seepage from the TSF is approximately 8.3 ha, an area that is substantially less than the combined ECD and water reservoir wetlands. Both a surface flow and a subsurface flow wetland will be used to remove the ammonia and nitrate loads predicted at closure, as well as the cadmium and zinc that could be present in TSF seepage. A 4.9 ha subsurface flow wetland could treat lower predicted ammonia and nitrate loads, as well as all the predicted cadmium and zinc loads, under the worst-case scenario analyzed. Both wetlands will also function to remove sulphate by reduction to insoluble sulphide.

An overburden layer at least 0.3 m thick, and up to 5 m thick over the exposed tailings beaches, will be placed as cover over tailings and PAG waste rock in the TSFs. The purpose of this layer is to provide physical separation of underlying metal leaching materials from the pond water column, thereby minimizing contamination to surface water discharges from the TSF. It will do this by providing a barrier to the upward migration of dissolved solutes from underlying tailings and waste rock. Vertical-downward hydraulic gradients will also serve to minimize the potential for upward diffusion transport.

The outside edges of the TSF dams will be reclaimed into upland slopes. The top third of the outer dam faces will be covered with up to 0.3 m of overburden to allow revegetation. NAG rock along the bottom of the dams will naturally segregate during dumping to mimic a talus slope. Coarse gravel and cobbles will be dumped into the crevices of the larger rocks to create cover and trails for wildlife.

2.5.3.3 Waste Rock Dumps

The embankments of the West and East waste rock dumps will be re-contoured to a 3H:1V slope and reclaimed by covering with over-burden and re-vegetating with native plant species adapted to the climate and surficial materials of the region. Much of the waste rock dumps will be reclaimed progressively during mine operations as final slopes are constructed. A minimum cover of 0.3 m of overburden will be placed on each dump to reduce infiltration and possible metal leaching and to function as a reclamation substrate for revegetation.

Seepage and runoff from the East waste rock dump will continue to be collected and discharged to the TSF unless water quality is acceptable for direct discharge to Creek 661. If acceptable, the collection ditch will be breached and reclaimed and the runoff and seepage allowed to flow to Creek 661, thus restoring natural drainage patterns.

Seepage and runoff from the West waste rock dump will be collected and continue to discharge to the TSF via the constructed ditch used during operations. This ditch will be upgraded as required to pass the Probable Maximum Flood.

2.5.3.4 Low-Grade Ore Stockpile

The low-grade ore stockpile will be processed during the last years of operations, or if not processed for economic reasons, placed underwater in the TSF and/or open pit where the material will be submerged. The compacted overburden liner under the stockpile will be checked for metal contamination, and if contaminated, will be excavated and placed into the TSF or pit. The drainage collection ditch and sump will be removed. The entire disturbed area will be covered with 0.3 m of soil and re-vegetated.

2.5.3.5 Freshwater Supply System

Operation of the FSS pipeline will continue during the closure/decommissioning phase until the open pit is filled with water, the TSF starts to discharge to Davidson Creek, and sufficient flow is provided for downstream fisheries in Davidson and Chedakuz creeks. As mentioned above, a wetland will be constructed in the freshwater reservoir in Davidson Creek for seepage treatment.

2.5.3.6 Mine Site Buildings and Infrastructure

Reclamation of areas with mine buildings and infrastructure will begin with removal of hazardous materials and decommissioning of the facilities, including removal of equipment and structures, the mill building, maintenance shops, camp, explosives storage, power lines, pump house, and other facilities. After decommissioning, the areas will be re-graded, covered with 0.3 m of soil or overburden, and re-vegetated.

All culverts will be removed from road crossings (unless the roads are required for post-closure activities) and water courses will be returned to their natural channels to the extent practical, or new, stable water courses established. All crossings will be back-sloped and rip-rapped as appropriate to minimize potential for erosion. All permanent ditches and channels will be designed to pass the PMF.

2.5.3.7 Borrow Areas

The Site C Dam and eskers borrow areas will be reclaimed by re-contouring steep areas and benches. The areas will be graded, ripped, and re-vegetated.

2.5.3.8 Linear Developments

The mine access road and the Kluskus-Ootsa FSR will be regularly maintained during the closure/decommissioning phase to allow access by work crews. This will be done by the Proponent or the primary road user as designated by the Road Use Permit. The airstrip buildings will be removed and the disturbed areas under these buildings, the runway, and taxi-ways will be ripped-up and re-vegetated.

The transmission line ROW will be returned to near pre-mining conditions. The majority of power line poles will be removed although poles adjacent to creeks and wetlands could be retained and

augmented to provide potential nesting sites for raptors such as ospreys. The number to be left will be defined prior to closure. Access roads will be ripped-up and re-vegetated.

2.5.4 Post-Closure

The post-closure phase will begin as soon as water quality in the TSF is sufficient to release downstream to Davidson Creek. To do so, this water will need to meet site-specific water quality objectives for the protection of fish and aquatic biota. Those site-specific objectives will be determined in consultation with regulatory agencies during the permitting phase of this Project.

Activities during the post-closure phase will be focused on monitoring the effectiveness of reclamation (**Table 2-5**). This will include monitoring of reclamation activities at the plant site, waste rock dump areas, TSF, lay-down areas, camps, roads, FSS, airstrip, and transmission line.

Once the pit is filled and water quality in the TSF is sufficient to discharge to Davidson Creek, the FSS will be decommissioned. To do this, the pump-house and pipeline will be removed. Disturbed areas will be ripped-up for de-compaction and seeded. The pump station access road may be left to provide long-term recreational access to Tatelkuz Lake if requested by First Nations and approved by regulatory agencies. Otherwise, the roadbed will be ripped-up and re-vegetated.

Table 2-5: Project Activities during the Post-closure Phase

Project Component	Project Component	Activities
Mine Site	Site Infrastructure and Roads	Monitor reclamation
	Mine Pit	Discharge pit water overflow to TSF
	Ore Processing Area	Monitor reclamation
	Waste Rock Area	Monitor reclamation
	TSF	Monitor reclamation
	Wetland and Water Management System, Freshwater Reservoir	Fill seepage ponds and ditches, and re-vegetate ECD and Water Reservoir: Breach dams and construct rip-rap channel, re-grade dams, re-vegetate, reshape basins and wetlands for seepage treatment. Monitor water quality
	Borrow areas	Monitor reclamation
Linear Developments	Mine Access Road	Maintenance and occasional transportation of people
	Kluskus-Ootsa FSR	Occasional transportation of people
	FSS	None
	Airstrip	None
	Transmission Line	None

3.0 DESCRIPTION OF FISH AND FISH HABITAT

3.1 Study Areas

Watersheds in the Local Study Area (LSA) included Davidson Creek, Creek 661, and Turtle Creek (**Figure 1-1**). All of these watersheds (**Table 3-1**) are tributaries to Chedakuz Creek. The LSA also included Chedakuz Creek from its confluence with Creek 661 downstream to its confluence with Turtle Creek, Tatelkuz Lake and its unnamed tributaries that enter from the south, and Creek 705, a tributary of Fawnie Creek. Creek 705 was included in the LSA because it is potentially affected by mitigation described in the Project Description and offsetting projects described in this FMOP.

Table 3-1: Main Drainages of the Aquatics LSA

Gazetted Name	Local Name	BC Freshwater Atlas Code	Tributary of
Chedakuz Creek	Chedakuz Creek	100-567134-610692	Nechako Reservoir
n/a	Turtle Creek	100-567134-610692-480511	Chedakuz 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

Note: n/a = not applicable

Besides Tatelkuz Lake, the LSA also contains four smaller headwater lakes: Lake 01682LNRS in the Davidson Creek Watershed; lakes 01538UEUT and 01428UEUT in the Creek 705 Watershed; and Snake Lake in the Tatelkuz Lake Tributaries Watershed (**Figure 1-2**).

The regional study area (RSA) was used to assess potential cumulative effects of the Project with other past, present, and reasonably foreseeable future projects on fish and aquatic resources, and to put Project-specific effects into the larger regional context. The RSA included (**Figure 1-2**):

- All streams and lakes within the LSA;
- Kuyakuz Lake and its tributaries;
- Middle Chedakuz Creek between Kuyakuz Lake and Tatelkuz Lake, and all tributaries to that creek;
- Lower Chedakuz Creek downstream of Tatelkuz Lake to its confluence with the Nechako Reservoir; and
- The upper Fawnie Creek Watershed, including Top Lake, Laidman Lake, Williamson Lake, Creek 705 and Mathews Creek.

Separate study areas were assessed for the 140 km long transmission line and the existing 194 km long Kluskus and Kluskus-Ootsa FSR. This transmission line study area included a 100 m buffer width on either side of the centre line (i.e., 200 m in total) extending between the BC Hydro Glenannan sub-station near Endako and the mine site. The FSR study areas included all stream crossings along both roads.

3.2 Methods

Methods for characterizing fish habitat and fish communities within the local and linear development study areas included reviews of existing information and field studies developed to address data gaps found between the existing information and information necessary to assess Project-specific effects of the Project. Summaries of fish habitat and fisheries resources in the RSA were conducted using existing information collected by government, First Nations, or by consultants working on behalf of government or for logging and mining companies.

3.2.1 Review of Historical Data

Historical data on fish and fish habitat in the LSA and RSA were available from previous studies conducted between 1977 and 2010. Primary sources of historical data included:

- 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), EcoCat, FishWizard, and HabitatWizard databases (BC MOE, 2013);
- Reconnaissance 1:20,000 fish and fish habitat inventory data for the Creek 705 Watershed (Golder Associates Ltd. (Golder), 1998);
- Fish and fish habitat inventory data obtained from CanFor Forest Products Ltd. (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,2010a, 2010b, 2010c, 2010d); and
- Benthic macroinvertebrate (BMI) data from historical sampling sites within the study areas available through the Canadian Aquatic Biomonitoring Network (CABIN) (CABIN, 2011, 2012).

Secondary information sources included:

- Provincial 1:20,000 Freshwater Atlas stream and waterbody data layer issued by the BC MFLNRO (2011);

- Light Detection and Ranging (LiDAR) imagery and ortho-photographs;
- Species summary and status reports from the BC Conservation Data Centre (BC CDC) (BC CDC, 2013) and the Committee on the Status of Endangered Wildlife in Canada (COSEWIC);
- Vanderhoof Land and Resource Management Plan prepared by the British Columbia Integrated Land Management Bureau (BC ILMB) (BC ILMB, 1997); and
- Vanderhoof Sustainable Forest Management Plan (BC ILMB, 2010).

3.2.2 Field Studies

Baseline field studies to describe existing fish habitat and to characterize the fish communities in the local study area (LSA) were conducted in 2011, 2012, and 2013. Field studies were designed and conducted using the following guidelines:

- BC MOE's *Water and Air Baseline Monitoring Guidance Document for Mine Proponents and Operators* (BC MOE, 2012a);
- Environment Canada's (EC) *2010 Metal Mining EEM Technical Guidance Document* (EC, 2011b);
- Standards and procedures for inventories of fish and fish habitat established by the BC Resources Information Standards Committee (RISC) (RISC, 1997, 1999a, 1999b, 2000, 2001, 2008, 2009a, 2009b);
- Standards and procedures for reconnaissance-level fish and aquatic field inventories established by the BC Ministry of Forests (BC MOF) (BC MOF, 1995, 1998);
- Other standards and procedures for fish and aquatic field inventories developed by the BC government (Johnston and Slaney, 1996; Clark, 2003; Beatty et al., 2006);
- Standard methods for hydro-acoustic surveys of fish in lakes (Thorne, 1983; Brandt, 1996; Simmonds and MacLennan, 2005), with special measures to ensure thorough coverage of the upper water column (Johnston, 1981; Yule, 2000; Beauchamp et al., 2009);
- CABIN protocols for field surveys of streams (EC, 2010), and for laboratory methods of processing BMI (McDermott et al., 2010);
- Procedures for lake benthic macro-invertebrate (BMI) sampling established by the Ontario Benthos Biomonitoring Network (Jones et al., 2004) because BC does not yet have a similarly robust BMI sampling protocol for lakes; and
- Procedures for classification and quantification of fish habitat in lakes (Bradbury et al., 2001).

Fish and fish habitat studies in the LSA and RSA in 2011, 2012, and 2013 included:

- Continuous measurement of stream water temperatures with data loggers in 2011, 2012 and 2013;
- Sampling of periphyton communities at 14 stream sites (2011 and 2012) downstream, upstream, and under the proposed mine site footprint;
- Sampling of BMI communities at the same 14 stream sites sampled for periphyton;
- Bathymetry of the four headwater lakes and Tatelkuz Lake;
- Physical limnology (i.e., vertical profiles of temperature, conductivity, and dissolved oxygen (DO), and water transparency (Secchi disk)) of the four headwater lakes and Kuyakuz Lake in mid-summer and in Tatelkuz Lake in winter, summer, and fall;
- Sampling of phytoplankton, zooplankton, littoral BMI, and profundal BMI in the headwater lakes (except Snake Lake) and in Tatelkuz Lake in mid-summer;
- Lake fish inventories in the four headwater lakes in summer 2011, summer 2012, and fall 2012 using gillnets, minnow traps, shoreline backpack electrofishing, and angling;
- Surveys of littoral fish habitat in the headwater lakes (except Snake Lake) and Tatelkuz Lake including substrate characteristics, depth and presence/absence of submerged and emergent vegetation;
- Hydro-acoustic survey of Tatelkuz Lake to estimate the absolute abundance and relative species composition of the Tatelkuz Lake fish community;
- Gillnet and minnow trap survey of the Tatelkuz Lake fish community to ground-truth the hydroacoustic survey and to describe the species richness and biological characteristics of the fish community;
- Assessment of stream fish habitat at 34 sites in 2011 and 2012) and 11 sites in 2013 using *Fish Habitat Assessment Procedure* (FHAP) (Johnston and Slaney, 1996). Continuous FHAP surveys (i.e., full stream length surveys) were conducted in Davidson Creek within the proposed site of the TSF and in Creek 505659, a tributary of Creek 661, within the proposed East Waste Rock Dump, and modified FHAP surveys (i.e., sub-sampled stream length surveys) were conducted for 250 m-long sections around fish sampling sites in other selected streams;
- Surveys of stream fish habitat at another 113 sites (2011 and 2012) using the *Reconnaissance 1:20,000 Fish and Fish Habitat* (RISC, 2001) methods. These sites were mainly smaller tributary streams within the Project area and at stream crossings along the proposed access road and transmission line alignment;
- Rainbow trout spawning surveys in June 2011 using paired hoop nets (upstream and downstream) installed in Turtle Creek, Davidson Creek, Creek 661, and Creek 705;
- Stream fish inventories in the summers of 2011 and 2012 and 2013 using one-pass backpack electrofishing, minnow traps, and angling. Sites were located in Turtle Creek, Davidson Creek, Creek 661, Creek 705, and in the Tatelkuz Lake Tributaries;
- Survey of fish and fish habitat in lower Chedakuz Creek using minnow traps, visual counts and FHAP;

- Survey of fish and fish habitat in Creek 705 using electrofishing, minnow traps, FHAP and reconnaissance 1:20,000 methods. This was required because flows in Creek 705 downstream of Lake 01538UEUT will increase once Lake 01682LNRS is diverted into Lake 01538UEUT during mine construction;
- Stream bank walks to identify spawning kokanee and kokanee redds in Davidson Creek and Creek 661 in the summer/fall of 2011, 2012, and 2013;
- Aerial over-flights to record the relative number and location of kokanee spawners and their redds in lower, middle and upper Chedakuz Creek and all third-order tributaries of Chedakuz Creek from the Nechako Reservoir to Kuyakuz Lake in summer/fall 2012;
- Mountain whitefish spawning surveys in fall 2012 using hoop nets, one-pass backpack electrofishing (in open stream sections), and seine nets in the lower reaches of Davidson Creek, Creek 661, Turtle Creek, and Creek 705;
- Survey of overwintering fish habitat in streams and headwater lakes in the LSA in the winters of 2012 and 2013 to determine the abundance and quality of available overwintering habitat for fish;
- Survey of fish and fish habitat at stream sites that will be crossed by the transmission line and mine access road using backpack electrofishing and minnow traps and standardized reconnaissance 1:20,000 site card methods;
- Surveys of fish and fish habitat at stream crossings along the proposed FSS pipeline from Tatelkuz Lake to the mine site and along the airstrip access road, using electrofishing and reconnaissance 1:20,000 methods;
- DNA microsatellite analysis of adipose fin-clips to determine genetic relatedness of rainbow trout captured in Davidson Creek, Creek 661, Turtle Creek, and Chedakuz Creek in the Chedakuz Creek watershed and Creek 705 in the Fawnie Creek watershed; and
- DNA microsatellite analysis of adipose fin-clips to determine genetic relatedness of kokanee captured in Davidson Creek, Creek 661, Turtle Creek, and Chedakuz Creek in the Chedakuz Creek Watershed and from kokanee captured in the Fawnie Creek Watershed and in the Meadow Creek Watershed in the Kootenay Region of BC during a concurrent study.

Table 3-2: Summary of Fish and Fish Habitat Studies conducted in the Blackwater Local Aquatics Study, 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
Overwintering stream and lake habitat	Sites	5	2	3	1	2	13
Stream temperature monitoring	Sites	6	3	2	1	1	13
Stream periphyton	Sites	5	2	2	2	1	12
Stream benthic macroinvertebrates	Sites	5	2	2	2	1	12
Bathymetry (headwater lakes)	Lake	1	0	0	2	0	3
Physical limnology (headwater lakes)	Sites	1	0	0	2	1	4
Phytoplankton (headwater lakes)	Sites	1	0	0	2	0	3
Zooplankton (headwater lakes)	Sites	1	0	0	2	0	3
Lake benthic macroinvertebrates (littoral)	Sites	1	0	0	2	1	3
Lake benthic macroinvertebrates (profundal)	Sites	1	0	0	2	2	3
Fish habitat (streams)	FHAP sites	22	5	5	0	2	34
	Recon. 1:20,000K sites	64	10	21	5	13	113
Fish littoral habitat (headwater 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 (headwater 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
Rainbow trout diet (stomachs)	Fish	7	7	4	33	0	51
Rainbow trout tissue metals concentrations	Tissues	58	27	26	83	0	194
Fish microsatellite DNA sampling	Fish[(1)]	71	32	71	59	65	298

Note: [(1)]includes both rainbow trout and kokanee

Table 3-3: Summary of Fish and Fish Habitat Studies Conducted in the Blackwater Local Aquatics Study Area, 2013

Field Component	Units	Watershed							Total
		Davidson Creek	Turtle Creek	Creek 661	Creek 705	Tatelkuz Lake Tributaries	Chedakuz Creek	Tatelkuz Lake	
Overwintering stream and lake habitat	Sites	12	2	5	3	0	1	0	23
Stream temperature monitoring	Sites	4	2	1	0	0	0	0	7
Lake bathymetry	Lakes	0	0	0	0	0	0	1	1
Hydroacoustic estimate of fish number	Lakes	0	0	0	0	0	0	1	1
Lake fish community survey (gillnets)	Sites	0	0	0	0	0	0	78	78
Lake fish community survey (minnow trap groups)[(1)]	Sites	0	0	0	0	0	0	27	27
Physical limnology	Sites	0	0	0	0	0	0	2	2
Phytoplankton	Sites	0	0	0	0	0	0	2	3
Zooplankton	Sites	0	0	0	0	0	0	2	3
Lake BMI (littoral)	Sites	0	0	0	0	0	0	20	20
Lake BMI (profundal)	Sites	0	0	0	0	0	0	2	2
Fish habitat (lake)	Shoreline transects	0	0	0	0	0	0	21	21
Fish habitat (streams)	FHAP sites	0	0	1	9	0	1	0	11
	Recon. 1:20,000K sites	1	0	1	11	6	0	0	19
Summer fish inventory (streams)	Sites	3	0	0	11	0	12	0	25
Summer-fall kokanee spawning survey	Sites	4	0	3	0	0	8	0	15
Fish diet (stomachs)	Fish[(2)]	0	0	0	0	0	0	37	37
Fish tissue metals concentrations	Tissues[(3)]	0	0	0	0	0	0	79	79

Note: [(1)]Six traps per groups
[(2)]includes kokanee, rainbow trout, and mountain whitefish
[(3)]includes rainbow trout and mountain whitefish.

3.3 Fish Habitat

This section provides an overview of stream and lake fish habitat that may be affected by the Project. Detailed descriptions of watersheds and fish habitat in the LSA and RSA are provided in the *Fish and Aquatic Resources Baseline Reports* for 2011-2012 (**Appendix 5.1.2.6A** of the Application) and 2013 (**Appendix 5.1.2.6B** of the Application). A *Fish and Fish Habitat Baseline Summary* is provided in **Section 5.1.2.6** of the Application. **Figure 3-1** is an overview map of fish habitat quality in streams of the LSA. Photos of representative the streams and lakes described in the sections below are provided in **Annex A**.

3.3.1 Davidson Creek Watershed

Davidson Creek is a fourth-order stream that flows from Mount Davidson north-east to its confluence with lower Chedakuz Creek approximately 800 m downstream of Tatelkuz Lake. It has a watershed area of approximately 86 km^2. Elevations range from 1,700 metres above sea level (masl) at the summit of Mount Davidson to 950 masl at the confluence with Chedakuz Creek. Davidson Creek originates from a small headwater lake (Lake 01682LNRS) located near the drainage divide between the Chedakuz and Fawnie Creek watersheds. In addition to Lake 01682LNRS, 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 Mount Davidson and merge with upper Davidson Creek on the west and east sides of the creek, respectively.

The Davidson Creek mainstem can be roughly divided into upper, middle, and lower reaches of relatively homogeneous habitat. Lower Davidson Creek (i.e., Reaches 1 to 4) is characterized by riffle-pool morphology, which, combined with abundant suitably-sized gravels, provides good spawning habitat for kokanee and rainbow trout. Stable banks, deep pools, and good channel and hydraulic habitat complexity from large woody debris provide high-quality rearing habitat for juvenile rainbow trout.

Middle Davidson Creek (Reaches 5 to 8) is characterized by riffle and glide habitat, with fewer pools than are present in the lower section of the creek. Substrates are characterized by a mixture of cobbles and boulders, with spawning gravels present in more isolated pockets.

Habitat in Reach 6 and 7 of Davidson Creek is predominantly riffles with cobble/gravel substrates and glides with very little pool habitat. Where they exist, cover in pools is provided by large woody debris and overhanging vegetation. Suitable spawning gravels exist in both reaches in the riffles and pool tail-outs. Habitat quality for rainbow trout spawning/egg incubation is good but only fair for summer rearing and overwintering due to the relative paucity of pools.

364000 371000 378000 385000 392000

5908000 5901000 5894000

N

Lower Nechako Reservoir Regional Watershed

Chedakuz Creek

Proposed Transmission Line

Kluskus-Ootsa FSR

Fawnie Nose 1926m

Fawnie Dome 1726m

FAWNIE RANGE

NECHAKO RANGE

Turtle Creek

Davidson Creek

Tatelkuz Lake

Tatelkuz Lake Tributaries

Proposed Mine Access Road

Proposed Fresh Water Pipeline

Snake Lake

Top Lake

Fawnie Creek

Creek 661

Checakut Creek

Lake 01428UEUT

Lake 01682ENRS

Lake 01538UEUT

Creek 705

Kuyakuz Lake

Mount Davidson 1856m

Upper Eutsuk Lake Regional Watershed

Euchiniko Lake Regional Watershed

Mathews Creek

Kluskus-Blue FSR

364000 371000 378000 385000 392000

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\EIA\10-200-168_FishHabitatQuality.mxd

Legend

- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream
- Waterbody
- Regional Watersheds

Watersheds

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

Project Components

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

Fish and Aquatic Resources

- Local Study Area
- Regional Study Area

Fish Habitat Quality

- High
- Medium
- Low
- Nil

Scale:1:105,000

0 1 2 4 6

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish Habitat Quality

DATE: April, 2014	ANALYST: KA	**Figure** 3-1
JOB No: VE52095	QA/QC: MM	PDF FILE: 10-200-168_FishHabitatQuality.pdf
GIS FILE: 10-200-168_FishHabitatQuality.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Like habitat in Reach 8, 9, and 10 above, habitat in Reach 7.1 is diverse and includes roughly equal amounts of steep boulder cascades, riffles with cobble substrate, and glides with boulder/gravel substrate. Isolated pockets of spawning gravels are present in riffle and glide habitats. Pools are less abundant but where present provide good cover for fish from depth, over-cut banks and over-hanging vegetation. Large woody debris is limited to riffle and cascade habitats only. Habitat quality for rainbow trout is good for spawning/egg incubation and fair for overwintering and rearing due again to the paucity of pools.

The upper reaches of Davidson Creek (Reaches 9 to 12) are dominated by glides and runs, rather than by pools and riffles, as in the lower reaches of Davidson Creek. As a result, habitat complexity and suitability of spawning and juvenile rearing habitat is lower in the upper reaches of Davidson Creek than in the lower reaches of Davidson Creek.

The lower reaches of Davidson Creek's headwater tributaries provide good quality spawning and rearing habitat for rainbow trout. Habitat in these lower reaches is typically riffle-pool morphology with abundant cover from large woody debris, overhanging vegetation, and under-cut banks. Habitat quality decreases moving upstream as the creeks get smaller, substrates become more embedded with silt and fine organics. Overwintering habitat in these headwater tributaries is typically the habitat limiting characteristic owning to the paucity of pools with sufficient depth and flow to support fish.

Habitat in Reach 8, 9 and 10 of Davidson Creek is used only by the migratory rainbow trout population from Tatelkuz Lake. Habitat in these three reaches is diverse and includes cobble/gravel riffles and glides, boulder cascades, side-channels, and pools with fine substrates and cover from large woody debris and boulders. Spawning habitat is extensive in Reach 8 but only available in isolated pockets in Reaches 9 and 10. Good quality fry and juvenile summer rearing habitat for rainbow trout exists throughout all three reaches. Overwintering habitat for juvenile rainbow trout is better in Reach 8 than in reaches 9 and 10 due to the greater pool depths, higher winter flows, and presence of groundwater inputs.

Habitat in Reaches 11 to 12 of Davidson Creek is used only by the resident rainbow trout population in Lake 01682LNRS. This is because of the cascade partial barrier that exists at the bottom of Reach 11. Habitat in Reach 11 is comprised of boulder riffles and glides with small, isolated pockets of spawning gravels. Habitat in Reach 12, directly downstream of Lake 01682LNRS, consists predominantly of pools and deep glides with boulder/cobble/fine substrates. No suitable spawning gravels are present in this reach. Some portion of the rainbow trout spawned in Reach 11 of Davidson Creek is lost from the Lake 01682LNRS population each spring and summer over the cascade barrier. However, enough rainbow trout fry return upstream or are spawned in the lake or its headwater tributaries each year to sustain the lake population.

Habitat quality in Creek 704454, a headwater tributary of Davidson Creek, is moderate for rainbow trout. While gradients vary from low (~1%) to moderate (~4%) over its length, cobble-dominated riffles are the most common habitat type and isolated patches of suitable spawning gravels exist. Overwintering habitat quality is low owing to the low winter flows and generally shallow residual pool depths. Habitat quality in the Creek 704454 tributaries is lower. Gradient in these tributaries is steeper (3%-5%) and habitat is dominated by boulder cascades. Flows in

summer are low. These features limit the spawning and overwintering potential for rainbow trout and most of these headwater tributaries provide only summer rearing habitat for fry and juveniles.

The lower reaches of Creek 704454 are dominated by riffles with cobble substrate. Small patches of spawning gravels are present but are generally low quality because of silt. Overall habitat quality for rainbow trout spawning and overwintering is low in Creek 704454 while habitat quality for fry and juvenile rearing is good.

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

Habitat in Reach 1 of Creek 688328, another tributary to upper Davidson Creek, is dominated by riffles with cobble substrate; shallow glides and pools are also present. Good quality summer rearing opportunities for fry and juvenile rainbow trout exist here and suitable gravels for spawning are also present in isolated patches. However, no spawning activity or fry have been observed or captured, and juvenile rainbow trout densities were low in Reach 1. Habitat quality in reaches 2, 3, and 4 of Creek 688328 decreases moving upstream. Here, spawning habitat is limited to Reach 2 and reaches 3 and 4 only provide low quality rearing habitat. Overwintering habitat in Creek 688328 and its headwater tributaries is low to none due to the absence of pools deep enough to support fish and the very low winter flows.

3.3.2 Creek 661 Watershed

The Creek 661 Watershed lies south of Davidson Creek. The mainstem flows north-east from the eastern flank of Mount Davidson to middle Chedakuz Creek upstream of Tatelkuz Lake. Elevations range from 1,550 masl in the headwaters to 980 masl at the confluence with Chedakuz Creek. Creek 661 receives inflow from three main headwater tributaries: Creek 505659, Creek 146920, and Creek 543585. Unlike Davidson Creek, Creek 661 does not have a headwater lake.

Creek 661 exhibits similar physical habitat conditions to those found in Davidson Creek, albeit on a smaller scale, and with more wetlands and beaver impoundments in its middle to upper reaches. Lower Creek 661, above the confluence with Chedakuz Creek, is laterally stable, with riffle-pool morphology, and good habitat complexity and diversity. High quality spawning gravels in the lower reaches of Creek 661 (Reaches 1 to 3) provide good spawning habitat for both kokanee and rainbow trout. Above Reach 3, habitat is only used by rainbow trout. Here, habitat diversity and cover is high and good quality rearing habitat for rainbow trout exists in Reaches 4, 5, and 6. Spawning habitat is generally restricted to Reach 4, however, because substrates in Reaches 5 and 6 are too large for trout spawning.

Habitat in Creek 505659 is dominated by riffle habitat throughout. Abundant stream cover and suitable spawning gravels are present in its lower reaches where habitat quality in is good for all

rainbow trout life stages. Habitat quality decreases in the upper reaches of Creek 505659 as substrates become dominated by fines, and pool frequency, size, and depth decreases. Creek 146920 and Creek 543585 are first-order tributaries that provide only summer rearing habitat.

3.3.3 Turtle Creek Watershed

The Turtle Creek Watershed lies north of Davidson Creek. The mainstem flows roughly parallel to Davidson Creek. The confluence of Turtle Creek and Chedakuz Creek is approximately 3 km downstream of Tatelkuz Lake and is downstream of the confluence of Davidson Creek and Chedakuz Creek. Elevations in the watershed range from approximately 1,270 masl at its headwaters to 940 masl at the confluence with Chedakuz Creek. Turtle Creek has one main tributary, Creek 700, which drains the northwestern flank of Mount Davidson. Turtle Creek does not have a headwater lake.

The lower to middle reaches of Turtle Creek are dominated by low-gradient pools and glides. Riffles are rare but typically present downstream of the numerous beaver dams that proliferate these sections of Turtle Creek. As a result of these beaver dams, multiple wetlands have formed, particularly in the lower half of the watershed. Fine substrates are the dominant bed materials.

Spawning gravels for rainbow trout are present only in isolated pockets in the middle and lower reaches of Turtle Creek and spawning habitat quality is generally poor. However, juvenile rearing habitat is excellent in the beaver dam ponds and in the unimpounded areas where overhanging vegetation, deep pools, and patches of large and small woody debris provide good cover for fish.

3.3.4 Tatelkuz Lake Tributaries

Tatelkuz Lake Tributaries Watershed lies between Davidson Creek and Creek 661 Watersheds and includes the numerous tributaries that drain into the west side of Tatelkuz Lake. Streams in the Tatelkuz Lake Tributary Watershed are typically narrow, shallow, and low gradient. Habitat quality ratings for streams in the Tatelkuz Lake Tributary Watershed indicate that these streams have the capacity to support only limited rearing habitat. Spawning habitat is absent in most of these streams and overwintering habitat quality is nil or poor owing to the paucity of sufficient deep pools and the low winter flows.

3.3.5 Chedakuz Creek

Chedakuz Creek extends from upstream of Kuyakuz Lake to the Nechako Reservoir. Portions of Chedakuz Creek within the LSA include “middle” Chedakuz Creek which extends from the confluence of Creek 661 to Tatelkuz Lake and “lower” Chedakuz Creek (i.e., Reach 15) which extends from the outlet of Tatelkuz Lake to the confluence with Turtle Creek.

Habitat units in Reach 15 of lower Chedakuz Creek are larger than in Davidson Creek, Turtle Creek or Creek 661. Here, average bankfull width is approximately 14 m. Habitat in this reach of Chedakuz Creek is diverse and includes regularly alternating patterns of glides, riffles, and pools. Abundant gravels provide good quality spawning habitat for rainbow trout and kokanee in

lower Chedakuz Creek. Deep pools and instream vegetation provide good cover and excellent rearing and overwintering opportunities for juvenile trout. Abundant off-channel habitat also exists in this reach including side-channels, sloughs, and various wetland habitat types.

3.3.6 Creek 705 Watershed

The Creek 705 Watershed drains the south-west side of Mount Davidson to Fawnie Creek. Creek 705 has two headwater lakes: Lake 01538UEUT and Lake 01428UEUT. Elevations range from approximately 1,500 masl upstream of Lake 01538UEUT to 1,000 masl near the confluence of Creek 705 with Fawnie Creek. Besides the two headwater lakes, Creek 705 receives run-off from a number of small unnamed tributaries in the middle of the watershed downstream of the confluence of the two lake outlets. Water from Lake 01428UEUT flows through Creek 606013 to the mainstem of Creek 705. Because it is higher in elevation, water from Lake 01538UEUT flows directly into Creek 705.

Good quality rainbow trout rearing habitat is present throughout the lower to middle reaches of Creek 705. Here, cover is provided by deep pools, overhanging vegetation, and under-cut banks. Habitat complexity is high in these lower reaches and spawning and overwintering habitat for rainbow trout is good, particularly in Reach 1 near the confluence with Fawnie Creek. Spawning habitat quality is more variable in the upper watershed, ranging from good to poor depending on the availability of suitably sized gravel substrates. However, there are areas of habitat with suitable spawning gravels at the outlets of both headwater lakes, and this habitat is assumed to be used by lake-resident adults.

3.3.7 Tatelkuz Lake

Tatelkuz Lake is a long (~9 km), narrow (<1 km wide), steep-sided lake typical of valley lakes found in the BC interior plateau. It has an approximately south-east to north-west aspect with Chedakuz Creek, its main inlet and outlet, entering and exiting in its south-west and north-east corners, respectively. It is a large lake with a surface area of 910 ha, a mean depth of 21.4 m, and a volume of 195 Mm^3. Tatelkuz Lake is deep enough to stratify in summer with a thermocline typically forming by July and strengthening into August between the 5 m to 10 m depth intervals.

Littoral area comprises only 11% of total lake area. Low gradient, sand/silt/gravel beach areas at the northwest and southeast ends of the lake comprise approximately 43% of the total littoral area despite comprising only 23% of the total shoreline length (22.1 km). In comparison, steeper, rockier areas along the east and west shorelines comprise 77% of the total shoreline length, but only 58% of the total littoral area. Aquatic vegetation is sparse in Tatelkuz Lake. Beds of submergent and emergent vegetation are found exclusively in the northwestern end of the lake.

Tatelkuz Lake has conductivity readings (93 to 212 µS/cm) typically three to five times higher than conductivities measured in the headwater lakes of Davidson Creek and Creek 705 (32 to 69 µS/cm). The reason for this is that the three headwater lakes are at the head of watersheds and receive relatively little inflows per unit lake volume, while Tatelkuz Lake receives inflows

from the numerous watersheds of the Chedakuz Creek Valley. Differences in surficial geology and groundwater may also be factors.

3.3.8 Headwater Lakes

Four headwater lakes exist in the LSA: Lake 1682LNRS in the headwaters of the Davidson Creek Watershed; "Snake Lake" in the Tatelkuz Lake Tributaries watershed; and Lake 01538UEUT and Lake 01428UEUT in the headwaters of the Creek 705 watershed.

Lake 01682LNRS has one circular basin with a total area of approximately 92,000 m^2. It has a maximum depth of 16.3 m and a mean depth of 5.5 m. It is deep enough to stratify thermally in summer. It has shallow basin slopes that create a large littoral area relative to its total surface area (62% of total area). Seventy five percent of the habitat in this littoral zone is comprised of cobble/boulder shorelines. The lake has one small inlet tributary on the opposite side of the lake from its outlet where small quantities of suitable spawning gravels exist. However, it appears that the majority of spawning habitat for the rainbow trout population that exists in the lake is in Reach 11 of Davidson Creek downstream. Lake 01682LNRS is drained by Reach 12 of Davidson Creek.

Table 3-4: Elevation and Bathymetry of Lakes of the LSA

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

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

A headwater lake exists in the Tatelkuz Lake Tributaries Watershed, locally known as Snake Lake because of the "snake-like" esker that divides the lake into two basins. The lake has a total area of 519,000 m^2, a maximum depth of 11 m and a mean depth of 3.2 m. The littoral zone of Snake Lake comprises 93% of the total lake area. Here, habitat is generally comprised of two main categories: low gradient shorelines with fines-gravel substrates and abundant emergent vegetation; and steeper shorelines with harder gravel and cobble dominated substrates and no aquatic vegetation. This lake is too shallow to stratify and is well-mixed throughout the year.

Lake 01538UEUT is the southernmost headwater lake in the Creek 705 Watershed. It has a surface area of approximately 357,000 m^2 of which 52% is littoral zone habitat. The lake has two distinct basins, both oriented in an east-west direction. The smaller western basin is less than 9 m deep and has a large littoral area near the lake outlet. The eastern basin is deeper and larger than the western basin. This lake is too shallow (mean depth of 5.5 m) to stratify and is well-mixed throughout the year.

Lake 01428UEUT is the northernmost headwater lake of the Creek 705 Watershed. It is the shallowest of the four headwater lakes and littoral area makes up 97% of total area. This lake has one large main basin, with a small, shallow bay at the north-eastern end. The main basin is deepest near the middle with steep gradients along the north shore. This lake is too shallow (mean depth of 3.1 m) to stratify and is well-mixed throughout the year.

3.4 Fish Community

Detailed descriptions of fish community in the local and regional study areas are provided in the *Fish and Aquatic Resources Baseline Reports* for 2011-2012 (**Appendix 5.1.2.6A** of the Application) and 2013 (**Appendix 5.1.2.6B** of the Application). A *Fish and Fish Habitat Baseline Summary* is provided in **Section 5.1.2.6** of the Application. **Figure 3-2** is a map of the distribution of rainbow trout and kokanee in streams of the LSA.

364000 371000 378000 385000 392000

5908000 5901000 5894000

Lower Nechako Reservoir Regional Watershed

Chedakuz Creek

Proposed Transmission Line

Kluskus-Ootsa FSR

Fawnie Nose 1926m

Fawnie Dome 1726m

FAWNIE RANGE

NECHAKO RANGE

Turtle Creek

Davidson Creek

Tatelkuz Lake Tributaries

Tatelkuz Lake

Proposed Mine Access Road

Proposed Fresh Water Pipeline

Snake Lake

Top Lake

Fawnie Creek

Davidson Creek

Creek 661

Chedakuz Creek

Lake 01428UEUT

Lake 01682ENRS

Lake 01538UEUT

Creek 705

Kuyakuz Lake

Mount Davidson 1856m

Upper Eutsuk Lake Regional Watershed

Euchiniko Lake Regional Watershed

Mathews Creek

Kluskus-Blue FSR

N

Legend

- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Stream
- Waterbody
- Regional Watersheds

Watersheds

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

Project Components

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

Fish and Aquatic Resources

- Local Study Area
- Regional Study Area

Fish Distribution

- Known Kokanee and Rainbow Trout Distribution
- Known Rainbow Trout Distribution
- Unconfirmed Rainbow Trout Distribution
- Non Fish-bearing
- No data available

Scale:1:105,000

0 1 2 4 6

Kilometres

Reference
BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Fish Distribution

DATE: April, 2014	ANALYST: WR	**Figure** 3-2
JOB No: VE52277	QA/QC: MM	PDF FILE: 10-100-197_FishDistributions.pdf
GIS FILE: 10-100-197_FishDistributions.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\Baseline\10-100-197_FishDistributions.mxd

3.4.1 Fish Species Richness

A total of 12 fish species were captured or observed in streams and lakes of the LSA in 2011, 2012, and 2013 (**Table 3-5**). This list includes all fish species captured at stream crossings of the transmission line, access road, water pipeline, and airstrip access road. It also includes all fish species identified in historical reports and in interviews with Lhoosk'uz Dene elders. It also includes the fish species that were captured at stream crossings of the transmission line LSA and the access road LSA, but it does not include the fish species that are known from historical reports to be present in those streams.

Table 3-5: Fish Species Captured in the LSA

Common Name	Scientific Name	BC Fish Species Code
Kokanee	*Oncorhynchus nerka*	KO
Rainbow trout	*Oncorhynchus mykiss*	RB
Mountain whitefish	*Prosopium williamsoni*	MW
Northern pikeminnow	*Ptycheilus oregonensis*	NSC
Longnose sucker	*Catostomus catostomus*	LSU
Largescale sucker	*Catostomus macrocheilus*	CSU
Burbot	*Lota lota*	BB
Brassy minnow	*Hybognathus hankinsoni*	BMC
Lake chub	*Couesius plumbeus*	LKC
Slimy sculpin	*Cottus cognatus*	CCG
Longnose dace	*Rhinichthyes cataractae*	LNC
White sucker	*Catostomus commersonii*	WSU

Coombes (1985b) reported that one additional fish species – prickly sculpin (*Cottus asper* – BC fish code CAS) was present in Laidman Lake. Prickly sculpin are not reported to be present in any other waterbody in the RSA.

Only brassy minnow is classified as sensitive or vulnerable according to the BC Conservation Data Centre (BC CDC) (BC CDC, 2013). The BC Provincial Conservation Status ranking of brassy minnow is S2S3 (i.e., a blue-listed). Blue-listed taxa are at risk, but are not extirpated, endangered or threatened. The BC CDC (2013) classifies brassy minnow as sensitive or vulnerable because its 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 and Taylor, 2013). Brassy minnow is not ranked by COSEWIC (2013).

Fish species richness in the different streams and lakes in the LSA and RSA ranged from one to five species in streams and from one to 10 species in lakes (**Table 3-6**). As expected, fish species richness increased with increasing size of the watercourse or lake. Among streams, Chedakuz Creek had the greatest species richness (5 species) followed by Creek 705 (4 species). Turtle Creek had the lowest species richness (one species). Among lakes, Tatelkuz Lake had the greatest species richness (10 species), followed by Kuyakuz and Laidman lakes

(six species each). Snake Lake and Lake 01682LNRS each support only one fish species, lake chub and rainbow trout, respectively. Populations of rainbow trout and longnose sucker reside in Lake 01538UEUT and Lake 01428UEUT in the Creek 705 watershed.

Table 3-6: Fish Species Present in the LSA and RSA

Stream/Lake	RB	LSU	MW	KO	CSU	NSC	BB	CCG	LKC	BMC	WSU	LNC	CAS	Total
Local Study Area														
Davison Creek	X	-	X	X	-	-	-	-	-	-	-	-	-	3
Turtle Creek	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Creek 661	X	-	-	X	-	-	-	-	-	-	-	-	-	2
Creek 705	X	X	X	-	-	-	X	-	-	-	-	-	-	4
Chedakuz Creek	X	X	-	X	-	-	-	X	-	-	-	X	-	5
Lake 01682LNRS	X	-	-	-	-	-	-	-	-	-	-	-	-	1
Lake 01538UEUT	X	X	-	-	-	-	-	-	-	-	-	-	-	2
Lake 01428UEUT	X	X	-	-	-	-	-	-	-	-	-	-	-	2
Snake Lake	-	-	-	-	-	-	-	-	X	-	-	-	-	1
Tatelkuz Lake	X	X	X	X	X	X	X	X	-	X	X	-	-	10
Sub-Total	9	5	3	4	1	1	2	2	1	1	1	1	0	
Regional Study Area														
Fawnie Creek	X	-	-	X	-	-	-	-	-	-	-	-	-	2
Kuyakuz Lake[(1)]	X	X	X	X	X	-	-	-	X	-	-	-	-	6
Laidman Lake[(2)]	X	X	X	-	X	X	-	-	-	-	-	-	X	6
Top Lake[(3)]	X	X	X	-	-	-	-	-	-	-	-	-	-	3
Sub-Total	4	3	3	2	2	1	0	0	1	0	0	0	1	
Total	**13**	**8**	**6**	**6**	**3**	**2**	**2**	**2**	**2**	**1**	**1**	**1**	**1**	

Note: [(1)]Burns (1977); [(2)]Coombes (1985b); [(3)]Coombes (1985a).
Note: RB = rainbow trout; LSU = longnose sucker; MW = mountain whitefish; KO = kokanee; CSU = largescale sucker; NSC = northern pikeminnow; BB = burbot; CCG = slimy sculpin; LKC = lake chub; BMC = brassy minnow; WSU = white sucker; LNC = longnose dace; CAS = prickly sculpin.

Rainbow trout are the most common species in the LSA and RSA, being present in every watercourse and waterbody except Snake Lake. Longnose sucker were the second most common species, followed by mountain whitefish and kokanee. The remaining nine species were each present in only one to three waterbodies.

3.4.2 Rainbow Trout

Rainbow trout were the most common fish species captured and observed in the four creeks potentially most-directly affected by the Project. In Davidson Creek, adult rainbow trout are only found in spring when they spawn in the upper, middle, and lower reaches. Adult fish then migrate back downstream to Chedakuz Creek and Tatelkuz Lake where they spend the rest of the year foraging and overwintering. Thus, rainbow trout in lower and middle Davidson Creek are part of a migratory population in Tatelkuz Lake or Chedakuz Creek and do not represent a resident population.

Rainbow trout fry and juveniles spend one to two years in Davidson Creek before migrating downstream. While in the streams, they feed on drifting aquatic insect larvae and terrestrial insects that fall on the water surface. Once in the lake, they rear and forage on benthic invertebrates, zooplankton, and other fish, if available, until becoming sexually mature adults, typically within 3 to 5 years.

A resident rainbow trout population exists in Lake 01682LNRS upstream of the cascade partial barrier at the bottom of Reach 11. This barrier isolates this headwater lake population from the downstream migratory population but fish from the headwater population presumably move downstream over the cascade and mix with the migratory population downstream. Spawning habitat for the headwater lake population is limited to small patches of gravel in Reach 11 downstream of the lake.

Migratory populations of rainbow trout also use Creek 661 and Turtle Creek for spawning in spring. Rainbow trout use at least the lower six reaches of Creek 661 for spawning while rainbow trout use the middle and lower reaches of Turtle Creek for spawning. Similar to Davidson Creek, fry and juveniles of these migratory fish use the pools and glides of Creek 661 and the numerous beaver ponds in Turtle Creek to rear and forage.

Migratory rainbow trout from Fawnie Creek as well as resident rainbow trout populations in Lake 01538UEUT and Lake 01428UEUT use spawning habitat in Creek 705. Presumably, juvenile and fry that use Creek 705 in summer for rearing represent a mixture of all three of these populations. Unlike Lake 01682LNRS where they are a monoculture, rainbow trout in Lake 01538UEUT and Lake 01428UEUT co-exist with longnose sucker.

3.4.3 Kokanee

Kokanee are temporarily the most abundant fish species in lower Davidson Creek, lower Creek 661, and in Chedakuz Creek when they move from Tatelkuz Lake and Kuyakuz Lake and enter creeks to spawn. In Davidson Creek, kokanee only spawn as far upstream as Reach 4. In Creek 661, kokanee only spawn as far upstream as Reach 3. In Chedakuz Creek, they use mainstem habitat downstream of Tatelkuz Lake to at least the Turtle Creek confluence and mainstem habitat upstream the confluence of Creek 661 and further upstream to Kuyakuz Lake. Unlike rainbow trout, kokanee do not use Turtle Creek or Creek 705 for spawning.

Kokanee fry that emerge from the gravels of Davidson Creek, Creek 661, and Chedakuz Creek immediately migrate to Tatelkuz Lake. Once the fry have left and the adult spawners have died, no kokanee are present in any creek until the following summer and fall.

3.4.4 Tatelkuz Lake

The fish community of Tatelkuz Lake requires special mention because of its diversity of species and source for all of the fish species using Davidson Creek, Creek 661, Turtle Creek, and Chedakuz Creek for spawning. The Tatelkuz Lake fish community is comprised of 10 different species. These include, in order of summer abundance: kokanee, rainbow trout, mountain whitefish, longnose sucker, and northern pikeminnow plus small-bodied species such as brassy

minnow and slimy sculpin and more rare large-bodies species such as white sucker, large-scale sucker and burbot. The hydroacoustic study of Tatelkuz Lake in early July 2013, calibrated by the gillnet survey of the fish community of mid-July 2013, estimated a total of 606,274 kokanee in Tatelkuz Lake (**Table 3-7**). That was 78% of all of fish counted in the lake. Rainbow trout were a distant second-most abundant species, having approximately 117,068 fish in the lake or 15% of the total. Mountain whitefish, longnose sucker, and northern pikeminnow represented <5% of the total Tatelkuz Lake fish community each. All other species, represented <1% of the total fish community combined.

Table 3-7: Estimated Number and Density of Fish in Tatelkuz Lake, July 2013, from Hydroacoustic Survey

Species	Number				Density (number/ha)		
	Estimate	Lower 95% CL	Upper 95% CL	Percent of Total	Estimate	Lower 95% CL	Upper 95% CL
Kokanee	606,274	503,207	709,340	78.2	676	561	791
Rainbow trout	117,068	97,167	136,970	15.1	131	108	153
Mountain whitefish	26,360	21,879	30,841	3.4	29	24	34
Longnose sucker	13,955	11,583	16,328	1.8	16	13	18
Northern pikeminnow	11,629	9,652	13,606	1.5	13	11	15
Total	775,286	643,487	907,085	100.0	864	717	1,011

Note: CL = confidence limit; ha = hectare.
Density calculated from lake surface area of 897 ha at time of hydroacoustic survey.
Total number of fish estimated in the lake does not include benthic fish species (slimy sculpin, brassy minnow, burbot, largescale sucker, and white sucker) that were undetectable with acoustics and that were not caught in large numbers in gillnets.

The relatively high abundance of kokanee in the lake is due to their preference for relatively shallow (5 to 15 m deep) offshore habitat, which is the single largest type of habitat by volume in Tatelkuz Lake.

3.5 Fisheries

There are no commercial fisheries in the LSA or RSA. However, there are recreational fisheries for rainbow trout, as shown, for example, by the presence of a fishing resort at the northern end of Tatelkuz Lake. The fishing resort provides a boat, canoes and kayaks for visitors to use on Tatelkuz Lake. Representatives of First Nations groups noted that boating supports fishing activity in these areas (Interviews with Lhoosk'uz Dene Elders, 2013). However, the magnitude and geographic extent of this recreational fishery is not known because there have been no creel surveys conducted to date. In a May 2013 Open House, a community member noted the south-east side of Tatelkuz Lake is used for recreational purposes such as camping and fishing.

There are also Aboriginal fisheries in the LSA. Indian Reserve (IR) No. 28 is located at the northern end of Tatelkuz Lake (**Figure 1-1**) and is occupied by one family with four members. Fishing remains an important food source for this family who estimates that approximately three to four meals per week consist of fresh or dried fish. In an interview with residents of IR No. 28

on 4 July 2013, it was reported that they harvest rainbow trout, suckers, and kokanee in Tatelkuz Lake, Davidson Creek, and lower and middle Chedakuz Creek (Interviews with Lhoosk'uz Dene Elders, 2013). The elder described Davidson Creek as an area where kokanee spawn and the areas near lower Chedakuz Creek where suckers spawn. They usually fish in the spring when rainbow trout and suckers migrate from their residence lakes into spawning streams. Rainbow trout and suckers are also fished in the "Twin Lakes" (Lake 113 and Mills Lake) located within the north-east corner of the RSA. Representatives of Ulkatcho and Saik'uz First Nations noted the use of Tatelkuz Lake to harvest fish although specific species were not identified.

There were also historical Aboriginal fisheries in the RSA as evidenced by the numerous archaeological sites distributed along the shorelines of Tatelkuz and Kuyakuz lakes (New Gold, 2012). Kuyakuz Lake remains an important fishing spot for Lhoosk'uz Dene Nation and Ulkatcho First Nation.

3.6 Factors Limiting Fish Production

The relationship between habitat and its ability to produce fish is generally not well understood. Interactions between physical, chemical, and biological attributes of the habitat, the seasonal and annual variability in flow conditions, energy inputs, and water quality, and complex predator-prey and inter- and intra-specific competition make these relationships difficult. Despite these complexities, it is possible to make assumptions about what physical, chemical, and/or biological factors are currently limiting the number of fish produced in a stream or lake using professional judgment and knowledge of physical habitat, water quality and fish species composition and abundance from baseline field programs.

Survival, growth, and reproduction of rainbow trout and kokanee populations near the Project area are dependent on physical, chemical, and biological processes in both stream and lake environments. However, because of their different life histories, the factors likely to be limiting the productivity of rainbow trout and kokanee in the Project area are likely to be different.

Kokanee only use streams for spawning. However, because there is abundant kokanee spawning habitat in lower Davidson Creek, Creek 661, and in Chedakuz Creek above and below Tatelkuz Lake, and because spawning habitat availability is rarely the bottleneck limiting freshwater fish populations, it is more likely that the habitat factor controlling the production of kokanee in the Project area is habitat, including food supply and nutrient levels, in their resident lakes: Tatelkuz and Kuyakuz lakes.

Adult kokanee in Tatelkuz Lake feed on amphipods, chironomids, and other insect larvae. Zooplankton are also an important prey item for kokanee in Tatelkuz and Kuyakuz lakes, particularly for fry and juveniles. Because the abundance and availability of these invertebrates vary seasonally, annually, and in the case of zooplankton, weekly in response to the density of phytoplankton, the productivity of kokanee in Tatelkuz and Kuyakuz lakes is most likely limited by the production of benthic and pelagic invertebrate communities in these lakes. In lakes, the production of plankton is controlled by the availability of phosphorus, nitrogen, and carbon, water temperature, and the intensity of sunlight entering the water column. Production of benthic invertebrates in lakes is largely controlled by the amount of littoral habitat present and the

amount of organic material and oxygen concentrations on the lake bottom. Thus, the productivity of kokanee in these lakes is dependent on a wide array of physical, chemical, and biological parameters any one of which varies widely on a monthly and yearly basis. Densities of predatory species (e.g., northern pikeminnow) and competitor species (e.g., mountain whitefish, rainbow trout) likely influence kokanee production in Tatelkuz and Kuyakuz lakes but to a much smaller degree than prey densities.

Unlike kokanee, rainbow trout fry and juveniles rearing in Davidson Creek and Creek 661 for at least one year before moving downstream to mature in Chedakuz Creek or Tatelkuz and Kuyakuz lakes. Therefore, because the production of fish populations is most often limited by the survival of the youngest life stages, production of rainbow trout in the Project area is most likely to occur in their natal streams. This is likely to be particularly true of rainbow trout populations in the Project area because there are no resident rainbow trout populations in Davidson Creek or Creek 661. Instead, the only rainbow trout found in these creeks in summer and winter are instead progeny of the migrant rainbow trout that entering Davidson Creek and Creek 661 from Chedakuz Creek and Tatelkuz and Kuyakuz lakes to spawn in spring. Thus, the productivity of rainbow trout populations in these larger systems would appear to be highly dependent on the survivorship and growth of fry and juveniles rearing and overwintering in these creeks. While these populations likely use other smaller tributaries to spawn as well, the relatively large number of adults using these streams in spring for spawning suggests that Davidson Creek and Creek 661 are important for their annual recruitment.

A number of physical, chemical, and biological factors may be controlling the survival and growth of fry and juvenile rainbow trout in the Davidson Creek and Creek 661 watersheds. Most likely, it is a combination of a number of factors. However, although not directly comparable because the Davidson Creek and Creek 661 summer fish catches only include fry and juveniles and no resident adults that would naturally increase self-thinning of fry and juveniles, the average summer density of rainbow trout in Davidson Creek (6.9 fish/100 m^2) and Creek 661 (4.7 fish/100 m^2) are higher than the BC bio-standard for natural, non-enhanced streams (3.6 fish/100 m^2; Koning and Keeley 1997). This suggests that whatever factor is limiting rainbow trout in these creeks, it is no more severe than most other streams where rainbow trout are found in BC.

Water quality and food production is unlikely to be limiting rainbow trout production in Davidson Creek or Creek 661. Concentrations of phosphorous, nitrogen, and inorganic carbon are low, but these nutrients are rapidly assimilated by photosynthetic periphyton that form one of the two energy sources for stream ecosystems and low concentrations in the water is typical and not considered suggestive of low productivity. This is supported by the relatively diverse and abundant algae community in these streams. The other energy source, terrestrial inputs of organic leaf litter and insects, is also unlikely to be limiting trout production because the riparian areas around both streams are intact and fully functional.

Inter-specific competition between fish species and predation are also unlikely to be limiting rainbow trout production in Davidson Creek and Creek 661 watersheds. This is because rainbow trout are almost the exclusive fish species found in Davidson Creek and Creek 661 at most times of the year. Kokanee are more abundant in these creeks than rainbow trout during the late

summer spawning period but these fish are generally not feeding at this time, and are not predators of rainbow trout. Slimy sculpin, a species that resides in similar habitat and feeds on similar prey as rainbow trout, are rare. No other competitor or predator fish species are known to utilize Davidson Creek or Creek 661 in any great numbers.

Intra-specific competition between juvenile rainbow trout is common in small streams and is undoubtedly one of the biological factors limiting rainbow trout production in Davidson Creek and Creek 661. Juvenile rainbow are territorial in summer and compete for the best combination of cover, low water velocities, and access to drifting invertebrate prey. Larger, older trout are better able to acquire and defend the best territories and, in doing so, relegate smaller, younger fish to less desirable habitats. The result of this intra-specific competition is the "self-thinning" of rainbow trout in a stream caused by younger, smaller fish dispersing downstream. When this occurs, the density of rainbow trout reaches the carrying capacity of the stream, which is typically dictated by the availability of pools for larger fish, runs and glides for smaller juveniles and stream margins and pocket-pools for fry.

The availability and suitability overwintering habitat is likely the physical feature limiting rainbow trout production in Davidson Creek and Creek 661. This hypothesis is based on two lines of evidence available from baseline studies conducted in 2011 and 2012. First, water depths under the ice were shallow (0.40 m on average in Davidson Creek and 0.3 m on average in Creek 661) in pools specifically selected in both creeks as those most likely to provide overwintering habitat for trout. Therefore, although dissolved oxygen concentrations in these pools was generally suitable for trout (i.e., >9 mg/L), the shallow depths of these pools suggests that the volume of overwintering habitat in Davidson Creek and Creek 661 limits the number of fish pools in these creeks can support.

Second, the relative number of adult rainbow trout returning to Davidson Creek and Creek 661 in spring (103 and 324 fish,respectively) was significantly lower than the number of rainbow trout returning to Turtle Creek (the creek adjacent to and immediately west of Davidson Creek) to spawn in 2011 (584 fish). Assuming the majority of fish born in each creek returns to their natal stream to spawn, a reasonable assumption given the homing tendancies of migratory rainbow trout, Turtle Creek likely produces significantly more rainbow trout each year than either Davidson Creek or Creek 661. Rainbow trout summer densities were lower in Turtle Creek (0.9 fish/100 m^2) than in Davidson Creek or Creek 661, and were lower than the BC bio-standard of 3.6 fish/100 m^2). However, electrofishing did not include any of the deeper beaver ponds that dominate the middle and lower reaches of Turtle Creek. Therefore, these ponds most likely provide the majority of summer rearing and overwintering habitat needed by juvenile trout to produce the larger number of returning adults to Turtle Creek. The number of beaver dam ponds in Davidson Creek and Creek 661 is significantly lower than in Turtle Creek.

This hypothesis is consistent with research in other BC watersheds where the factor limiting salmonid densities is most often attributed to availability of adequate overwintering habitat rather than the amount of summer rearing habitat (Bustard and Narver, 1975). Stream-dwelling salmonids, like rainbow trout, actively choose overwintering habitats that minimize energy expenditure while maximizing concealment and survival (Cunjak, 1996). Overwintering habitats for trout generally have low water velocities, depths sufficient to provide protection from ice

scour, cover from predators, and an accessible food supply (Anderson, 2002). In Davidson Creek and Creek 661, pools with these attributes are limited and are most likely limiting rainbow trout production in these creeks as a result.

Summer water temperatures are also likely limiting growth and production of rainbow trout in Davidson Creek. Average July and August water temperatures in Davidson Creek (<15ºC) fall below the BC MoE optimal temperature range (17ºC to 19ºC) for juvenile trout (BC MoE, 2001). While water temperatures in Davidson Creek are well within the range tolerated by juvenile rainbow trout, warmer temperatures in summer would increase the metabolic rates of juvenile trout, increase their prey consumption rates, and subsequently, increase their growth rates in response. This increased consumption would likely be supported by increased production of periphyton and benthic macro-invertebrates communities in the warmer stream.

4.0 DESCRIPTION OF POTENTIAL EFFECTS TO FISH AND FISH HABITAT

Potential effects to fish and fish habitat from the Project include direct and indirect effects. Direct effects are those that could result directly in the death of fish or the permanent alteration or destruction of fish habitat. Potential direct effects of the Project include the death of fish impinged or entrained in intake pumps, trapped under waste rock or other mine infrastructure, or stranded in dewatered areas of streams and lakes. They also include the direct loss of fish habitat under the footprint of various mine components. Indirect effects are those that could result in changes to the growth, survival and reproductive success of fish due to changes in downstream flow regimes and water quality including stream temperatures, isolation in upstream habitats that do not provide all requisites for all species life stages, changes in lake levels, changes in riparian vegetation, and changes in the quantity and quality of prey items in streams (i.e., BMI drift) and lakes (i.e., zooplankton, BMI, and forage fish).

Fish and fish habitat could potentially be affected by all six main components of the Project:

- Mine site;
- FSS;
- Mine access road;
- Kluskus-Ootsa FSR upgrade;
- Airstrip; and
- Transmission line.

Descriptions of the potential unmitigated serious harm to fish resulting from each of these mine components are provided in the sections below. This includes:

- A description of specific proposed works or activities required for each of these mine components likely to result in serious harm to fish;
- The specific effect likely to result in serious harm to fish created by the specific work or activity;
- Quantification of the likely serious harm to fish in terms of absolute or relative numbers of fish likely to be affected and/or spatial area of potentially affected habitat;
- A description of the fish species and life stages most likely affected; and
- A description of the likelihood of serious harm to fish occurring because of the specific work or activity before mitigation.

This information is provided to differentiate and identify any and all serious harm to fish likely to result from the works and activities necessary to build, operate, and close the six main components of the Project prior to mitigation (i.e., the worst-case scenario). It is also meant to identify which potential effects require mitigation.

4.1 Quantifying Potential Effects to Fish and Fish Habitat

4.1.1 Fish Species and Life Stage Selection

Rainbow trout and kokanee were selected as the key indicator species to evaluate potential effects to fish and fish habitat due to the Project. These two fish species were selected based on their predominance in lakes and streams of the LSA, their importance to local recreational and Aboriginal fisheries, and their distribution relative to the streams and lakes potentially affected by the Project.

Life stages of rainbow trout and kokanee that will likely be most affected by the Project were selected based on findings from the baseline field programs (**Appendix 5.1.2.6A** and **Appendix 5.1.2.6B** of the Application). Based on the current knowledge of rainbow trout and kokanee populations in the Project area (**Section 3.0**), kokanee spawning and egg incubation and all five rainbow trout life stages were selected for analysis of potential effects to fish and fish habitat in streams for the Project (**Table 4-1**). Kokanee only use the lower four reaches of Davidson Creek and the lower three reaches of Creek 661 for spawning and egg incubation. Kokanee fry immediately migrate downstream to Chedakuz Creek and Tatelkuz Lake where they rear and mature into juveniles and adults. Adult kokanee die soon after spawning in streams. Therefore, no other kokanee life stage, besides the spawning/egg incubation stage, will be affected by potential changes cause to stream habitat by the Project.

Table 4-1: Rainbow Trout and Kokanee Life Stages Using Streams and Lakes Potentially Affected by the Project

Life Stage	Rainbow Trout		Kokanee	
	Streams	Lakes	Streams	Lakes
Spawning/Egg Incubation	√	-	√	-
Fry Summer Rearing	√	√	-	√
Juvenile Summer Rearing	√	√	-	√
Adult Summer Foraging	-	√	-	√
Overwintering	√	√	-	√

In contrast, four of the five rainbow trout life stages use stream habitat in the Project area. Adult rainbow trout use habitat in Davidson Creek and Creek 661 watersheds only to spawn (**Appendix 5.1.2.6A** and **Appendix 5.1.2.6B** of the Application). They return to the lake in late June immediately after spawning). Therefore, this life stage was not used to evaluate potential effects to stream habitats.

Kokanee use lakes for all of their life history stages except spawning and egg incubation. In the Project area, only Tatelkuz Lake supports fry, juvenile, and adult summer rearing and foraging habitat and overwintering habitat. Here, kokanee are the most abundant fish species present.

Rainbow trout use lakes for all of their life history stages except spawning and egg incubation. In the LSA, rainbow trout reside in the headwater lakes of the Davidson and Creek 705 watersheds and in Tatelkuz Lake, where they are the second most abundant species.

Where possible, these same fish species and life stages were used for evaluating habitat benefits from mitigation and offsetting measures. This is because all mitigation measures and most offsetting measures will target kokanee and rainbow trout, the two fish species most likely affected by the Project. By minimizing effects to individual rainbow trout and kokanee and by maintaining the productive capacity of fish habitat used by the different rainbow trout and kokanee life stages, it is assumed that mitigation and offsetting measures will provide similar protection and productive capacity of fish habitat used by other fish species in area lakes and streams.

4.1.2 Spatial Boundaries

Assessment of potential serious harm to fish, including the permanent alteration or destruction of fish habitat was limited to the LSA and to ROWs along the various linear developments (e.g., transmission line) required for the Project. This was because the LSA includes all streams and lakes that could be directly or indirectly affected by construction, operation, and closure of the mine site, the FSS, and the airstrip. The LSA included the following streams and lakes (**Figure 1-2** and **Figure 1-3**):

- Davidson Creek and its headwater streams and Lake 01682LNRS: the majority of the mine site components, including the open pit, the Site C and Site D TSFs, the West Waste Rock Dump, the low-grade stockpile, the construction lay-down area, the ECD, the freshwater reservoir, pipeline, and access road, borrow areas, water management systems (e.g., seepage collection ponds and ditches, spillways), and the majority of the mine access road fall within the Davidson Creek Watershed;
- Creek 661 and its headwater tributaries: the open pit, the East Waste Rock dump, the construction and operations camps, plant site, a portion of the Site D TSF fall, and portions of the FSS pipeline and mine access road fall within the Creek 661 Watershed;
- Turtle Creek and its headwater tributaries: the airstrip, airstrip access road, and small portions of the mine access road and transmission line ROWs fall within the Turtle Creek watershed;
- Tatelkuz Lake: the FSS intake structure will be located on the western shoreline of Tatelkuz Lake and will draw water from the lake during mine construction, operations and closure phases to augment flows in Davidson Creek and to provide make-up water for the mill and, perhaps, water to submerge PAG rock in the TSF. Tatelkuz Lake is also downstream of Creek 661 where various mine site facilities will be located;
- Tatelkuz Lake Tributaries: The FSS pipeline and access road will cross various tributaries to Tatelkuz Lake that enter from the south;
- Chedakuz Creek: downstream of Tatelkuz Lake and the receiving watercourse for run-off from Davidson Creek, Creek 661 and Turtle Creek watersheds; and
- Creek 705 and its headwater tributaries and Lake 01538UEUT: Lake 01538UEUT, and ultimately Creek 705, will receive flow diverted from Lake 01682LNRS as part of the FMOP.

Potential effects of the transmission line, mine access road, and the Kluskus-Ootsa FSR upgrade largely fall outside of this LSA and, therefore, required separate study areas. For each

of these linear developments, the study areas were 200 m wide strips centred on the ROW centre-lines. The study area for the transmission line was approximately 140 km long and extended from the Glenannon sub-station near Endako, BC, to the mine site. The stream crossings long this route are listed in **Section 2.2** and are not repeated here. The study area for the mine access road was approximately 18 km long and extended from the Kluskus-Ootsa FSR at 123+973 km to the mine site. The study area for the Kluskus-Ootsa FSR upgrade included the 22 km section of existing road that requires re-gravelling (from 101+650 km to 123+973 km) and the 1.8 km section of existing road that requires re-alignment (from 104+900 km to 106+738 km).

4.2 Potential Effects of the Mine Site

Collectively, construction, operation, and closure of the mine site components (e.g., open pit, TSFs, low-grade stockpile, camps, plant site, waste rock dumps) could result in serious harm to fish including the permanent alteration or destruction of fish habitat. This serious harm to fish includes:

- Direct loss of fish and fish habitat under the mine site footprint;
- Indirect reduction in growth, survival and recruitment of fish due to isolation of fish populations upstream of the mine site footprint;
- indirect reduction in growth, survival, and recruitment of fish and indirect reduction in habitat quality and quantity downstream of the mine site due to flow changes; and
- indirect reduction in growth, survival, and recruitment of fish due to changes in downstream water quality, temperature, and suspended solid concentrations due to working in or around water.

The potential unmitigated direct and indirect effects to fish and fish habitat from construction, operation, and closure of the various mine site components is summarized in **Table 4-2** and described in the sections below. The mine site components can be combined into seven categories:

- Site infrastructure and site roads: fuel site, warehouses and materials storage buildings, administrative buildings, construction lay-down area, truck stop, explosives facilities, construction and operations camps and maintenance buildings, camp waste management system (site landfill and domestic sewage system), and haul roads;
- open pit;
- Ore-processing area: plant site, mill and processing area, core logging area, crusher and conveyor and low-grade ore stockpile;
- TSF (Site C and Site D);
- Waste rock dumps (East and West);
- Wetland and Water Management System: including seepage collection ponds and ditches, TSF dams and spillways and an ECD and pond; and
- Borrow areas: includes the sand and gravel screening plant.

All of these mine site components are located in the Davidson Creek and Creek 661 Watersheds.

Table 4-2: Summary of Potential Direct and Indirect Effects to Fish and Fish Habitat due to the Blackwater Mine Site

Phase	Mine site component	Proposed work, undertaking or activity	Potential Effects	Streams and Lakes Affected	Fish species and life stages
Construction	Site Infrastructure and Site Roads	Clearing, grading and topsoil salvage, construction and lay-down areas, surface drainage controls, construction of site infrastructure (fuel site, warehousing and materials storage, construction lay-down area, truck stop, camp and maintenance buildings, explosives facility), camp waste management system (site landfill, domestic sewage system)	**Direct Effects**: 1) mortality of fish in streams under site infrastructure and site roads; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under site infrastructure and sites roads **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** 1) Creek 704454; 2) Creek 704454 tributaries **Creek 661:** downstream of Reach 5 **Creek 661 tributaries:** 1) Creek 505659; 2) Creek 146920; 3) Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Mine pit	Stripping of top-soil and over-burden	**Direct Effects**: 1) mortality of fish in streams under the mine pit; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under the mine pit **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Ore Processing Area	Clearing and construction of ore processing area (plant site, mill and processing area, core logging area) foundations and building construction, crusher and conveyor and low grade ore stockpile.	**Direct Effects**: 1) mortality of fish in streams under ore processing area; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under ore processing area **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** Creek 704454 and Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Waste Rock Areas	Mine waste rock dumps construction	**Direct Effects**: 1) mortality of fish in streams waste rock areas; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under waste rock areas **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	TSF	Clearing, grading and topsoil salvage, construction of TSF (tailings and return water lines), construct dams and collect water, Site C west dam, Site C main dam, Site D main dam and embankment	**Direct Effects**: 1) mortality of fish in streams under TSFs; 2) mortality of fish stranded in streams directly downstream of work areas; 3) stranding of fish upstream; 4) permanent alteration or destruction of fish habitat under TSFs; 5) isolation of habitat upstream **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows;	**Davidson Creek:** Reaches 8 - 12 under footprint **Davidson Creek**: Reaches 1-7.1 downstream of TSF **Davidson Creek tributaries**: 1) Creek 636713; 2) Creek 668328; 3) Creek 704454 Lake 01682LNRS **Creek 661**: downstream of Reach 5 **Creek 661 tributaries**: Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; adult summer foraging; overwintering **Kokanee**: spawning/egg incubation
	Wetland and Water Management System, Freshwater Reservoir	Construction of water management system (site surface drainage management, erosion and sediment control, water recovery and recycle system from TSF)	**Direct Effects**: 1) mortality of fish in streams under dams for environmental control pond and freshwater reservoir; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under environmental control pond and dam **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek:** Reach 8 **Davidson Creek**: downstream of Reach 8 including Reach 7.1	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation
	Borrow areas	Development of borrow sites (Site C main dam, esker borrow source and sand and gravel screening plant)	**Direct Effects**: 1) mortality of fish in streams under Site C dam; 2) mortality of fish stranded in streams directly downstream of work areas; 3) stranding of fish upstream of Site C dam; 4) permanent alteration or destruction of fish habitat under Site C dam **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Davidson Creek:** Reach 11 **Davidson Creek**: Reach 10 downstream of Site C dam	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering

Phase	Mine site component	Proposed work, undertaking or activity	Potential Effects	Streams and Lakes Affected	Fish species and life stages
Operations	Site Infrastructure and Site Roads	Worker accommodations operation, hazardous materials management (waste, explosives, spills), camp and offices waste management	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under site infrastructure and roads; 2) mortality of fish due to hydrocarbon spills **Indirect Effects:** 1) changes in downstream water quality due to sewage effluent, spills, and erosion; 2) reduction in downstream flows	**Davidson Creek tributaries:** 1) Creek 704454; 2) Creek 704454 tributaries **Creek 661:** downstream of Reach 5 **Creek 661 tributaries:** 1) Creek 505659; 2) Creek 146920; 3) Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Mine Pit	Drill, blast, excavate, transport ore	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under the mine pit; 2) mortality of fish in streams due to blasting	**Davidson Creek tributaries:** Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Ore Processing Area	Process area operations	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent alteration or destruction of fish habitat under ore processing area **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** Creek 704454 and Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Waste Rock Areas	Mine waste rock dump placement	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent alteration or destruction of fish habitat under waste rock areas **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) change in downstream water quality due to waste rock run-off; 3) reduction in downstream flows	**Davidson Creek tributaries:** Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	TSF	TSF ongoing development and operations	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream 2) permanent isolation of fish upstream; 3) permanent alteration or destruction of fish habitat under TSFs **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows; 3) changes in downstream water quality due to TSF seepage	**Davidson Creek:** Reaches 8, 9, 10, 11, and 12 under footprint **Davidson Creek**: Reaches 1-7.1 downstream of TSF **Davidson Creek tributaries**: 1) Creek 636713; 2) Creek 668328; 3) Creek 704454 **Lake 01682LNRS** **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; adult summer foraging; overwintering **Kokanee**: spawning/egg incubation
	Wetland and Water Management System, Freshwater Reservoir	Water management system operation and maintenance	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent alteration or destruction of fish habitat under environmental control pond and dam **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek:** Reaches 8 **Davidson Creek**: downstream of Reach 8 including Reach 7.1	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation
	Borrow areas	Operate sand and gravel screening equipment. Excavate and transport material	**Direct Effects**: permanent alteration or destruction of fish habitat under Site C dam **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Davidson Creek:** Reach 11 **Davidson Creek**: Reaches 10 downstream of Site C dam	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
Closure	Site Infrastructure and Site Roads	Decommission, dismantle and remove equipment (conveyors, crusher, warehousing, fuel storage, truck stop), reclaim areas of soil contamination, implement reclamation plan (grade and level site, implement erosion and sediment control features and spread overburden and topsoil)	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under site infrastructure and sites roads; 2) mortality of fish due to spills of hydrocarbons **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** 1) Creek 704454; 2) Creek 704454 tributaries **Creek 661:** downstream of Reach 5 **Creek 661 tributaries:** 1) Creek 505659; 2) Creek 146920; 3) Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Mine Pit	Construct rock safety berm, spillways, and channel to TSF, overburden in bench flats, fertilize pit water while filling if required	**Direct Effects**: permanent alteration or destruction of fish habitat under the mine pit **Indirect Effects**: none	**Davidson Creek tributaries:** Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering

Phase	Mine site component	Proposed work, undertaking or activity	Potential Effects	Streams and Lakes Affected	Fish species and life stages
	Ore Processing Area	Decommission, dismantle and remove equipment	**Direct Effects**: permanent alteration or destruction of fish habitat under ore processing area Indirect Effects: none	**Davidson Creek tributaries:** Creek 704454 and Creek 704454 tributaries **Creek 661 tributaries:** Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Waste Rock Areas	Re-grade, construct drainage control swales, cover, and re-vegetate	**Direct Effects**: permanent alteration or destruction of fish habitat under waste rock areas **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	**Davidson Creek tributaries:** Creek 704454 tributaries **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 543585	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	TSF	Area C: Remove pumps/pipelines, cover, wetland and upland beach revegetation, outlet connection, reseed downstream slope, and decommission seepage sump Area D: Pump supernatant and Tatelkuz Lake water to pit, construct spillways, cover, deflector berm, outlet connection,	**Direct Effects**: 1) permanent isolation of fish upstream; 2) permanent alteration or destruction of fish habitat under TSFs **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows; 3) changes in downstream water quality due to TSF seepage	**Davidson Creek:** Reaches 8, 9, 10, 11, and 12 under footprint **Davidson Creek**: Reaches 1-7.1 downstream of TSF **Davidson Creek tributaries**: 1) Creek 636713; 2) Creek 668328; 3) Creek 704454 **Lake 01682LNRS** **Creek 661**: downstream of Reach 5 **Creek 661 tributaries:** Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; adult summer foraging; overwintering **Kokanee**: spawning/egg incubation
	Wetland and Water Management System, Freshwater Reservoir	Monitor water quality	**Direct Effects**: permanent destruction of fish habitat under ECD dam and permanent alteration of fish habitat within ECD pond **Indirect Effects:** none	**Davidson Creek:** Reach 8	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Borrow areas	Re-grade, cover, and re-vegetate	**Direct Effects:** none **Indirect Effects**: none	n/a	n/a
Post-closure	Site Infrastructure and Site Roads	Monitor reclamation	**Direct Effects:** none **Indirect Effects**: none	n/a	n/a
	Mine Pit	Discharge pit water overflow to TSF	**Direct Effects:** none **Indirect Effects**: none	n/a	n/a
	Ore Processing Area	Monitor reclamation	**Direct Effects:** none **Indirect Effects**: none	n/a	N/a
	Waste Rock Areas	Monitor reclamation	**Direct Effects:** none **Indirect Effects**: none	n/a	N/a
	TSF	Discharge TSF overflow to Davidson Creek; Monitor reclamation of TSF dams and interior wetlands	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under TSF dams and within TSFs; 2) permanent isolation of habitat upstream of TSFs **Indirect Effects**: 1) changes in downstream water quality due to release of TSF supernatant; 2) changes in downstream water temperature due to release of TSF supernatant	**Davidson Creek:** Reaches 8, 9, 10, 11, and 12 under footprint **Davidson Creek**: Reaches 1-7.1 downstream of TSF Site D **Davidson Creek tributaries**: 1) Creek 636713; 2) Creek 668328; 3) Creek 704454 **Lake 01682LNRS** **Creek 661 tributaries:** Creek 505659	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; adult summer foraging; overwintering **Kokanee**: spawning/egg incubation
	Wetland and Water Management System, Freshwater Reservoir	Fill seepage ponds and ditches, and re-vegetate ECD and Water Reservoir: Breach dams and construct rip-rap channel, re-grade dams, re-vegetate, reshape basins and wetlands for seepage treatment. Monitor water quality	**Direct Effects**: permanent destruction of fish habitat under ECD dam and permanent alteration of fish habitat within ECD pond **Indirect Effects:** none	**Davidson Creek:** Reach 8	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Borrow areas	Monitor reclamation	**Direct Effects:** none **Indirect Effects**: none	N/a	n/a

4.2.1 Construction Phase

Unmitigated, potential serious harm to fish during the construction of the mine site infrastructure includes:

- Permanent alteration or destruction of fish habitat in streams under the footprints of site infrastructure and site roads, the open pit, the ore processing area, the TSF, the wetlands and water management systems, and the borrow areas;
- Direct mortality of fish in streams that will be lost under the footprints of these mine site facilities;
- Direct mortality of fish in streams that will be dewatered downstream of these mine site facilities;
- Direct mortality of fish in streams trapped upstream of these mine site facilities where upstream habitat is insufficient to meet all of their life history stages;
- Reductions in the growth, survival, and recruitment of fish due to changes in downstream water quality from elevated suspended sediment concentrations; and
- Reductions in the growth, survival, and recruitment of fish due to reductions in downstream flow.

Each of these potential unmitigated effects is described in the sections below.

4.2.1.1 Permanent Alteration or Destruction of Fish Habitat

Site Infrastructure, Site Roads, Open Pit, Ore-processing Area, and Waste Rock Dumps

Site infrastructure, including the fuel site, warehouses and materials storage buildings, administrative buildings, construction lay-down area, truck stop, explosives facility, construction camp and maintenance buildings, camp land-fill and domestic sewage system, haul roads, and ore-processing facilities (i.e., plant site, mill and processing area, core logging area, crusher and conveyor) and the low-grade ore stockpile will be located in the headwaters of the Davidson Creek and Creek 661 Watersheds. Construction of these facilities will require clearing and grading of land, preparation of foundations, and where these facilities will over-lie streams, the streams will be dammed, diverted or dewatered and eventually covered with fill as foundations for these buildings, lay-down areas, and rock storage areas. These streams will be permanently lost and include headwater portions of:

- Creek 704454 and its tributaries in the Davidson Creek Watershed;
- Creek 505659 and its tributaries in the Creek 661 Watershed; and
- Creek 146920 and its tributaries in the Creek 661 Watershed.

The mine pit area will be stripped of top-soil and over-burden during the construction phase. Similarly, the footprints of the future west and east waste rock dumps will be stripped of top-soil and the foundations will be prepared by adding fill to these areas as necessary. Streams within the footprints of the open pit and two waste rock facilities that will be permanently lost include:

- Headwater tributaries of Creek 704454 in the Davidson Creek Watershed;
- The Creek 704454 mainstem; and
- Headwater portions of Creek 543585 in the Creek 661 Watershed.

Tailings Storage Facility

The TSF will be constructed using a staged approach. TSF Site C will be constructed first and will be used to provide mine tailings disposal during the first two years of operations. The TSF Site C dam will be located in the middle of Reach 10 in Davidson Creek. The subsequent pond behind this dam will flood the upper portions of Reach 10 as well as Reach 11 of Davidson Creek. A second dam, Site C West Dam, will be built at the top of Reach 11 during the construction phase. The purpose of this dam is two-fold: to prevent tailings supernatant in the Site C TSF from flowing to Lake 01682LNRS and to back-flood Reach 12 of Davidson Creek so that the outflow of Lake 01682LNRS diverts to Lake 01538UEUT in the adjacent Creek 705 watershed.

Construction of the larger TSF Site D will commence during early operations and will be used to capture upstream run-off to submerge tailings and a source of mill process water and to provide long-term storage of mine tailings for the remaining 15 years of mining. The TSF Site D dam will be centred in Reach 9 of Davidson Creek and will back-flood the upper half of Reach 9 and the lower half of Reach 10 of Davidson Creek upstream to the base of the TSF Site C dam. The TSF Site D dam will also extend to the north and south of Davidson Creek and will intercept and flood six Davidson Creek tributaries including Creek 668328, Creek 636713, and the lower reaches of Creek 704454 as well as the upper reaches of Creek 505659 in the Creek 661 Watershed.

In addition to these streams under the Site C and Site D TSF dams or within their tailings impoundment areas, habitat downstream will also be permanently affected by construction of the TSF. Habitat in Reach 8 of Davidson Creek immediately downstream of the TSF Site D dam will be completely dewatered once construction of the dam begins. This effect will continue throughout operations, closure into post-closure phases.

Upstream of the TSF Site D, habitat in the upper reaches of Creek 668328 will be isolated from habitat in Davidson Creek downstream. Habitat in Lake 01682LNRS will also be isolated from habitat in Davidson Creek with construction of the Site C West dam.

The rainbow trout population in Lake 01682LNRS is expected to persist throughout the mine life and beyond. This is because the lake will be enlarged by the back-flooding of Reaches 11 and 12 of Davidson Creek by the Site C West Dam which will allow the lake to be connected to Lake 01538UEUT in the adjacent Creek 705 Watershed. These two lakes will be connected by construction of a new connector channel. This channel will allow water from Lake 01682LNRS to

flow to Lake 01538UEUT, will allow fish from both lakes to mix, and will provide rainbow trout in Lake 01682LNRS with access spawning habitat in the Lake 01538UEUT outlet. Lake 01538LNRS is known to support populations of rainbow trout and longnose sucker.

Wetland, Water Management System, and Freshwater Reservoir

This mine component includes the water recovery and recycle system from the TSF but also includes mitigation measures necessary to reduce erosion and control sediment, to manage site contact run-off and groundwater seepage, and to improve downstream water quality and flow. From a footprint perspective, the two main facilities included in this category are the ECD and pond and the freshwater reservoir portion of the FSS.

Both the ECD and the freshwater reservoir will be located in the Davidson Creek mainstem downstream of the TSF Site D dam. The ECD will be located in the middle of Reach 7.1 and will back-flood the upper half of Reach 7.1 and the lower half of Reach 8. The dam for the freshwater reservoir will be located at the top of Reach 6 and will back-flood all of Reach 7 and the lower half of Reach 7.1 upstream to the ECD.

Borrow Areas

The main borrow area downstream of the TSF Site D dam is located on land between Davidson Creek and its tributary Creek 428073. No fish habitat will be permanently lost or altered during its development and operation.

The borrow area at the TSF Site C dam area will used prior to construction of the TSF Site C dam. This area at the top of Reach 11 of Davidson Creek has already been described above and is not repeated here.

4.2.1.2 Direct Mortality of Fish in Streams of Under, Upstream, or Downstream of Mine Site Facilities

Without fish salvage, rainbow trout will be killed in all streams that will need to be dammed, diverted, and filled with rock during construction of the various mine site facilities. Similarly, without fish salvage, rainbow trout in Reach 8 of Davidson Creek will be stranded in the creek channel as it is gradually dewatered during construction of the TSF Site D dam. Finally, it is expected that rainbow trout in Creek 688328 and Creek 704454 upstream of the TSF will eventually be extirpated. This is because the amount and quality of habitat in these creeks upstream of the TSF is too small and too low to support self-sustaining rainbow trout populations. The absence of pools with sufficient depth and winter flow to avoid freezing to the bottom and to provide sufficient dissolved oxygen for trout is the habitat likely most limiting the ability of these fish to survive beyond one or two years.

4.2.1.3 Reduction in Fish Growth, Survival, and Recruitment due to Elevated Suspended Sediment Concentrations

Construction of the various mine site facilities includes a number of activities that have the potential to erode instream and upland sediments and to increase TSS concentrations and sedimentation in streams downstream of the project. These activities include clearing and grading, topsoil salvage, soil storage, preparation of facility foundations, and construction of dams, diversion channels, and water storage ponds.

Increased TSS concentrations may affect the growth and survival of rainbow trout directly by impairing gill respiration, decreasing feeding efficiency (rainbow trout are visual feeders), and decreasing gas exchange in incubating eggs. Increased TSS concentrations may affect rainbow trout indirectly by altering the density, diversity, and drift of BMI. When these sediments drop out of suspension in lower gradient, slower flow areas such as pools and glides, they fill interstitial spaces between spawning gravels and cover fish eggs. If the volume of sediment is high enough, the exchange of gases between the eggs and the surrounding water is reduced leading to higher egg mortality rates. Rainbow trout and BMI can tolerate elevated TSS concentrations for short periods but adverse direct and indirect effects can occur if TSS concentrations are high, elevated frequently or persist for years. Multiple years of high TSS concentrations can lead to successive year class failures, lower annual recruitment rates, and eventually the extirpation of local fish populations.

Without mitigation, potential negative effects to rainbow trout due to elevated suspended sediment concentrations could occur in Davidson Creek downstream of the TSF Site C dam, the TSF Site D dam, the ECD, and below the freshwater reservoir dam. They may also occur in Creek 704454 downstream of the West Waste Rock Dump, the open pit, construction lay-down area, low-grade stockpile, and plant site.

In the Creek 661 Watershed, this potential effect could occur in Creek 505659, Creek 146920, and Creek 543585. The downstream extent of this potential effect will be dependent on the amount of sediment mobilized by heavy machinery in and near these streams and the volume of natural run-off occurring during construction. Conceivably, these effects could be experienced by fish down to the mouths of Davidson Creek and Creek 661 and into Chedakuz Creek downstream without mitigation.

4.2.1.4 Reduction in Fish Growth, Survival, and Recruitment due to Reductions in Downstream Flow

Reduction of stream flow in Davidson Creek downstream of the mine site facilities will not occur during the construction phase for two reasons. First, all run-off from the Davidson Creek catchment area upstream of each of the four dams that will be built (i.e., TSF Site C Dam, TSF Site C dam, ECD, and freshwater reservoir dam) will be diverted around the construction sites by coffer dams, diversion channels or pumps. This will allow construction of each of these dams “in-the-dry” and will maintain flows downstream. Second, once the TSF Site D dam is completed and beginning to store upstream run-off, the FSS will be operational and, therefore, providing water from Tatelkuz Lake to augment flows in middle and lower Davidson Creek. Water from the

freshwater reservoir will be discharged to Davidson Creek to meet instream flow requirements for rainbow trout and kokanee during the various biological stanzas important to both species (for details refer to **Appendix 5.1.2.6D** of the Application). **Table 4-3** shows the potential reduction in watershed areas in Davidson Creek due to construction of the TSF. Those reductions in area are reasonable proxies for the potential flow reductions that will occur in middle and lower Davidson Creek without the FSS.

Table 4-3: Estimated Change in the Davidson Creek Watershed Area, by Mine Phase, without Operation of the Freshwater Supply System

Location		Confluence	FSR Crossing	Below TSF
Reaches		**Reach 1-3**	**Reach 4-5**	**Reach 6**
Hydrology Node		**1-DC**	**H4B**	**H2**
Baseline	km^2	76.2	61.4	44.4
Construction	km^2	64.7	49.8	32.8[2]
	% Change	-15%	-19%	-26%
Operations (Year +17)	km^2	31.9	17.0[1]	0.0
	% Change	-58%	-72%	-100%
Closure	km^2	34.8	20.0	5.7
	% Change	-54%	-67%	-87%
Post-Closure (Year +45)	km^2	79.5	64.7	5.7
	% Change	+4%	+5%	-87%

Note: TSF = tailings storage facility; % Change = percent change relative to baseline catchment area
[1] catchment area decreased by area upstream of ECD; [2] assumes all surface water upstream of the Site C dam is captured.

A similar flow augmentation system is not proposed for Creek 661 as part of the Project. Thus, flow reductions in the Creek 661 mainstem and in its headwater tributaries downstream of the East Waste Rock Dump (i.e., Creek 146920), the construction camp (i.e., Creek 543585), and the plant site and TSF Site D (i.e., Creek 505659) will occur immediately following diversion of water from these streams to the TSF. Flows in these streams are assumed to be reduced by the run-off volume corresponding to the upstream watershed areas lost under and upstream of these facilities (**Table 4-4**).

Rainbow trout and kokanee spawn in the lower three reaches of Creek 661. Rainbow trout are also known to use habitat higher up in the watershed for spawning, rearing, and foraging. These include Reach 4 and 5 of Creek 661 as well as the lower reaches of Creek 543585, Creek 146920, and Creek 505659.

Table 4-4: Estimated Change in the Creek 661 Watershed Area during each Mine Phase

Location		Creek 661 Confluence	Creek 661 (D/S Creek 505659)	Creek 505659 Confluence
Reaches		**Reach 1-3**	**Reach 4**	**Reach 1-4**
Baseline	km^2	56.3	23.4	14.5
Construction	km^2	55.6	22.7[(1)]	14.0
	% Change	-1%	-3%	-3%
Operations (Year 17)	km^2	51.3	18.5	9.6[(2)]
	% Change	-9%	-21%	-34%
Closure	km^2	50.1	17.3	8.4[(3)]
	% Change	-11%	-26%	-42%
Post-Closure	km^2	50.1	17.3	8.4
	% Change	-11%	-26%	-42%

Note: % Change = percent change relative to baseline catchment area; U/S = upstream
[(1)] catchment area decreased due to routing of water to surface collection pond;
[(2)] catchment area decreased by area contributing to open pit;
[(3)] catchment area decreased by area lost to the TSF spillway

Reductions in flow can reduce the quantity and quality of habitat used by fish for spawning, rearing, foraging, and overwintering. Stream-spawning fish species, such as rainbow trout and kokanee, have specific criteria for selection of spawning sites. These sites typically provide a specific combination of water depth, water velocity, up-welling (i.e., flow of water up through the gravels), and substrate size and shape. Reductions in flow during the spring (rainbow trout) or summer-fall (kokanee) spawning periods can reduce the depth and velocity of water in the stream and reduce the amount of upwelling occurring in areas where these fish species typically spawn (e.g., pool tail-outs and glides). If the flow reductions occur after spawning, eggs can be stranded and desiccated. Lower flows in summer and winter will reduce the total amount of habitat available to juvenile and rainbow trout fry, reduce the volume and area of pools where these fish prefer to reside, and lower the concentration of dissolved oxygen in the water.

4.2.2 Operations Phase

Permanent alteration or destruction of fish habitat under site infrastructure and site roads, the mine pit, ore-processing area, waste rock areas, TSF, and borrow areas on fish and fish habitat are the same during operations as they are during construction. This is because the description provided for the construction phase above was for the maximum project footprint, something that actually does not occur until Year 17 of mining. For this reason, potential effects to fish and fish habitat under, upstream and downstream of these mine site facilities are not repeated here.

The only additional potential effects to fish and fish habitat that could occur during mining and operation of the mine site facilities, that were not discussed already for the construction phase or that are different than those discussed for the construction phase, are:

- Direct mortality of fish due to spills of hazardous materials (e.g., cyanide, diesel, oil);

- Direct mortality of fish due to blasting in the mine pit;
- Reductions in the growth, survival, and recruitment of fish due to changes in water quality from TSF seepage; and
- Reductions in the growth, survival, and recruitment of fish due to further reductions in downstream flow in Creek 661.

The nature and scope of adverse effects is less during Operations compared with Construction because all of the dams in Davidson Creek will be built and all of the waste rock dumps, open pit, camps and other building at the plant site and ore-processing facilities will be prepared or built during the construction phase. Also, the ECD and FSS will be fully operational during Operations, effectively eliminating potential sediment releases and flow reductions in Davidson Creek. Each of the potential "new" effects to fish and fish habitat during Operations are described below.

4.2.2.1 Direct Mortality of Fish due to Spills of Hazardous Materials

Acute and chronic affects to fish from spills of hazardous materials such as ammonium nitrate (a component of the ANFO explosives), cyanide, and hydrocarbons such as diesel fuel, oils and hydraulic fluid may occur during mine operations. This potential effect is most likely to occur in and around the ore-processing facilities and site facilities and site roads. Streams downstream of these facilities and roads include Creek 704454 in the Davidson Creek Watershed and Creek 505659 in the Creek 661 Watershed.

Acute effects of these spills could include the direct mortality of individual fish, reproductive deformities, egg loss, and damage to internal organs (e.g., liver) and gills. Chronic effects could include sub-lethal damage to internal and external organs, scales, fins, and gills as well as reduced egg viability and fecundity in females. These effects could ultimately reduce the growth, survival, health, and reproductive fitness of individual fish.

4.2.2.2 Direct Mortality of Fish due to Blasting in the Mine Pit

No fish will be killed by blasting in the open pit because:

- Any fish in the headwater tributary of Creek 704454 that drains the pit area will have already been affected by the diversion, damming and filling of the stream during stripping of top-soil and overburden;
- The likelihood of any fish being in Creek 704454 after construction is low given that this creek will have been isolated from habitat in Davidson Creek and diverted to the TSF during construction; and
- The distance between the open pit and the closest fish-bearing stream not already dewatered or destroyed during construction is at least 1.5 km away which is at least 10 times further than the federal guidelines for minimum set-back distances to prevent damage or mortality of fish and fish eggs when blasting solid rock (Wright and Hopky, 1998).

4.2.2.3 Reduction in Fish Growth, Survival, and Recruitment due to Changes in Water Quality from TSF Seepage

Mine effluent stored in the TSF will not be released to the downstream receiving environment during mine operations. Instead, this water will be recycled and re-used in the mill and ore processing system. This will include water stored behind the TSF Site C dam during the first two years of mining and water stored behind the TSF Site D dam during the final 15 years of mining.

Mine effluent stored in the TSF Site C will not seep into Lake 01682LNRS. This will not occur because the Site C West Dam will be built prior to the TSF Site C reaching its maximum water elevation. This dam will form a partial barrier to seepage but, more importantly, will back-flood Reach 12 of Davidson Creek high against the upstream face of the dam to create a hydraulic gradient that will cause water to flow towards the TSF and prevent TSF supernatant from flowing towards Lake 01682LNRS.

Despite efforts to limit, capture, and pump-back seepage below the TSF Site D dam, approximately 2 L/sec, or 4% of all seepage, is conservatively predicted to be unrecoverable. Depending on the concentration of various water quality parameters in this seepage and the volume of water it mixes with downstream, this seepage could create acute or chronic toxicity effects to rainbow trout and kokanee in lower Davidson Creek. This will include any water quality parameter whose concentrations would exceed provincial or federal water quality guidelines or water quality parameters whose increased concentrations could synergistically interact with another elevated water quality parameter. For example, aluminum toxicity is positively correlated to pH; the higher the pH of water the greater the concentration of potentially toxic forms of aluminum (e.g., Al^{3+}). Conversely, the opposite circumstance may also occur when the elevated concentrations of two antagonistic parameters (e.g., aluminum and fluoride) lowers the potentially toxic effect of one or both parameters.

4.2.2.4 Reduction in Fish Growth, Survival, and Recruitment due to Reductions in Downstream Flow

The watershed area above the mouth of Creek 505659 is estimated to decrease by 34% during operations from 3% during construction (**Table 4-4**). In Creek 661 downstream of the confluence of Creek 505659, the upstream watershed area is predicted to decrease by 21% compared to 3% during construction. This larger watershed reduction in the Creek 661 Watershed during operations compared to construction is due to the diversion of water in upper Creek 505659 to the TSF and to the greater draw-down of groundwater due to expansion of the open pit. At the mouth of Creek 661, the combined effect of all mine site infrastructure in the upper watershed is a 9% decrease during operations compared to only a 1% decrease during construction.

The potential effect to rainbow trout using the Creek 661 Watershed for spawning, rearing, foraging, and overwintering and to kokanee using the lower reaches of the Creek 661 mainstem for spawning will be the same as it will during the construction phase but of greater magnitude.

4.2.3 Closure/Decommissioning Phase

Closure/Decommissioning phase activities will be focused on reclaiming disturbed land, re-contouring waste-rock areas and tailings dams and covering these areas with overburden so it can be re-vegetated. Water management closure/decommissioning activities, such as creation of wetlands in the ECD pond and in the TSF, pumping and diverting water from the TSF to the open pit, continued pumping of seepage below the TSF dam back to the TSF, and continued operation of the FSS to maintain flows in Davidson Creek and to help fill the pit, are all mitigation measures that will minimize or prevent effects to fish and fish habitat downstream.

Therefore, the only difference between potential effects to fish and fish habitat during the closure/decommissioning and those that could occur during the construction and operations phases is the larger reduction in flows in Creek 505659 and, therefore, Creek 661 due to the construction of the TSF spillway. This flow reduction will occur because the spillway will encroach into the upper Creek 505659 watershed and divert water from Creek 505659 to Davidson Creek. The potential effect of this further reduction in flow on rainbow trout is similar to that already described for the construction phase and is not repeated here.

4.2.4 Post-Closure Phase

Post-closure phase activities are focused on monitoring closure reclamation. None of these activities will negatively affect fish or fish habitat. However, two other activities will also occur during post-closure that could affect fish and fish habitat.

First, water from the TSF will be discharged to Davidson Creek via the over-flow spillway built during the closure phase. This water will be a mixture of TSF supernatant and water from the open pit which will begin to flow into the TSF via a spillway constructed between the two once the pit is full.

The quality of this water will be gradually improved over the closure and post-closure periods by the wetlands constructed in the TSF during the closure phase. Because this water will not be released to Davidson Creek until it meets site-specific water quality objectives for the protection of aquatic life, potential effects to fish and other aquatic biota are expected to be negligible. However, as with seepage below TSF Site D dam during operations, any incremental increase in any water quality parameter whose baseline concentrations are already above provincial or federal water quality guidelines or whose increased concentration could synergistically interact with another elevated water quality parameter could pose an acute or chronic toxic effect to fish.

The second activity that will occur during the post-closure phase that could affect fish and fish habitat is the decommissioning and reclamation of the water management system. This will include the decommissioning of the ECD pond and freshwater reservoir. Filling the seepage ponds and diversion ditches, breaching the ECD and freshwater reservoir dam, and reshaping the basins in preparation for establishing “polishing” wetlands, has the potential to re-mobilize sediments and increase TSS concentrations in Davidson Creek downstream. In particular, breaching the ECD and freshwater reservoir dam could allow release of sediments trapped in

their upstream ponds during mine operations and closure. The potential effects of these sediment releases on fish and fish eggs have been described above and is not repeated here.

4.2.5 Summary of Potential Unmitigated Effects to Fish and Fish Habitat due to the Mine Site

Table 4-5 shows the total amount of fish habitat that would be permanently altered or destroyed under each of the mine site facilities, downstream of the TSF, waste rock dumps, site infrastructure and water management systems, and permanently isolated upstream of the TSF. **Table 4-6** shows the total amount of different habitat types and classes that would be permanently altered or destroyed in the Davidson Creek and Creek 661 Watersheds under, downstream, or upstream of the various mine site facilities. Totals in both of tables reflect the spatial areas potentially lost or altered prior to mitigation not included in the Project Design. Both tables exclude habitat in Lake 01682LNRS upstream of the TSF and habitat in Davidson Creek downstream of the freshwater reservoir.

Potential losses of fish habitat in this lake and in lower Davidson Creek are assumed to be mitigated by the Lake 01682LNRS diversion and operation of the FSS, respectively, which are components of the Project. Similarly, potential flow reductions in Creek 661 are also excluded from this table. This is because, even if it is assumed that all flow in the two headwater creeks (Creek 505659 and Creek 146920) is lost, the resulting reduction in flow in Creek 661 would be small due to attenuation from the remaining Creek 661 Watershed that would not be affected by the Project. **Figure 4-1** shows the location of these different types of permanent alteration or destruction of fish habitat in the Davidson Creek and Creek 661 Watersheds.

Without mitigation, the total spatial area that will potentially be lost or altered by the Project is estimated to be 381,344 m^2. Based strictly on spatial area, most of the potentially affected habitat (220,126 m^2 or 58% of the total) will be associated with the downstream flow changes in Davidson Creek (31,022 m^2) and the assumed reduction in fish access to wetlands (171,163 m^2) and tributary streams (17,941 m^2) in Davidson Creek tributaries below the TSF.

The second largest component of the potential fish habitat loss resulting from the Project, without mitigation, will be from the mine site facilities footprint. The total habitat areas lost, under the mine site facilities, and within the areas potentially subject to the deposit of deleterious mine tailings in the Davidson Creek Watershed (TSF, waste rock dump and low-grade ore stockpile footprints), are estimated to be approximately 52,283 m^2 and 58,129 m^2, respectively (**Table 4-6**). About 36% of this total loss is lower quality habitat the upper headwater tributaries.

Upstream habitat will account for 25,076 m^2 or 7% of the total potential loss (**Table 4-6**). The inclusion of Lake 01682LNRS (91,860 m^2) to the total upstream habitat would bring it to 116,936 m^2. This would make isolated upstream habitat the second largest component of the potential fish habitat loss resulting from the Project. This would cause upstream habitat to increase to 20% of the grand total.

Table 4-5: Potential Permanent Alteration or Destruction of Fish Habitat, by Stream and Reach, due to the Mine Site

Impact Type		Upstream Habitat Isolation	Downstream Flow Changes	Mine Site Facilities Footprint	TSF Footprint	Waste Rock Dumps	Total Area
Stream	**Reach**	**m^2**	**m^2**	**m^2**	**m^2**	**m^2**	**m^2**
Davidson	1 - 6	0	31,020	0	0	0	31,020
	6	0	0	9,391	0	0	9,391
	7	0	0	1,154	0	0	1,154
	7.1	0	0	4,415	0	0	4,415
	8	0	0	6,662	0	0	6,662
	9	0	0	3,880	2,215	0	6,095
	10	0	0	286	16,342	0	16,628
	11	0	0	105	1,646	0	1,751
	12	1,872	0	91	0	0	1,963
	tributaries	3,943	189,106	4,917	3,287	0	201,253
Creek 636713	1	0	0	1,854	0	0	1,854
	2	0	0	10,772	0	0	10,772
	3	0	0	279	1,702	0	1,981
	4	0	0	0	465	0	465
	5	901	0	364	504	0	1,770
	tributaries	0	0	658	1,502	0	2,160
Creek 668328	1	0	0	0	6,376	0	6,376
	2	3,768	0	0	1,491	0	5,259
	3	1,436	0	0	0	0	1,436
	4	1,362	0	0	0	0	1,362
	tributaries	4,091	0	0	0	0	4,091
Creek 704454	1	0	0	0	3,528	0	3,528
	2	0	0	0	3,158	0	3,158
	3	0	0	0	667	0	667
	4	0	0	2,095	1,585	0	3,681
	5	0	0	2,879	0	2,879	5,759
	6	0	0	0	0	3,605	3,605
	7	790	0	0	0	0	790
	tributaries	6,913	0	2,480	0	7,175	16,568
Davidson Cr. Watershed Total		**25,076**	**220,126**	**52,283**	**44,469**	**13,660**	**355,613**

Continued…..

Impact Type		Upstream Habitat Isolation	Downstream Flow Changes	Mine Site Facilities Footprint	TSF Footprint	Waste Rock Dumps	Total Area
Creek 505659	1	0	1,951	0	0	0	1,951
	2	0	1,333	0	0	0	1,333
	3	0	3,144	0	0	0	3,144
	4	0	411	0	0	0	411
	5	0	2,218	3,624	0	0	5,842
	6	0	0	1,137	129	0	1,266
	7	0	0	1,022	115	0	1,137
	tributaries	0	0	447	749	0	1,196
Creek 146920	1	0	3,265	2,907	0	0	6,172
	2	0	0	2,256	0	86	2,342
	3	0	0	0	0	938	938
	4	0	0	0	0	0	0
	5	0	0	0	0	0	0
Creek 661 Watershed Total		**0**	**12,322**	**11,393**	**993**	**1,023**	**25,731**

Note: TSF = tailing storage facility, m^2 = square metres. Includes habitat lost in Davidson Creek without FSS; includes stream and wetland area in tributaries to lower Davidson Creek assumed to be inaccessible to fish due to flow reductions in Davidson Creek; excludes habitat in Lake 01682LNRS.

Table 4-6: Potential Unmitigated Habitat Area Lost, by Habitat Type and Class, Due to Mine Site Development

Watershed		Davidson Creek					Creek 661					Total Area by Habitat Type/Class (m^2)
Impact Type		Isolated Upstream Habitat[4] (m^2)	Downstream Flow Changes (m^2)	Mine Site Facilities Footprint[5] (m^2)	Inside TSF (m^2)	Waste Rock Dumps (m^2)	Isolated Upstream Habitat (m^2)	Downstream Flow Changes (m^2)	Mine Site Facilities Footprint[5] (m^2)	Inside TSF (m^2)	Waste Rock Dumps (m^2)	
Habitat Type	Class											
Cascade	1	0	0	1,509	1,714	0	0	0	0	0	0	3,223
Riffle	1	0	3,325[1]	38	2,186	0	0	588	0	0	0	6,137
	2	1,495	19,864[1]	13,850	7,288	0	0	1,914	0	0	0	44,411
	3	336	0	2,081	4,741	1,747	0	0	0	0	0	7,157
Glide	1	0	1,738[1]	200	11,429	0	0	2,168	0	0	0	15,535
	2	1,754	2,981[1]	9,148	3,531	0	0	1,230	0	0	0	18,645
	3	951	0	725	760	669	0	0	0	0	0	2,436
Pool	1	0	3,113[1]	2,059	2,996	0	0	0	0	0	0	8,168
	2	0	0	1,319	2,158	0	0	529	0	0	0	4,006
	3	1,104	0	28	205	464	0	0	0	0	0	1,337
Other	1	0	0	0	0	0	0	0	0	0	0	0
	2	0	171,164[2]	14,131	0	0	0	0	0	0	0	185,295
Tributary Streams	1	988	4,639[3]	2,183	1,702	4,176	0	2,218	4,761	129	0	20,796
	2	16,671	2,198[3]	4,005	3,596	6,604	0	3,676	6,632	864	86	44,331
	3	866	11,104[3]	1,006	2,162	0	0	0	0	0	938	16,077
	4	911	0	0	0	0	0	0	0	0	0	911
Total by Impact Type (m^2)[6]		**25,076**	**220,126**	**52,283**	**44,469**	**13,660**	**0**	**12,322**	**11,393**	**993**	**1,023**	**381,344**
Total by Watershed (m^2)		**355,613**					**25,731**					

Note: TSF = tailing storage facility, m^2 = square metres; [1] habitat lost in Davidson Creek without FSS; [2] wetland area in tributaries to lower Davidson Creek assumed to be inaccessible to fish due to flow reductions in Davidson Creek; [3] tributaries to Davidson Creek assumed to be inaccessible to fish due to flow reductions in Davidson Creek; [4] excludes habitat in Lake 01682LNRS; [5] includes TSF dams, [6] Totals are based on the unrounded numbers.

372000 376000 380000 384000 388000 392000

5908000 5904000 5900000 5896000 5892000

Kluskus-Ootsa FSR

Turtle Creek

Creek 700

Davidson Creek

Creek 314089

Creek 226858

NECHAKO RANGE

Tatelkuz Lake

FAWNIE RANGE

Sand and Gravel Screening Plant

Esker Borrow Source

Seepage Collection Trench

Site D Main Dam

Creek 423073

Diversion Ditches

Freshwater Reservoir

Environmental Control Dam

Creek 636713

Creek 688328

Pond 1 Site D Main Dam

Site C Main Dam

Tailings Beach

Pond 1 Site C Main Dam

Tailings Beach

Site C West Dam

Lake 01428UEUT

Lake 01538UEUT

Lake 01682LNRS

Creek 705

Creek 704454

Plant Site

Low-Grade Stockpile

West Waste Rock Dump

East Waste Rock Dump

Open Pit

Creek 505659

Creek 543585

Creek 1469201

Construction Camp

Operation Camp

Creek 661

Creek 661

Chedakuz Creek

Snake Lake

Kuyakuz Lake

Mount Davidson 1856m

Scale:1:75,000

0 0.5 1 2 3

Kilometres

Legend

- Reach Break
- Kluskus-Ootsa FSR
- Contour (25m)
- Stream
- Lake
- Watershed Boundary
- Proposed Mine Footprint
- Proposed Site Facilities
- Flow Direction
- Seepage Collection Trench

Permanently Altered or Destroyed Fish Habitat

- Upstream Habitat Isolation
- Mine Site Facilities Footprint
- Inside Tailings Impondment
- Downstream Flow Reductions

Hydrology, Surface Water and Sediment Quality, Fish and Fish Habitat

- Regional Study Area
- Local Study Area

Reference

BC Government GeoBC Data Distribution
Knight Piesold 'Year 17' Drawing May 24, 2013
AMEC 2011-2012 Baseline Report Fish & Aquatic Resource

CLIENT: newgold

PROJECT: Blackwater Gold Project

Distribution of Permanently Altered or Destroyed Fish Habitat in the Davidson Creek and Creek 661 Watersheds

DATE:	ANALYST:	
May, 2014	WR	**Figure**
JOB No: VE52420	QA/QC: BM	PDF FILE: 10-100-111_DistPotFishHabLoss_v7.pdf
GIS FILE: 10-100-111_DistPotFishHabLoss_v7.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Most permanent fish habitat losses in the Creek 661 drainage occur within Creek 505659 and Creek 146920, below mine infrastructure, and downstream of flow diversions that will result in stream flow reductions expected to permanently affect habitat quantity and quality.

Potential habitat losses in the Creek 661 Watershed (25,731 m^2) are much smaller than those in the Davidson Creek Watershed (355,613 m^2). Approximately 12,322 m^2, or 48% of the total potential habitat loss in the Creek 661 Watershed, will be caused by flow downstream reductions resulting from diversion of upstream runoff to the TSF. Another 993 m^2 of habitat in the Creek 661 Watershed, all of it in Creek 505659, will be affected by the deposit of deleterious mine tailings in the TSF. This will bring the total area of habitat potentially affected by the deposit of deleterious mine tailings in the Davidson Creek and Creek 661 Watersheds to 60,145 m^2, or approximately 16% of the grand total.

4.3 Potential Effects of the Freshwater Supply System

The potential effects of the FSS include:

- Direct loss of fish and fish habitat under the freshwater reservoir in Davidson Creek;
- Direct mortality of fish impinged or entrained in the FSS intake at Tatelkuz Lake;
- Direct loss of fish habitat in Tatelkuz Lake due to the water level reductions;
- Direct loss of fish habitat at stream crossings along the pipeline and access road ROW;
- Indirect reduction in growth, survival and recruitment of fish due to loss of littoral habitat in Tatelkuz Lake resulting from water withdrawals;
- Indirect reduction in growth, survival, and recruitment of fish in lower Chedakuz Creek due to water withdrawals from Tatelkuz Lake;
- Indirect reduction in growth, survival, and recruitment of fish due to changes in downstream water quality and interruption of fish passage at stream crossings along the pipeline and access road ROW; and
- Indirect reduction in growth, survival, and recruitment of fish in Davidson Creek due to changes in downstream water quality and temperature from water released from the freshwater reservoir.

The potential unmitigated direct and indirect effects to fish and fish habitat from construction, operation, and closure of the FSS are summarized in **Table 4-6** and described in the sections below. The potential effects of the freshwater reservoir footprint were described in **Section 4.2** and are not repeated here.

4.3.1 Direct Mortality of Fish Impinged or Entrained in the FSS Intake

Two 610 mm intake pipes will be directionally drilled out into Tatelkuz Lake from the southern shore. When installed, both pipes will be at 8 to 12 m depth. During operations, fish may become impinged and die on the screens placed over the ends of these pipes when the pumps are

pulling water from the lake. Smaller fish passing through these screens may become entrained in the pipeline and pumps and die. As pumping will only begin during operations and continue throughout closure until the open pit is filled, this potential effect will only occur during the operations and closure phases of the Project.

4.3.2 Direct Loss of Fish Habitat in Tatelkuz Lake due to Water Level Reductions

Water withdrawals from Tatelkuz Lake, via the FSS, may result in the loss of littoral fish habitat around the perimeter of the lake. This will occur if the volume of water withdrawn to meet instream flow requirement in Davidson Creek, to fill the pit, and to provide make-up water in the mill is significantly greater than the monthly or annual inflow from the lake's upstream watershed.

The amount of littoral habitat potentially dewatered in any given month or any given year during operations will depend on the volume of water required to augment flows in Davidson Creek and, critically, on the natural variability in monthly and yearly run-off volumes. During closure, the amount of littoral habitat potentially dewatered will depend on the volume of water pumped to the pit, the volume of water required to augment flows in Davidson Creek and again on the natural variability in monthly and yearly run-off volumes. In wetter years, potential changes in annual lake levels will be smaller than potential changes in drier years. Similarly, potential changes in monthly lake levels during higher run-off months, such as during the spring freshet or during the fall rainy period, will be smaller than potential changes in drier months such as during the summer and winter low flow periods.

In wetter years and during wetter months, the change in littoral habitat area available to fish may be indistinguishable from baseline. However, in drier years and during drier months, changes in littoral habitat area may be lower than what will naturally occur in the lake without the FSS. The scenario when lake levels were reduced the most and when the amount of littoral habitat area dewatered will be greatest will be in a dry month during a dry year (e.g., August during a 1:50 year dry run-off).

Besides the lake level, the other driver determining how much littoral habitat will be dewatered in Tatelkuz Lake due to operation of the FSS is the lake's bathymetry. More littoral habitat will be dewatered in areas which are naturally shallow and have a shallow gradient. Less littoral habitat will be dewatered along steep shorelines. In Tatelkuz Lake, the majority of the east and west shorelines are steep and rocky. However, the north-western and south-eastern ends of the lake are shallow with sandy/gravel beaches. The north-western end is also the location for almost all of the emergent and submergent aquatic vegetation in the lake. It is at these two ends that the greatest amount of littoral habitat will be exposed during mine operations and closure phases.

Beds of aquatic vegetation in the north-western end of the lake could be reduced in size or completely eliminated if water depths necessary for their growth and survival are lowered. Alternatively, these beds could become re-established at different locations, further from shore, where the water depths are more suitable. However, this will depend on suitable substrates also being present at these locations.

4.3.3 Indirect Reduction in Growth, Survival and Recruitment of Fish due to Reduction of Littoral Habitat in Tatelkuz Lake

Littoral habitat in lakes is typically used by forage fish species (e.g., minnows) and juveniles of larger species as cover from predators and for foraging in summer. The suitability of the littoral habitat for these fish in summer is dependent on the presence and abundance of substrates big enough to hide within, the mix of substrates that provide benthic invertebrate prey, the presence and abundance of aquatic vegetation as a source of cover and as a location for finding prey, and the presence and abundance of overhanging riparian vegetation or large and small woody debris.

Some species also use littoral areas for spawning. In Tatelkuz Lake, these species include lake chub, brassy minnow, sculpin, and possibly kokanee, although this has not been confirmed. The sites selected by females of these species is species-specific. For many species, site selection is dependent on substrate size and composition (e.g., sculpin). For other species, the presence of aquatic vegetation is the primary characteristics (e.g., brassy minnow).

Use of different littoral areas by these fish for foraging and rearing will vary spatially depending on the distribution of different littoral habitat types in the lake. This use will be dependent on the spatial variability in quality and quantity of the cover, the presence and abundance of aquatic vegetation, the substrate composition, and on the density of prey and predators in the different littoral areas.

Littoral habitat use by fish will also vary temporarily within the day, between months, and between years. This is because the quality and quantity of cover, particularly aquatic vegetation, and the density and composition of benthic invertebrate prey will vary over time. It is also because littoral habitats become less important to many fish species as they grow older and become less susceptible to predators than when they are small. It is also because different species spawn at different times of the year (e.g., kokanee spawn in late summer while sculpin spawn in spring).

Because littoral habitat types are distributed differently in Tatelkuz Lake and because different fish species and life stages use different littoral habitats at different times of the day, month, and year, effects of the potential draw-down of Tatelkuz Lake due to operation of the FSS are difficult to accurately predict. However, some generalizations can be made including:

- Potential losses of shallow sandy/gravel beach areas, with and without aquatic vegetation, at the north-western and south-eastern ends of Tatelkuz Lake will likely be greater than losses of steep rocky littoral areas along the western and eastern shorelines. Therefore, species that rely more heavily on benthic invertebrates produced in sandy/gravel areas or rely more heavily on aquatic vegetation for cover, foraging areas, or for spawning will be more acutely affected;
- Species that rely more heavily on steep, rocky shorelines for rearing, foraging or spawning will likely be less affected because the area lost will be smaller, no aquatic vegetation grows along these shorelines, and because the rocky substrates along these

shorelines typically extend to at least 3 m further down, therefore providing similar habitat for these fish species in the lower lake;

- Species that rely on aquatic vegetation for rearing, foraging and spawning may be most acutely affected. This will be entirely dependent on how aquatic vegetation beds at the northwestern end of the lake adapt to the change in lake level however;
- Potential effects on rainbow trout include reduced littoral habitat for rearing juveniles and foraging adults. Adult rainbow trout are typically associated with logs and complex boulder habitat in the littoral zone (McPhail, 2007) in summer. Juveniles remain inshore during winter and early spring and, by day, are often associated with cover in the form of cobble/boulder substrates and woody debris; and
- Potential effects on kokanee include reduced littoral habitat for rearing juveniles and foraging adults.

4.3.4 Indirect Reduction in Growth, Survival, and Recruitment of Fish in Lower Chedakuz Creek due to Water Withdrawals from Tatelkuz Lake

Water withdrawals from Tatelkuz Lake during operations and closure phases may also reduce the volume of water flowing down lower Chedakuz Creek, the outlet of the lake. Any reduction in flow has the potential to negatively affect fish using lower Chedakuz Creek for spawning, rearing, foraging or overwintering. This is because any reduction in flow has the potential to reduce the quantity of habitat available, including reductions in the width of the channel and the depth of pools, but also the quality of habitat through changes in the depth and water velocity in the stream. While these changes will directly affect rainbow trout and kokanee using lower Chedakuz Creek for spawning, it could also indirectly affect the rearing and foraging of rainbow trout by reducing the density of benthic invertebrate drift. Therefore, if flow reductions are sufficient to alter the area, depth, water velocity, and lower trophic production of lower Chedakuz Creek, the potential exists that the growth and survival of rainbow trout and the annual recruitment of rainbow trout and kokanee, and likely other Tatelkuz Lake fish species, could be reduced.

Potential effects of flow reductions in Chedakuz Creek will only occur in the 800 m long section between the outlet of Tatelkuz Lake and the confluence with Davidson Creek. This is because any water withdrawn from Tatelkuz Lake by the FSS will return to lower Chedakuz Creek at the Davidson Creek confluence.

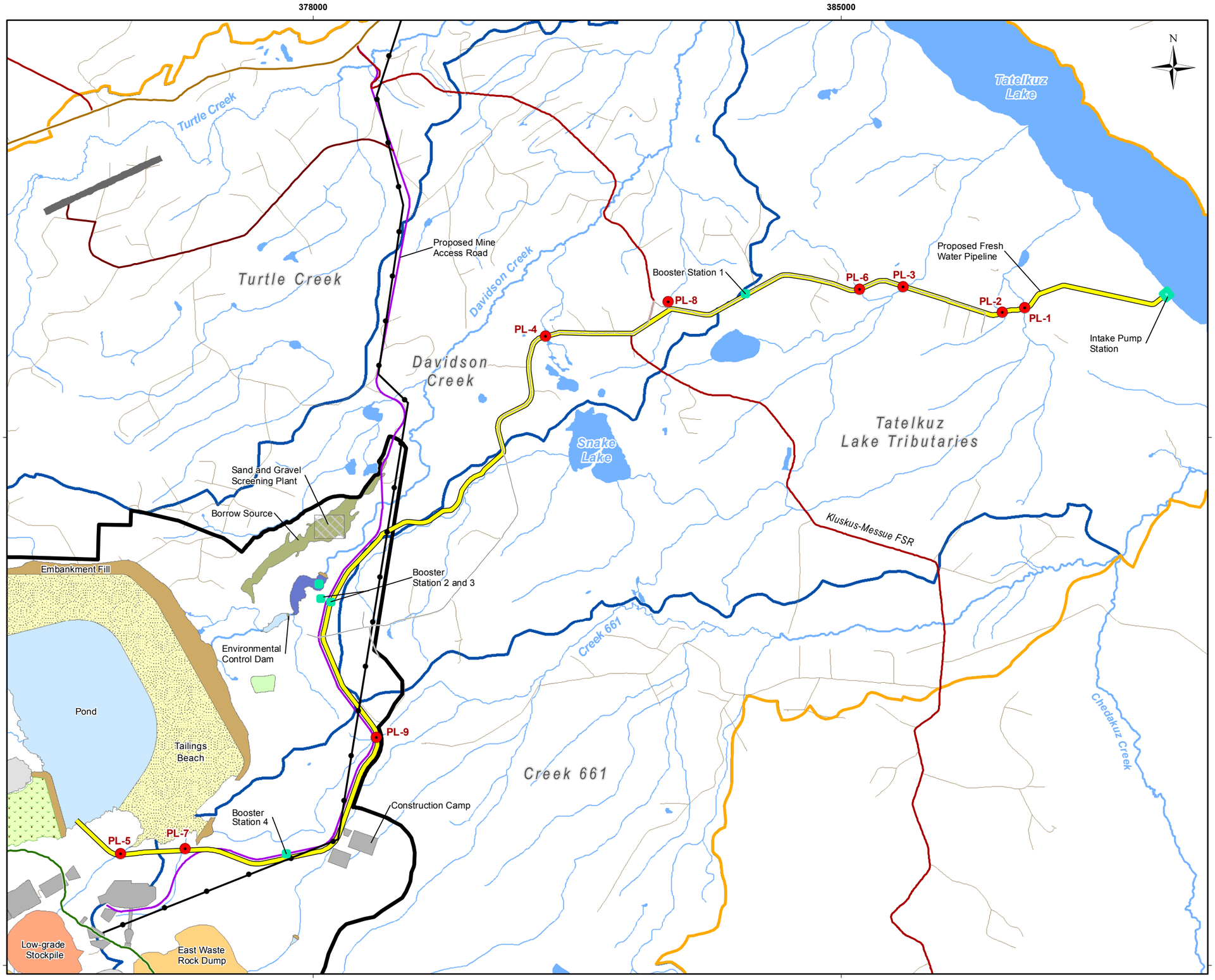
Lower Chedakuz Creek is used by most fish species residing in Tatelkuz Lake at some time during the year. In summer, this includes juvenile mountain whitefish, juvenile and adult rainbow trout, juvenile and adult longnose suckers, burbot and sculpins. In fall, kokanee are known to use lower Chedakuz Creek for spawning. Although not documented, rainbow trout, mountain whitefish, northern pikeminnow, longnose sucker, and burbot are also likely to use lower Chedakuz Creek for spawning, albeit at different times of the year.

4.3.5 Direct Loss of Fish Habitat at Stream Crossings along the Pipeline and Access Road

The total length of the FSS pipeline is approximately 28 km. In total, there are nine stream crossings along the pipeline and access road corridor (**Figure 4-2**). Seven of these nine crossings are along the 13.6 km length of pipeline from Tatelkuz Lake to the freshwater reservoir. The other two crossings are located between the freshwater reservoir and the plant site.

Potential effects to fish habitat at these stream crossings are dependent on the crossing techniques that will be used to install the pipeline and to build the access road. In the absence of mitigation measures, the proposed FSS pipeline could result in permanent or temporary alteration of fish habitat at the stream crossings through (DFO 2010a, 2010b, 2010c, 2010f, 2010g, 2010h, 2010i):

- Increased erosion and transport of sediment;
- Temporary and/or permanent loss of fish habitat if instream works or temporary ford crossings are required or if closed-bottom crossing structures are installed in fish-bearing watercourses;
- Constriction of the natural floodplain near the crossing sites due to crossing structure installations. This has the potential to increase erosion of stream sediments and increase water velocities at the crossing sites; and
- Temporary or permanent loss of riparian vegetation.



Legend

- Kluskus-Ootsa FSR
- Other FSRs
- Existing Road
- Stream
- Waterbody
- Watersheds

Project Components

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

Proposed Site Facilities

Name2

- Borrow Source
- Construction Site
- Embankment fill
- Esker Borrow Source
- Fresh Water Reservoir
- Low-Grade Stockpile
- NAG Waste Rock / Overburden
- Pond
- Tailings Beach
- Top Soil
- Upland Beach
- Sand and Gravel Screening Plant

Fish and Aquatic Resources

- Local Study Area
- Pipeline Stream Crossings
- Fresh Water Pumpstations

Scale:1:50,000

0 0.5 1 1.5

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Freshwater Supply Pipeline

DATE:	ANALYST:	**Figure** 4-2
April, 2014	KA	
JOB No: VE52095	QA/QC: MM	PDF FILE: 10-200-165_PipelineLSA_v2.pdf
GIS FILE: 10-200-165_PipelineLSA_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	

amec

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4.3.6 Indirect Reduction in Growth, Survival, and Recruitment of Fish Due to Stream Crossings along the Pipeline and Access Road ROW

Eight of the nine streams along the FSS pipeline and access road ROW are fish-bearing and are known to support rainbow trout; one is a non-visible channel (NVC) and is non-fish-bearing. Crossings PL-1 and PL-2 are located closest to Tatelkuz Lake and are fish-bearing streams with channel widths greater than 1.5 m. However, habitat quality for rainbow trout at each of these crossing is poor because there is little flow and silt content in the substrates is high. The stream at crossing PL-3 is on a fish bearing tributary of Tatelkuz Lake with a channel width greater than 5 m. Spawning gravels and cover for rainbow trout are present at the crossing. The stream at PL-6 is assumed to be fish-bearing but the channel is narrow (<1.5 m) and habitat quality for rainbow trout is low because the channel is dry during the summer and substrates are dominated by fines.

Crossings at PL-4, PL-5, and PL-8 are located on tributaries to Davidson Creek. The stream at PL-4 has no visible channel but there is a culvert installed where it crosses the road suggesting that this stream has flow in spring. The stream at crossing PL-5 has a gradient in excess of 7% with cobble substrate but habitat is suitable for all rainbow trout life stages. The stream at crossing PL-8 has an existing small perched culvert and the stream contains mostly fine substrates. Habitat quality is considered low for rainbow trout.

The remaining two crossings (PL-7 and PL-9) are on tributaries in the Creek 661 Watershed. The stream at crossing PL-7 is assumed fish-bearing with cobble substrates. However, this stream was dry during the baseline survey. The stream at crossing PL-9 is also fish-bearing with good quality rearing and spawning habitat present.

Potential effects to rainbow trout could occur at the eight known or assumed fish-bearing streams along the FSS pipeline and access road corridor. These potential effects include (DFO 2010a, 2010b, 2010c, 2010f, 2010g, 2010h, 2010i):

- Elevated TSS concentrations during construction. Elevated TSS concentrations can affect fish directly by impairing respiration, altering behaviour, or changing feeding efficiency and predator detection and indirectly by altering primary production and benthic invertebrate production upon which fish depend for food (Singleton, 1985; Lloyd et al., 1987; Newcombe, 1994);
- Direct fish mortalities if instream works or temporary ford crossings are required;
- Permanent or temporary loss or alteration of spawning, rearing, or foraging habitat;
- Temporary or permanent obstruction of fish passage at stream crossings; and
- Acute or chronic toxicity due to spills or leaks of deleterious substances, including fuel, oil, and grease.

4.3.7 Indirect Reduction in Growth, Survival, and Recruitment of Fish in Davidson Creek due to Changes in Downstream Water Quality and Temperature

During operations and closure phases, water from Tatelkuz Lake will be pumped to the freshwater reservoir built at the bottom of Reach 7 in Davidson Creek. This reservoir will have a storage capacity of approximately 700,000 m^3, enough to provide a minimum of 10 days water supply for Davidson Creek and the mill should any other part of the FSS system fail. Water in the freshwater reservoir will then be discharged, by gravity, to Davidson Creek.

Water from Tatelkuz Lake will not have the same water chemistry (e.g., nutrient, dissolved metal concentrations, and other chemical parameter such as pH, alkalinity, and hardness) as the existing water chemistry of Davidson Creek. In addition, water temperature of the water withdrawn from Tatelkuz Lake will be a relatively constant 8°C. Thus, water temperatures in Davidson Creek will be typically warmer in winter and cooler in summer than at present. As a result, the growth, survival, and spawning success of fish that use Davidson Creek for all or part of their life history may be altered. For juvenile rainbow trout that spend all year in Davidson Creek, the potential effects include:

- Lower growth rates depending on the water temperature at different times of the year; and
- Lower production of benthic invertebrates in lower Davidson Creek.

For spawning rainbow trout and kokanee and their eggs, the potential effects of the altered water chemistry and thermal regime of Davidson Creek during operations and closure phases includes:

- Increased straying of adults from their natal stream during spawning migrations;
- Higher egg mortality due to decreased gas concentrations in the water (i.e., water temperatures in spring are higher than baseline); and
- Higher egg mortality due to decreased gas diffusion rates between the eggs and the surrounding water caused by “hardening” of the egg membranes.

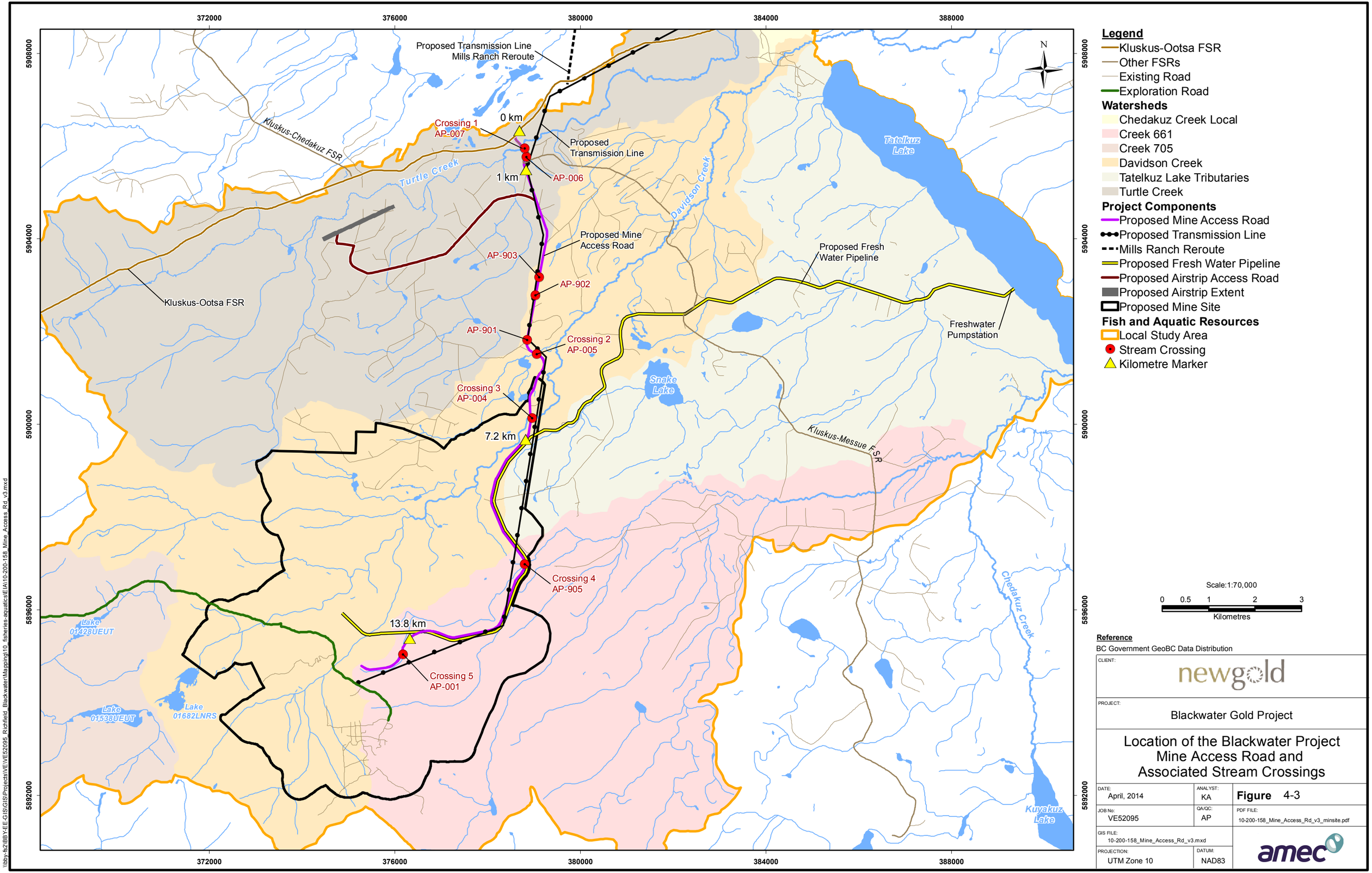
All of these potential effects could reduce the spawning success of rainbow trout and kokanee in Davidson Creek and could reduce the annual recruitment rates from Davidson Creek to the rainbow trout and kokanee populations in Tatelkuz Lake.

4.4 Potential Effects of the Mine Access Road

There are five permanent watercourses and four non-classified drainages along the new mine access road ROW (**Figure 4-3**). All five permanent watercourses are either confirmed or assumed to be rainbow trout-bearing streams: one on an unnamed tributary of Turtle Creek; one on an unnamed tributary of Davidson Creek; two on the Davidson Creek mainstem, and one on Creek 505659. The four non-classified drainages do not support fish or provide fish habitat.

Potential effects of construction, operations, and closure of the new mine access road on fish and fish habitat are the same as those for the FSS pipeline and access road. Based on the DFO Pathways of Effects models (DFO, 2010a, 2010b, 2010c, 2010d, 2010e), potential unmitigated effects to fish and fish habitat at the fish-bearing streams along the mine access road include:

- Increased erosion and transport of sediment;
- Temporary and/or permanent loss of fish habitat if instream works or temporary ford crossings are required or if closed-bottom crossing structures are installed in fish-bearing watercourses;
- Constriction of the natural floodplain near the crossing sites due to crossing structure installations;
- Temporary or permanent loss of riparian vegetation;
- Temporary or permanent obstruction of fish passage at stream crossings; and
- Spills or leaks of deleterious substances, including fuel, oil, and grease can reduce fish health, growth, and survival.


372000
376000
380000
384000
388000
5908000
5904000
5900000
5896000
5892000
Proposed Transmission Line
Mills Ranch Reroute
Kluskus-Chedakuz FSR
Crossing 1
AP-007
0 km
Proposed
Transmission Line
1 km
AP-006
Turtle Creek
Davidson Creek
Tatelkuz
Lake
Proposed Mine
Access Road
AP-903
AP-902
Kluskus-Ootsa FSR
Proposed Fresh
Water Pipeline
AP-901
Crossing 2
AP-005
Freshwater
Pumpstation
Crossing 3
AP-004
Snake
Lake
7.2 km
Kluskus-Messue FSR
Crossing 4
AP-905
13.8 km
Crossing 5
AP-001
Lake
01428UEUT
Lake
01538UEUT
Lake
01682LNRS
Chedakuz Creek
Kuyakuz
Lake
N
Legend
Kluskus-Ootsa FSR
Other FSRs
Existing Road
Exploration Road
Watersheds
Chedakuz Creek Local
Creek 661
Creek 705
Davidson Creek
Tatelkuz Lake Tributaries
Turtle Creek
Project Components
Proposed Mine Access Road
Proposed Transmission Line
Mills Ranch Reroute
Proposed Fresh Water Pipeline
Proposed Airstrip Access Road
Proposed Airstrip Extent
Proposed Mine Site
Fish and Aquatic Resources
Local Study Area
Stream Crossing
Kilometre Marker
Scale:1:70,000
0 0.5 1 2 3
Kilometres
Reference
BC Government GeoBC Data Distribution
CLIENT:
newgold
PROJECT:
Blackwater Gold Project
Location of the Blackwater Project
Mine Access Road and
Associated Stream Crossings
DATE:
April, 2014
ANALYST:
KA
Figure 4-3
JOB No:
VE52095
QA/QC:
AP
PDF FILE:
10-200-158_Mine_Access_Rd_v3_minsite.pdf
GIS FILE:
10-200-158_Mine_Access_Rd_v3.mxd
PROJECTION:
UTM Zone 10
DATUM:
NAD83
amec
\\bby-fs2\BBY-EE-GIS\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\E\A\10-200-158_Mine_Access_Rd_v3.mxd

4.5 Potential Effects of the Kluskus-Ootsa FSR Upgrade

The proposed FSR realignment route will cross two tributaries of Chedakuz Creek. Both tributaries enter Chedakuz Creek downstream of the Davidson Creek confluence (**Figure 4-4**). Only one of these two watercourses is fish bearing, Creek 522107. However, this stream is small (i.e., channel width less than 1.5 m). The other watercourse is a non-classified drainage and is not fish bearing nor does it provide fish habitat.

Potential effects of the proposed realignment and regarding of the Kluskus-Ootsa FSR on fish and fish habitat in this one fish-bearing stream are the same as those described for the streams along the new mine access road and, therefore, are not repeated here.

4.6 Potential Effects of the Airstrip

The airstrip itself is located on land and its construction, operation, and closure will therefore not affect fish or fish habitat. However, the airstrip access road will cross three tributaries to Turtle Creek (**Figure 4-5**). Only one of these streams is fish-bearing while the other two tributaries are non-classified drainages and do not provide habitat for fish. The fish-bearing tributary provides habitat for rainbow trout and rainbow trout have been documented at the crossing site (**Appendix 5.1.2.6B** of the Application).

Potential effects to fish and fish habitat are limited to the one fish-bearing Turtle Creek tributary crossed by the airstrip access road. Potential effects to fish and fish habitat in this stream are the same as those described for the mine access road and Kluskus-Ootsa FSR upgrade and, therefore, are not repeated here.

4.7 Potential Effects of the Transmission Line

The proposed transmission line will cross 143 watercourses along its ROW (**Figure 4-6**). Fifty of these watercourses are fish-bearing (i.e., S1, S2, S3, or S4) and include the Stellako River, the Nechako River, Big Bend Creek, Esker Creek, Fifteen Creek, Greer Creek, Smith Creek, Swanson Creek, Tahultzu Creek, Turtle Creek, and Chedakuz Creek. The remaining 93 watercourses are non-fishing bearing either because they are non-classified drainages (NCD), have NVC or because they are too small, steep, or ephemeral to support fish. An additional 18 watercourse crossings will be required for the Stellako and Mills Ranch reroutes. Four fish-bearing watercourses will be crossed by the Mills Ranch reroute and two fish-bearing watercourses will be crossed by the Stellako reroute.

320000 360000 400000 440000

5960000 5920000 5880000

François Lake
Southbank
Cheslatta Carrier
Danskin
Skin Tyee
Uncha Mountains Red Hills Park
Uncha Lake
Takysie Creek
Binta Lake
Cheslatta
Cheslatta River
Cheslatta Lake
Knapp Creek
Cheslatta
Bird Creek
Lucas Lake
Lucas Creek
Knewstubb Lake
Big Bend Creek
Natalkuz Lake (Nechako Reservoir)
Tetachuck River
Entiako River
Entiako Park
Entiako Lake
Tweedsmuir Park
Johnny Lake
Moose Lake
ULKATCHO 6
Laidman Lake
Fawnie Creek
Top Lake
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Tatelkuz Lake
Chedakuz Creek
Mills Ranch Reroute
Kuyakuz Lake
Euchiniko Lakes
Blackwater River
Kluskus
Kushya
Tsacha Lake
Nazko
Kluskus-Blue FSR
Kluskus FSR
Stellako Reroute
Endako
Stellako
Fraser Lake
Nadleh Whuten
Fort Fraser
Engen
Nechako River
Vanderhoof
Weneez
Sinkut River
Saik'uz
Nulki
Nulki Lake
Tachick Lake
Smith Creek
Nithi River
Tahultzu Lake
Nechako River
Hallett Lake
Greer Creek
Targe Creek
Corkscrew
Sinkut River
Mapes
Cluculz Lake
Cluculz Creek
Khai
Stuart River Park
Stuart River
Meridian Road (Vanderhoof) Ecological Reserve
Nechako Canyon Protected Area
Finger Lake
Tatuk Lake
Finger Tatuk Park
Chilako River Ecological Reserve
Chilako River
Taluk Creek
Euchiniko
Nazko
AE-013
AE-012
16
35

N

Legend

- Populated Place
- Stream Crossing
- Highway
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Kluskus-Ootsa FSR Realignment
- Railway
- Existing Transmission Line
- Alexander Mackenzie Heritage Trail
- Stream
- Waterbody
- Parks & Protected Areas

Project Components

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

Fish and Aquatic Resources

- Local Study Area

Watersheds

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

Scale: 1:500,000

0 5 10 20

Kilometres

Reference

BC Government GeoBC Data Distribution

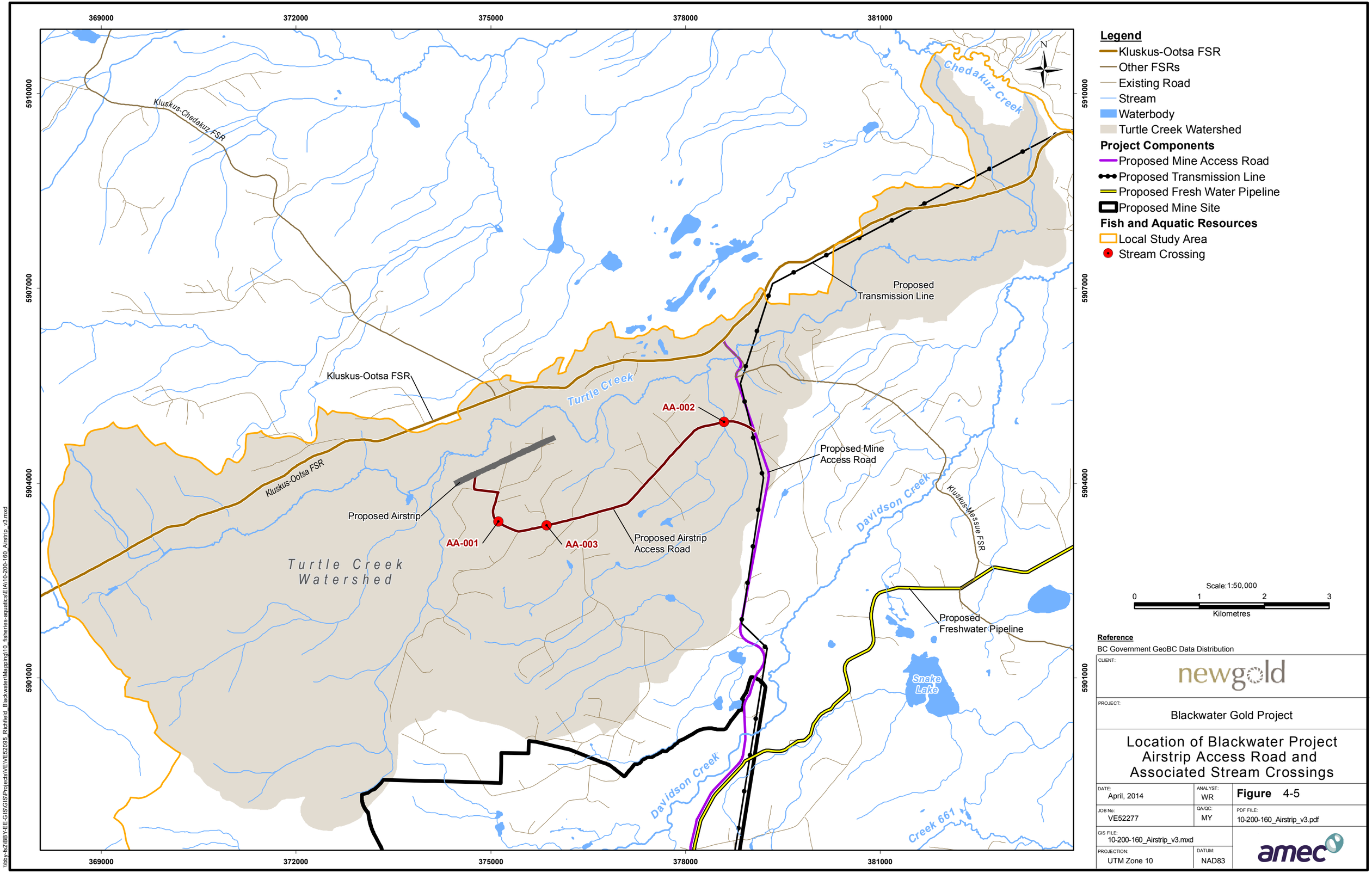
CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of the Blackwater Project Kluskus FSR and Kluskus-Ootsa FSR

DATE:	ANALYST:	Figure 4-4
April, 2014	WR	
JOB No: VE52277	QA/QC: AP	PDF FILE: 10-200-160_Kluskus FSR_v3.pdf
GIS FILE: 10-200-160_Kluskus FSR_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of Blackwater Project Airstrip Access Road and Associated Stream Crossings

DATE: April, 2014	ANALYST: WR	**Figure** 4-5
JOB No: VE52277	QA/QC: MY	PDF FILE: 10-200-160_Airstrip_v3.pdf
GIS FILE: 10-200-160_Airstrip_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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320000
360000
400000
440000
5960000
5920000
5880000

François Lake
Southbank
Cheslatta Carrier
Danskin
Skin Tyee
Cheslatta
Endako
Stellako
Fraser Lake
Nadleh Whuten
Fort Fraser
Engen
Vanderhoof
Weneez
Sinkut River
Saik'uz
Nulki
Mapes
Stellako Reroute
Uncha Mountains Red Hills Park
Uncha Lake
Takysie Creek
Binta Lake
Nithi River
Smith Creek
Tachick Lake
Nechako River
Tahultzu Lake
Nulki Lake
Stuart River
Stuart River Park
Cluculz Lake
Cluculz Creek
Khai
Sinkut River
Corkscrew
Hallett Lake
Greer Creek
Targe Creek
Knapp Creek
Cheslatta River
Cheslatta Lake
Cheslatta
Bird Creek
Nechako Canyon Protected Area
Kluskus FSR
Meridian Road (Vanderhoof) Ecological Reserve
Lucas Lake
Lucas Creek
Knewstubb Lake
Big Bend Creek
Finger Lake
Tatuk Lake
Finger Tatuk Park
Chilako River Ecological Reserve
Chilako River
Natalkuz Lake (Nechako Reservoir)
Tetachuck River
Entiako River
Entiako Park
Entiako Lake
Tweedsmuir Park
ULKATCHO 6
Mills Ranch Reroute
Chedakuz Creek
Taluk Creek
Batnuni Lake
Euchiniko River
Nataniko Creek
Euchiniko
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Tatelkuz Lake
Top Lake
Fawnie Creek
Laidman Lake
Johnny Lake
Moose Lake
Kuyakuz Lake
Kluskus-Blue FSR
Kluskoil Lake Park
Euchiniko Lakes
Alexander Mackenzie Heritage Trail
Nazko
Blackwater River
Kluskus
Tsacha Lake
Kushya
Baezaeko
Nazko

Legend

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

Project Components

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

Fish and Aquatic Resources

- Local Study Area

Watersheds

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

Scale: 1:500,000

0 5 10 20

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Location of Blackwater Project Proposed Transmission Line ROW

DATE: April, 2014	ANALYST: WR	**Figure** 4-6
JOB No: VE52277	QA/QC: AP	PDF FILE: 10-200-159_TransmissionLine_v3.pdf
GIS FILE: 10-200-159_TransmissionLine_v3.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Existing stream crossings will be used by trucks and heavy machinery to access transmission line crossings on the Stellako and Nechako Rivers and the majority of other watercourses. New stream crossings will be required at 35 watercourses along new temporary access roads required for construction and maintenance of the transmission line.

At each stream crossing along the transmission line ROW, riparian vegetation will be cleared such that it does not impede construction of the line or pose a threat to the line if vegetation were to fall. Similarly, riparian vegetation will need to be removed to allow construction of the 35 new stream crossings required for the new temporary access roads.

Potential effects on fish and fish habitat at stream crossings along the transmission line ROW and at existing and temporary access road stream crossings will be similar to those described for the other linear developments above.

4.8 Summary of Potential Effects of Linear Developments

Table 4-7 summarizes the potential effects to fish and fish habitat of all linear developments of the Project.

Table 4-7: Summary of Potential Direct and Indirect Effects to Fish and Fish Habitat due to Linear Developments Required for the Project

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Streams and Lakes Affected	Fish Species and Life Stages
Construction	Mine Access Road	Site clearing, grading and topsoil salvage, road and lay-down area construction including transfer and placement of granular materials and stream crossings. Transportation of workforce and materials	**Direct Effects**:) alteration or destruction of fish habitat at access road stream crossings; 2) mortality of fish during construction of access road stream crossings; 3) mortality of fish due to spills of hydrocarbons and hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	**Turtle Creek**: mainstem downstream of road crossing **Davidson Creek**: mainstem downstream of Reach 6 **Creek 661**: mainstem downstream of Reach 5 **Creek 661 tributaries**: Creek 505659 and Creek 146920	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation
	Kluskus-Ootsa FSR	Road upgrades. Transportation of workforce and materials	**Direct Effects**: 1) alteration or destruction of fish habitat at stream crossings; 2) mortality of fish during construction of stream crossings; 3) mortality of fish due to spills of hydrocarbons and hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	**Chedakuz Creek tributaries:** two unnamed tributaries in the Creek 522107 watershed **Chedakuz Creek**: downstream of creeks in the Creek 522107 watershed	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation
	FSS	ROW clearing and grading, timber salvage and soil management, facilities construction (pump-house, water intake, electrical hook-up), road construction, installation of water pipeline and fresh water reservoir. Transportation of workforce and materials	**Direct Effects**: 1) permanent loss of fish habitat under freshwater reservoir dam; 2) permanent alteration of fish habitat within freshwater reservoir pond; 3) temporary alteration of fish habitat at pipeline and access road stream crossings; 4) mortality of fish within the freshwater reservoir dam and pond work area; 5) mortality of fish stranded immediately downstream of the freshwater reservoir dam and pond work area **Indirect Effects:** 1) interruption of fish passage at stream crossings along pipeline route; 2) interruption of fish passage in Davidson Creek above freshwater reservoir dam; 3) change in downstream water quality below freshwater reservoir dam; 4) change in downstream water quality at stream crossings along pipeline and access road;	**Davidson Creek:** mainstem Reaches 7 and 7.1 under freshwater reservoir dam and pond footprint **Davidson Creek**: downstream of Reach 7 **Davidson Creek tributaries**: at and downstream of pipeline and access road stream crossings on Creek 314089 and Creek 226858 **Creek 661 tributaries**: at and downstream of pipeline and access road stream crossing on Creek 505659 and Creek 146920 **Tatelkuz Lake tributaries**: at and downstream of pipeline and access road stream crossings	**Rainbow trout:** spawning/egg incubation, fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation in Davidson Creek
	Airstrip	Site clearing and grading, timber and soil salvage, construction of runway and construction of airstrip ancillary facilities (service road installation and site infrastructure). Transportation of workforce and materials	**Direct Effects**: 1) alteration or destruction of fish habitat at access road stream crossings; 2) mortality of fish during ford crossings by heavy machinery or during construction of access road stream crossings; 3) mortality of fish due to spills of hydrocarbons and hazardous materials **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Turtle Creek**: mainstem downstream of road crossing **Turtle Creek tributaries**: two unnamed tributaries	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Transmission Line	ROW clearing and preparation, vegetation clearing, construction of access roads, installation of power line (pole foundations, poles and cable stringing). Transportation of workforce and materials	**Direct Effects**: 1) temporary alteration of fish habitat at ford crossings; 2) alteration or destruction of fish habitat at access road stream crossings; 3) mortality of fish during ford crossings by heavy machinery or during construction of access road stream crossings; 4) mortality of fish due to spills of hydrocarbons **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) decrease in shade, cover, nutrient additions due to management of riparian vegetation; 3) alteration of fish passage due to temporary ford crossings or during stream crossing construction	**Davidson Creek:** mainstem downstream of Reach 6 **Creek 661 tributaries:** Creek 505659 and Creek 146920 **Turtle Creek:** mainstem downstream of transmission line ROW Streams and rivers along the transmission line route outside of the LSA (listed in **Section 2.2**): downstream of transmission line ROW	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation Potentially Chinook salmon, sockeye salmon, coho salmon, mountain whitefish, and other species in the Nechako River watershed
Operations	Mine Access Road	Transportation of workforce and materials and maintenance	**Direct Effects**: mortality of fish due to spills of hydrocarbons or hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	**Turtle Creek**: mainstem downstream of road crossing **Davidson Creek**: mainstem downstream of Reach 6 **Creek 661**: mainstem downstream of Reach 5 **Creek 661 tributaries**: Creek 505659 and Creek 146920	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Streams and Lakes Affected	Fish Species and Life Stages
	Kluskus-Ootsa FSR	Maintenance and transportation of workforce and material	**Direct Effects**: mortality of fish due to spills of hydrocarbons or hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	**Chedakuz Creek tributaries:** two unnamed tributaries in the Creek 522107 watershed **Chedakuz Creek**: downstream of creeks in the Creek 522107 watershed	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation
	FSS	Pumping of water and maintenance of system	**Direct Effects**: 1) mortality of fish impinged on intake screens or entrained in pumps and pipeline; 2) permanent loss of fish habitat under freshwater reservoir dam; 3) permanent alteration of fish habitat within freshwater reservoir pond; 4) temporary alteration of fish habitat at pipeline and access road stream crossings **Indirect Effects:** 1) draw-down of Tatelkuz Lake levels and subsequent loss of littoral habitat area; 2) interruption of fish passage at stream crossings along pipeline route; 3) change in downstream water quality at stream crossings along pipeline and access road; 4) change in water temperature and water chemistry in Davidson Creek due to water releases from freshwater reservoir; 5) maintenance of flows in Davidson Creek	**Davidson Creek:** mainstem Reaches 7 and 7.1 under freshwater reservoir dam and pond footprint **Davidson Creek**: downstream of Reach 7 **Davidson Creek tributaries**: at and downstream of pipeline and access road stream crossings on Creek 314089 and Creek 226858 **Creek 661 tributaries**: at and downstream of pipeline and access road stream crossing on Creek 505659 and Creek 146920 Tatelkuz Lake: littoral areas **Tatelkuz Lake tributaries**: at and downstream of pipeline and access road stream crossings	**Rainbow trout:** spawning/egg incubation, fry summer rearing; juvenile summer rearing; overwintering in Davidson Cr. **Rainbow trout**: fry summer rearing; juvenile summer rearing; adult summer foraging; and overwintering in Tatelkuz Lake **Kokanee**: spawning/egg incubation in Davidson Creek **Kokanee**: fry summer rearing; juvenile summer rearing; adult summer foraging; and overwintering in Tatelkuz Lake
	Airstrip	Maintenance only. No regular scheduled flights	**Direct Effects:** none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Turtle Creek**: mainstem downstream of road crossing **Turtle Creek tributaries**: two unnamed tributaries	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Transmission Line	Maintenance	**Direct Effects:** none **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) decrease in shade, cover, nutrient additions due to management of riparian vegetation	**Davidson Creek:** mainstem downstream of Reach 6 **Creek 661 tributaries:** Creek 505659 and Creek 146920 **Turtle Creek:** mainstem downstream of transmission line ROW Streams and rivers along the transmission line route outside of the LSA (listed in **Section 2.2**): downstream of transmission line ROW	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation Potentially Chinook salmon, sockeye salmon, coho salmon, mountain whitefish, and other species in the Nechako River watershed
	Mine Access Road	Maintenance	**Direct Effects:** none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Turtle Creek**: mainstem downstream of road crossing **Davidson Creek**: mainstem downstream of Reach 6 **Creek 661**: mainstem downstream of Reach 5 **Creek 661 tributaries**: Creek 505659 and Creek 146920	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation
Closure	Kluskus-Ootsa FSR	Maintenance	**Direct Effects:** none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Chedakuz Creek tributaries:** two unnamed tributaries in the 522107 watershed	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	FSS	Pumping of water and maintenance of system, decommissioning of fresh water reservoir	**Direct Effects**: 1) mortality of fish impinged on intake screens or entrained in pumps and pipeline; 2) permanent loss of fish habitat under freshwater reservoir dam; 3) permanent alteration of fish habitat within freshwater reservoir pond; 4) permanent alteration of fish habitat at pipeline and	**Davidson Creek:** mainstem Reaches 7 and 7.1 under footprint **Davidson Creek**: downstream of Reach 7 **Davidson Creek tributaries**: at and downstream of	**Rainbow trout:** spawning/egg incubation, fry summer rearing; juvenile summer rearing; overwintering in Davidson Cr.

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Streams and Lakes Affected	Fish Species and Life Stages
			access road stream crossings **Indirect Effects:** 1) draw-down of Tatelkuz Lake levels and subsequent loss of littoral habitat area; 2) interruption of fish passage at stream crossings along pipeline route; 3) change in downstream water quality at stream crossings along pipeline and access road; 4) change in water temperature and water chemistry in Davidson Creek due to water releases from freshwater reservoir; 5) maintenance of flows in Davidson Creek	pipeline and access road stream crossings on Creek 314089 and Creek 226858 **Creek 661 tributaries**: at and downstream of pipeline and access road stream crossing on Creek 505659 and Creek 146920 Tatelkuz Lake: littoral areas **Tatelkuz Lake tributaries**: at and downstream of pipeline and access road stream crossings	**Rainbow trout**: fry summer rearing; juvenile summer rearing; adult summer foraging; and overwintering in Tatelkuz Lake **Kokanee**: spawning/egg incubation in Davidson Creek **Kokanee**: fry summer rearing; juvenile summer rearing; adult summer foraging; and overwintering in Tatelkuz Lake
	Airstrip	Maintenance; No regular scheduled flights	**Direct Effects:** none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Turtle Creek**: mainstem downstream of road crossing **Turtle Creek tributaries**: two unnamed tributaries	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
	Transmission Line	Decommissioning and removal of cables and poles, implement reclamation plan (re-contouring and revegetation)	**Direct Effects**: none **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) improvement of riparian vegetation growth and subsequent increases in shade, cover, nutrient additions, and decreases in sediment.	**Davidson Creek:** mainstem downstream of Reach 6 **Creek 661 tributaries:** Creek 505659 and Creek 146920 **Turtle Creek:** mainstem downstream of transmission line ROW Streams and rivers along the transmission line route outside of the LSA (listed in **Section 2.2**): downstream of transmission line ROW	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering **Kokanee**: spawning/egg incubation Potentially Chinook salmon, sockeye salmon, coho salmon, mountain whitefish, and other species in the Nechako River watershed
	Mine Access Road	Maintenance and occasional transportation of people	**Direct Effects:** none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	**Turtle Creek**: mainstem downstream of road crossing **Davidson Creek**: mainstem downstream of Reach 6 **Creek 661**: mainstem downstream of Reach 5 **Creek 661 tributaries**: Creek 505659 and Creek 146920	**Rainbow trout:** spawning/egg incubation; fry summer rearing; juvenile summer rearing; overwintering
Post-closure	Kluskus-Ootsa FSR	Occasional transportation of people	**Direct Effects:** none **Indirect Effects:** none	n/a	n/a
	FSS	None	**Direct Effects:** none **Indirect Effects:** none	n/a	n/a
	Airstrip	None	**Direct Effects:** none **Indirect Effects:** none	n/a	n/a
	Transmission Line	None	**Direct Effects:** none **Indirect Effects:** none	n/a	n/a

5.0 MEASURES AND STANDARDS USED TO AVOID OR MITIGATE SERIOUS HARM TO FISH

The Project design, Aquatic Resources Management Plan (ARMP) (**Section 12.2.1.18.4.2** of the Application), Fish Salvage Plan (**Section 12.2.1.18.4.21** of the Application) and Fish and Fish Habitat sections of the EA (**Section 5.3.8** and **Section 5.3.9** of the Application) include avoidance and mitigation measures to eliminate or minimize the potential serious harm to fish. These measures and their likely effectiveness are described in this section.

5.1 Avoidance Measures

Planning and designing the Project incorporated environmental design criteria and guiding principles intended to avoid or minimize potential serious harm to fish, including the permanent alteration or destruction of fish habitat. The following criteria and design principles were applied to achieve this goal:

- Massing, which refers to the early identification and avoidance of key sensitive areas in the Project area;
- Clustering, which refers to locating facilities to minimize the spatial extent of the project footprint. The TSF, open pit, waste rock dumps, stockpiles, and all other mine site facilities are clustered as closely together as possible in the headwaters of Davidson Creek and Creek 661;
- Minimizing the number of watersheds potentially affected by locating the TSF and all mine site facilities within the Davidson Creek and Creek 661 watersheds; and
- Optimizing the use of the existing access roads (i.e., Kluskus and Kluskus-Ootsa FSRs) for site access and existing ROW for the transmission line.

During early mine planning, two key sensitive habitat areas were identified and avoided. First, the Blackwater River Watershed has one of the most diverse fish assemblages in British Columbia (Porter et al., 2000) and has been designated as a Heritage River by the Province due to its unique combination of natural, cultural, and recreation values. Of particular importance is the long history of use by local First Nations. Second, kokanee spawning habitat was identified as important for the sustainability of kokanee populations in the area. Kokanee are a valuable species supporting recreational and Aboriginal fisheries. Avoidance of the Blackwater River Watershed and of kokanee spawning habitat were design principles established during early mine planning.

When a TSF that might require Schedule 2 listing is considered, the MMER requires a formal alternative assessment process. Formal assessment considered eight alternative TSF locations (**Appendix 2.5A** of the Application). The proposed TSF design was preferred based on quantitative consideration of technical, environmental, socio-economic and cost factors cost.

Despite the avoidance efforts described above, potential serious harm to fish, including alteration and destruction of fish habitat, may occur. However, further elimination or minimization of this

potential serious harm is possible with implementation of the mitigation measures described in the section below.

5.2 Mitigation Measures

Mitigation measures for the potential effects identified for the six mine components identified in **Section 4.0** are described in the following sections. The likely effectiveness of these measures and any remaining residual effects to fish and fish habitat are identified.

5.2.1 Mitigation for the Mine Site

Mitigation measures to eliminate or reduce potential effects to fish and fish habitat due to the construction, operation, and closure of the mine site facilities include those that:

- Minimize changes in downstream water quantity;
- Minimize changes in downstream water quality, including increases in TSS;
- Minimize the isolation of upstream habitat that cannot support fish without connection to downstream habitat; and
- Minimize direct mortality of fish under and upstream of mine site component footprints.

Table 5-1 identifies those mitigation measures that will be implemented to eliminate or minimize each of the potential effects to fish and fish habitat described in **Section 4**. Descriptions of each of these mitigation measures are provided in the sections that follow.

5.2.2 Mitigation of Changes in Downstream Water Quantity

Mitigation of potential effects to fish due to changes in downstream flows will begin with how water is managed during each phase of the Project. Construction will be phased, with the upstream portion of the TSF (Site C) built earlier. This approach will simplify water management and reduce potential effects during construction. During all construction, water will be captured and diverted around construction sites and allowed to continue downstream. Only when starter dams are completed, will water begin to be stored on site.

During operations, water use will be minimized by recycling water in the TSF for use in the mill and by capturing, collecting, and pumping all seepage back to the TSF. This approach minimizes freshwater make-up requirements for the mill process, the quantity of wastewater generated, and potential disturbances to the aquatic environment from water withdrawals and releases. The FSS, described above, will draw water from Tatelkuz Lake to provide mitigation flows to Davidson Creek downstream of the Project. Design of the mitigation flow regime explicitly considered trade-offs and the potential for adverse effects to Tatelkuz Lake and lower Chedakuz Creek as a result of water withdrawals.

Table 5-1: Summary of Mitigation Measures to Reduce or Eliminate Potential Serious Harm to Fish due to the Blackwater Mine Site

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Mitigation Measure	Likely Effectiveness
Construction	Site Infrastructure and Site Roads	Clearing, grading and topsoil salvage, construction and lay-down areas, surface drainage controls, construction of site infrastructure (fuel site, warehousing and materials storage, construction lay-down area, truck stop, camp and maintenance buildings, explosives facility), camp waste management system (site landfill and domestic sewage system)	**Direct Effects**: 1) mortality of fish in streams under site infrastructure and site roads; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under site infrastructure and sites roads **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	1. Isolate construction areas and conduct fish salvages 2. Erosion and sediment control plans 3. Sediment control ponds 4. Divert flows around construction areas	**Direct mortality effects:** High **Direct habitat effects**: low **Indirect water quality effects**: high **Indirect water quantity effects**: high
	Mine pit	Stripping of top-soil and over-burden	**Direct Effects**: 1) mortality of fish in streams under the mine pit; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under the mine pit **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	Same as above	Same as above
	Ore Processing Area	Clearing and construction of ore processing area (plant site, mill and processing area, core logging area) foundations and building construction, crusher and conveyor and low grade ore stockpile.	**Direct Effects**: 1) mortality of fish in streams under ore processing area; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under ore processing area **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	Same as above	Same as above
	Waste Rock Areas	Mine waste rock dumps construction	**Direct Effects**: 1) mortality of fish in streams waste rock areas; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under waste rock areas **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	Same as above	Same as above
	TSF	Clearing, grading and topsoil salvage, construction of TSF (tailings and return water lines), construct dams and collect water, Site C west dam, Site C main dam, Site D main dam and embankment	**Direct Effects**: 1) mortality of fish in streams under TSFs; 2) mortality of fish stranded in streams directly downstream of work areas; 3) stranding of fish upstream; 4) permanent alteration or destruction of fish habitat under TSFs; 5) isolation of habitat upstream **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows;	Same as above	Same as above
	Wetland and Water Management System, Freshwater Reservoir	Construction of water management system (site surface drainage management, erosion and sediment control, water recovery and recycle system from TSF)	**Direct Effects**: 1) mortality of fish in streams under dams for environmental control pond and freshwater reservoir; 2) mortality of fish stranded in streams directly downstream of work areas; 3) permanent alteration or destruction of fish habitat under environmental control pond and dam **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	Same as above	Same as above
	Borrow areas	Development of borrow sites (Site C main dam, esker borrow source and sand and gravel screening plant)	**Direct Effects**: 1) mortality of fish in streams under Site C dam; 2) mortality of fish stranded in streams directly downstream of work areas; 3) stranding of fish upstream of Site C dam; 4) permanent alteration or destruction of fish habitat under Site C dam **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	Same as above	Same as above
Operations	Site Infrastructure and Site Roads	Worker accommodations operation, hazardous materials management (waste, explosives, spills), camp and offices waste management	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under site infrastructure and sites roads; 2) mortality of fish due to spills of hydrocarbons **Indirect Effects:** 1) changes in downstream water quality due to sewage effluent, spills, and erosion; 2) reduction in downstream flows	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct mortality effects:** high **Direct habitat effects:** low **Indirect water quality effects**: high **Indirect water quantity effects**: moderate
	Mine Pit	Drill, blast, excavate, transport ore	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under the mine pit; 2) mortality of fish in streams due to blasting	none	N/A
	Ore Processing Area	Process area operations	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent alteration or destruction of fish habitat under ore processing area **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan 4. Cyanide Destruction circuit 5. Water recycling	**Direct mortality effects:** high **Direct habitat effects:** low **Indirect water quality effects**: high **Indirect water quantity effects**: moderate

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Mitigation Measure	Likely Effectiveness
	Waste Rock Areas	Mine waste rock dump placement	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent alteration or destruction of fish habitat under waste rock areas **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) change in downstream water quality due to waste rock run-off; 3) reduction in downstream flows	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct mortality effects:** high **Direct habitat effects:** low **Indirect water quality effects**: high **Indirect water quantity effects**: moderate
	TSF	TSF ongoing development and operations	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent isolation of fish upstream; 3) permanent alteration or destruction of fish habitat under TSFs **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows; 3) changes in downstream water quality due to TSF seepage	1. Erosion and sediment control plans 2. Operation of FSS 3. Instream Flow Requirements for rainbow trout and kokanee in Davidson Creek 4. Diversion of Lake 01682LNRS 5. "Zero-discharge" facility 6. Seepage collection trench and pump-back system 7. ECD 8. Construct wetland in TSF Site C pond 9. Water Management System	**Direct mortality effects:** high **Direct habitat effects:** low **Indirect water quality effects**: high **Indirect water quantity effects**: high
	Wetland and Water Management System, Freshwater Reservoir	Water management system operation and maintenance	**Direct Effects**: 1) mortality of fish stranded in streams directly downstream; 2) permanent alteration or destruction of fish habitat under environmental control pond and dam **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	none	N/A
	Borrow areas	Operate sand and gravel screening equipment. Excavate and transport material	**Direct Effects**: permanent alteration or destruction of fish habitat under Site C dam **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct mortality effects:** high **Direct habitat effects:** low **Indirect water quality effects**: high **Indirect water quantity effects**: moderate
Closure	Site Infrastructure and Site Roads	Decommission, dismantle and remove equipment (conveyors, crusher, warehousing, fuel storage, truck stop), reclaim areas of soil contamination, implement reclamation plan (grade and level site, implement erosion and sediment control features and spread overburden and topsoil)	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under site infrastructure and sites roads; 2) mortality of fish due to spills of hydrocarbons **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct Effects:** low **Indirect Effects:** high
	Mine Pit	Construct rock safety berm, spillways, and channel to TSF, overburden in bench flats, fertilize pit water while filling if required	**Direct Effects**: permanent alteration or destruction of fish habitat under the mine pit **Indirect Effects**: none	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Fill with water pumped from TSF and from Tatelkuz Lake	**Direct Effects:** low **Indirect Effects:** n/a
	Ore Processing Area	Decommission, dismantle and remove equipment	**Direct Effects**: permanent alteration or destruction of fish habitat under ore processing area **Indirect Effects**: none	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct Effects:** low **Indirect Effects:** n/a
	Waste Rock Areas	Re-grade, construct drainage control swales, cover, and re-vegetate	**Direct Effects**: permanent alteration or destruction of fish habitat under waste rock areas **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct Effects:** low **Indirect Effects:** high
	TSF	Area C: Remove pumps/pipelines, cover, wetland and upland beach revegetation, outlet connection, reseed downstream slope, and decommission seepage sump Area D: Pump supernatant and Tatelkuz Lake water to pit, construct spillways, cover, deflector berm, outlet connection,	**Direct Effects**: 1) permanent isolation of fish upstream; 2) permanent alteration or destruction of fish habitat under TSFs **Indirect Effects**: 1) changes in downstream water quality due to erosion and sedimentation; 2) reduction in downstream flows; 3) changes in downstream water quality due to TSF seepage	1. Erosion and sediment control plans 2. Continued operation of FSS 3. Instream flow requirements for rainbow trout and kokanee in Davidson Creek 4. Diversion of Lake 01682LNRS 5. "Zero-discharge" facility 6. Seepage collection trench and pump-back system 7. Construction of treatment wetlands in TSF Site D pond 8. Construction of treatment wetlands in ECD pond	**Direct Effects:** low **Indirect Effects:** high

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Mitigation Measure	Likely Effectiveness
				9. Water Management system	
	Wetland and Water Management System, Freshwater Reservoir	Monitor water quality	**Direct Effects**: permanent destruction of fish habitat under ECD dam and permanent alteration of fish habitat within ECD pond **Indirect Effects:** none	none	N/A
	Borrow areas	Re-grade, cover, and re-vegetate	**Direct Effects**: none **Indirect Effects:** none	1. Erosion and sediment control plans 2. Emergency spill response plans 3. Water management plan	**Direct Effects:** low **Indirect Effects:** high
Post-Closure	Site Infrastructure and Site Roads	Monitor reclamation	**Direct Effects**: none **Indirect Effects**: none	none	N/A
	Mine Pit	Discharge pit water overflow to TSF	**Direct Effects**: none **Indirect Effects**: none	none	N/A
	Ore Processing Area	Monitor reclamation	**Direct Effects**: none **Indirect Effects**: none	none	N/A
	Waste Rock Areas	Monitor reclamation	**Direct Effects**: none **Indirect Effects**: none	none	N/A
	TSF	Discharge TSF overflow to Davidson Creek; Monitor reclamation of TSF dams and interior wetlands	**Direct Effects**: 1) permanent alteration or destruction of fish habitat under TSF dams and within TSFs; 2) permanent isolation of habitat upstream of TSF **Indirect Effects**: 1) changes in downstream water quality due to release of TSF supernatant; 2) changes in downstream water temperature due to release of TSF supernatant	1. Pit over-flow to TSF 2. TSF over-flow to Davidson Creek only when water meets site-specific water quality objectives 3. Re-establishment of natural drainage patterns 4. Construct treatment wetland in former Freshwater Reservoir	**Direct Effects:** low **Indirect Effects:** high
	Wetland and Water Management System, Freshwater Reservoir	Fill seepage ponds and ditches, and re-vegetate ECD and Water Reservoir: Breach dams and construct rip-rap channel, re-grade dams, re-vegetate, reshape basins and wetlands for seepage treatment. Monitor water quality	**Direct Effects**: permanent destruction of fish habitat under ECD dam and permanent alteration of fish habitat within ECD pond **Indirect Effects**: none	none	N/A
	Borrow areas	Monitor reclamation	**Direct Effects**: none **Indirect Effects**: none	none	N/A

Water management during the closure phase will include continued pumping of seepage back to the TSF, and pumping of water from the TSF to the open pit to speed its filling with water to accelerate reclamation. Once the pit is filled, water will be allowed to over-flow through a spillway channel to the TSF. When water quality is confirmed suitable, the TSF will be connected to Davidson Creek through a spillway constructed in the TSF dam, and the FSS mitigation pumping will cease. Diversion ditches and collection ponds around the waste rock dumps, camps, ore-processing area, and site facilities in the Creek 661 Watershed headwater tributaries will be decommissioned allowing water, previously diverted to the TSF, to again flow to Creek 661. This closure water management plan will effectively restore the natural drainage patterns and restore most of the watershed areas of Davidson Creek and Creek 661 to near baseline condition. Specific mitigation measures designed to limit the alteration of flows in Davidson Creek, Creek 661, and Chedakuz Creek are described in the sections below.

Davidson Creek

During construction, operations, and closure, the FSS will be used to augment groundwater and tributary inflows to Davidson Creek downstream of the TSF. As described in **Section 2**, the FSS will pump water from Tatelkuz Lake to a freshwater reservoir built at the top of Reach 6 in Davidson Creek. Water will be discharged from the reservoir to Davidson Creek at rates designed to meet instream flow requirements over five biologically relevant stanzas for rainbow trout and kokanee, the two fish species potentially most affected by flow reductions in Davidson Creek. These stanzas include:

- Spring freshet (May 1 to May 15): period of highest natural discharge when substrate scour, gravel recruitment, and cleaning of fine sediments from spawning gravels occur;
- Rainbow trout migration and spawning (May 16 to June 30);
- Kokanee spawning, rainbow trout egg incubation and rainbow trout juvenile rearing (July 1 to August 31);
- Kokanee egg incubation and juvenile rainbow trout rearing (September 1 to November 30); and
- Juvenile rainbow trout overwintering (December 1 to April 30).

The mitigated flow regime in Davidson Creek was designed to provide the flows necessary such that the hydraulic conditions in the stream (i.e., depths and water velocities) were suitable for each rainbow trout and kokanee life stage in each biological stanza. It also includes a period of higher spring flows (i.e., 400% of mean annual discharge) necessary to flush accumulated sediments from the gravels. This is necessary to maintain the quality of spawning gravels. Transitional flows between each stanza are prescribed to provide fish with a signal that flows are increasing or decreasing, which is necessary to avoid stranding or flushing fish and their eggs in the creek. By providing these flows, the mitigated flow regime will maintain the availability and suitability of existing fish habitat and maintain the critical hydrological processes that regulate the channel geometry and morphology and consequently the diversity, quantity, and quality of fish habitat.

The *Instream Flow Study* (**Appendix 5.1.2.6D** of the Application) describes how risk-averse mitigation flows were derived for each biological stanza. The assessment of potential flow effects on fish habitat in Davidson Creek is provided in **Section 5.3.9** of the Application. Flow/habitat models were developed to predict habitat availability as a function of flow. Instream flow requirements in Davidson Creek were then defined assuming that low flow conditions within each stanza define a productivity bottleneck for rainbow trout and kokanee. Low flows were conservatively defined as the mean annual baseline 30-day low flow for each stanza. Within each stanza, the ecological bottleneck is actually defined by shorter-term variability in flows, such that the true population is always expected to be less than predicted based on average habitat availability. Therefore, instream needs were conservatively defined as flows sufficient to maintain at least 90% of the modelled habitat available during baseline low flow conditions. Providing at least 90% of baseline mean low flow habitat during construction, operations, and closure phases of the Project will result in no significant residual effect on rainbow trout or kokanee using Davidson Creek.

Specifications of the FSS that will improve the reliability of the system, its ability to meet instream flow requirements for rainbow trout and kokanee, and to minimize potential direct mortality of fish include the following:

- The intake structure includes a wet-well chamber fed by two 610 mm HDPE pipe intakes, each approximately 50 m long and equipped with appropriate sized fish screens;
- Pipe intakes will be positioned at depths between 8 and 12 m below the Tatelkuz Lake surface elevation;
- The pump house floor will house four 525 kW vertical turbine pumps (three operating, one installed contingency spare) that will draw a continuous supply of water from the wet-well chamber;
- The freshwater reservoir will store approximately 400,000 m^3 of water, enough to provide a minimum of seven days contingency water supply for Davidson Creek and for the mill should any other part of the FSS system fail;
- The FSS and freshwater reservoir were designed to ensure the system has additional pumping and storage capacity to provide an additional 3 Mm^3 of water per year as a contingency in dry years;
- A spillway will be built in the freshwater reservoir to carry storm flows, up to and including the 1 in 200 year, 24-hour storm, around the dam;
- Water will be discharged from the reservoir through two pipelines near the downstream toe of the dam: a 150 mm diameter pipe for instream flows and a concrete-enclosed, 610 mm diameter, steel pipe for flushing/channel maintenance flows; and
- The reservoir will discharge to a riprap-lined outfall channel to dissipate energy and to aerate the water with dissolved oxygen.

During the post-closure phase, when water quality in the TSF is sufficient for release to Davidson Creek, over-flow from the pit lake and TSF will be diverted to Davidson Creek through a spillway

channel. This channel will restore the watershed area in Davidson Creek to approximately baseline conditions. This will include the additional watershed area permanently diverted from the Creek 661 Watershed to Davidson Creek minus the watershed area no longer reporting to Davidson Creek above the Lake 01682LNRS diversion (**Section 5.2.1.3** of the Application).

Chedakuz Creek

Water withdrawn from Tatelkuz Lake to mitigate flow reductions in Davidson Creek will reduce flows in lower Chedakuz Creek between the lake outlet and the confluence with Davidson Creek. During construction, no change in baseline flows will occur because no water will be pumped from Tatelkuz Lake. However, during operations and closure phases when the FSS is operating, flows in lower Chedakuz Creek will be reduced, particularly between Tatelkuz Lake and the confluence with Davidson Creek (**Section 5.3.2** of the Application).

Potential effects to fish and fish habitat of flow changes in lower Chedakuz Creek were assessed using a flow/habitat model (**Appendix 5.1.2.6D** of the Application). Details of this assessment are also provided in **Section 5.3.9** of the Application. Potential effects were assessed by comparing modelled total available habitat for rainbow trout and kokanee over a 15-year time-series under baseline conditions to the total available habitat for rainbow trout and kokanee over the same 15-year time-series, but with Project components modelled, including the TSF footprint and pumping of mitigation flows from Tatelkuz Lake. This was done using the same biological stanzas described for Davidson Creek, with the following changes for lower Chedakuz Creek:

- The kokanee spawning period is August 1 to September 30; and
- The kokanee egg incubation period is October 1 to November 30.

These differences in kokanee spawn timing in lower Chedakuz Creek are caused by the warmer water temperatures downstream of Tatelkuz Lake, compared to temperatures in Davidson Creek.

The anticipated flow reductions during operations and closure in the 900 m section of lower Chedakuz Creek between Tatelkuz Lake and the confluence with Davidson Creek will result in the following changes from baseline:

- Up to a 9% reduction in rainbow trout spawning habitat in spring (May to June);
- An increase in total rainbow trout fry rearing habitat in summer (July to August) and fall (September to November);
- No more than 5% decrease in total juvenile rainbow trout rearing habitat in spring, summer, and fall; and
- No more than a 5% reduction in kokanee spawning habitat in late summer (August to September).

Therefore, assuming again that at least a 10% reduction in modelled total habitat availability is the threshold for a significant residual effect to rainbow trout and kokanee, no residual effect to

any life stage of rainbow trout or kokanee using lower Chedakuz Creek will occur. No additional mitigation measures are therefore required.

Creek 661

Besides limiting the amount of mine site infrastructure built in the Creek 661 Watershed, no other mitigation measure is proposed to minimize potential flow reductions in Creek 661 or any of its tributaries under or downstream of mine site infrastructure (i.e., Creek 505659, Creek 146920, and Creek 543585). Thus, potential flow reductions in these three headwater creeks and in the Creek 661 mainstem could occur during all phases of the Project as various components of the mine site infrastructure get built and encroach into the Creek 661 watershed. Potential effects to fish and fish habitat of flow changes in Creek 661 were assessed using a flow/habitat model (**Appendix 5.1.2.6D** of the Application). Details of this assessment are also provided in **Section 5.3.9** of the Application.

5.2.2.2 Mitigation of Changes in Downstream Water Quality

Mitigation measures to eliminate or reduce potential effects to fish and fish habitat due to changes in downstream water quality have been incorporated into Project design, the Project Description and are identified in the effects assessment sections for the Fish VC (**Section 5.3.8** of the Application) and the Fish Habitat VC (**Section 5.3.9** of the Application). These included measures that will be implemented during construction, operations, closure, and post-closure phases.

Construction Phase

The construction Sediment and Erosion Control Management Plan (SECMP) will be implemented during construction, to limit potentially detrimental increases in TSS concentrations in Davidson Creek, Creek 661, and Chedakuz Creek. This plan includes:

- Use of coffer dams around major instream construction areas (e.g., TSF dams) to minimize contact water volumes;
- Constructing surface water drainage ditching and temporary sediment ponds around mine site facilities to collect and capture site contact water during construction. Sediment ponds will be built downstream of each major disturbance area including:
  - Construction lay-down, truck shop, and contractor lay-downs and offices;
  - Plant site and crusher;
  - Construction camp;
  - Aggregate screening area;
  - Waste Rock Dumps;
  - TSF; and
  - Open pit;

- Using sump pits, wells, or removable pump stations to draw down the natural water table to provide dry, stable construction areas. Groundwater will be collected in the excavation sump pits and pumped to holding ponds, sediment basins, or sediment filter bags where required;
- Using BMPs and an adaptive management approach to minimise the volume of contact water and the amount of sediment in this water. BMPs will include:
  - Revegetation of disturbed areas;
  - Erosion control products such as silt fencing, coco-matting, filter fabrics, and other geo-textiles,
  - Surface roughening and re-contouring,
  - Filter bags and/or hay-bales,
  - Engineered diversion ditching and sediment traps,
  - Properly sized and installed culverts or open-bottom structures (i.e., clear-span bridges and/or open-bottom arch culverts); and
  - Exfiltration areas;
- Phasing sediment control to match the main construction activities: 1) land clearing and grading; 2) TSF construction; and 3) open pit development; and
- Routing of wastewater to rapid infiltration areas to avoid impacts to surface water streams.

Operations Phase

During operations, the primary mitigation measure to minimize changes in downstream water quality is the maintenance of a “zero-discharge” facility. This objective will be achieved through a variety of measures including:

- Constructing a seepage collection trench downstream of the TSF dam. This trench will be deep enough to intercept seepage infiltrating under and through the dam and extend far enough up the Davidson Creek valley to prevent seepage from flowing around the trench to Davidson Creek;
- Constructing an ECD in Davidson Creek downstream of the TSF Site D dam. This ECD will capture seepage flowing in the section of Davidson Creek downstream of the TSF dam and will also collect seepage delivered by the seepage collection trench;
- Collecting and pumping all seepage collected in diversion ditches, the seepage collection trench, the ECD pond and other seepage control ponds back to the TSF. This will include collection of all seepage and runoff from the East and West waste rock dumps. If the run-off from the East Waste Rock Dump meets site-specific water quality objectives, it may be discharged to Creek 661 instead of the TSF;
- Recycling water in the TSF for use in the mill. This recycling minimizes freshwater make-up requirements from Tatelkuz Lake and minimizes the volume of wastewater generated

while maintaining enough water in the TSF to keep PAG materials in a subaqueous state; and

- Constructing an additional dam upstream of the TSF Site C West Dam to back-flood Reach 12 of Davidson Creek and expand lake 01682LNRS. Raising the water level above the TSF will create a hydraulic gradient that prevents supernatant in the TSF Site C pond from seeping into the lake.

Seepage from the TSF Site D dam during mine operations and closure phases is anticipated to be 55 L/s. The majority of this seepage volume will be captured by the ECD; only 2L/s of seepage is expected to bypass the ECD dam and pond. This represents a 96% seepage recovery efficiency.

A cyanide destruction circuit will be incorporated into the mill effluent treatment prior to release of effluent to the TSF. This process will include:

- A high-power agitator each of three parallel tanks to assist with gas dispersion in the effluent slurry;
- A sparging system to inject sulphur dioxide and air into the effluent;
- Addition of milk-of-lime to maintain the slurry at the required pH level of 8.5;
- Addition of copper sulphate to maintain the reaction kinetics; and
- Dilution of the effluent slurry fed into the sparging system with water reclaimed from the TSF.

The circuit residence time will be 60 minutes at the rated throughput. The anticipated cyanide feed concentration of 100 mg/L coming into the cyanide destruction circuit will be reduced to less than 1 mg/L in effluent released to the TSF.

Water quality in the TSF will be improved by constructing passive treatment wetlands. This will include construction of wetlands in the TSF Site C pond in Years 4 and 5 of operations and construction of wetlands in the TSF Site D pond in the final year of operations (Year 18) and first year of closure (Year 19). The sinuous shape of the wetland constructed in the TSF Site D pond will ensure that when the pit lake over-flows to the TSF during closure that the inflow fully mixes with the TSF supernatant prior to discharge to Davidson Creek. The purpose of these wetlands is to lower the concentration of dissolved metals and nutrients (e.g., ammonia, nitrates) in the TSF supernatant.

Closure Phase

The mitigation measures to keep the Project a “zero-discharge” facility during operations will be maintained throughout the closure phase. Operation of the FSS will continue to augment flows in lower Davidson Creek. This will be continued until water quality monitoring shows that the TSF supernatant meets site-specific water quality objectives for Davidson Creek (expected to be approximately 18 years after mine operations have ceased).

Additional mitigation measures to reduce potential changes to downstream water quality during the post-closure phase will be constructed during the closure phase, but will not become active until water quality in the TSF is suitable for discharge and water is permitted to flow out into Davidson Creek. These measures include:

- Construction of a spillway in the Site D TSF dam that will terminate in a constructed plunge pool in Davidson Creek. Once water is discharged from the TSF, this plunge pool will prevent erosion of the stream bed and minimize the mobilization of sediment. The spillway elevation will be above the oxide/transition tailings interface elevation to ensure that the PAG tailings are kept saturated;
- Construction of treatment wetlands in the former ECD pond and freshwater reservoir. Once water is discharged from the TSF, these wetlands will be used to further reduce dissolved metal and nutrient concentrations of the TSF supernatant before it enters Davidson Creek. These wetlands will have a total combined area of about 26 ha; and
- As a contingency, provision for the construction of additional wetlands downstream of the freshwater reservoir has been included, in case this is required.

Post-Closure Phase

Mitigation measures during the post-closure phase of the Project to minimize potential changes in downstream water quality are related to when water from the mine site infrastructure can be released to the downstream receiving environment. In the Davidson Creek Watershed, the FSS will be operated until water quality in the TSF pond is sufficient to meet site-specific downstream water quality objectives developed in consultation with regulatory agencies during the permitting phase. The post-closure phase will begin when water can be discharged from the TSF to Davidson Creek. In the Creek 661 Watershed, run-off and seepage from the reclaimed East Waste Rock Dump will only be allowed to flow to Creek 661 if it meets site-specific water quality objectives. If not, this water will continue to be diverted to the TSF in the Davidson Creek Watershed.

5.2.2.3 Mitigation of Upstream Habitat Isolation

Habitat that will be isolated from Davidson Creek upstream of the various mine site facilities includes Reach 12 of Davidson Creek and Lake 01682LNRS, upstream of the TSF Site C West Dam, as well as tributaries to Reaches 8, 9, 10, and 12 of Davidson Creek:

- Reach 5 of Creek 636713 upstream of the TSF Site D pond;
- Reaches 2, 3, and 4 of Creek 668328 and its headwater tributaries upstream of the TSF Site D pond; and
- Reach 7 of Creek 704454 and its headwater tributaries upstream of the West Waste Rock Dump, ore-processing area and site infrastructure facilities.

Of these streams and lakes, only Reach 5 of Creek 636713 is non-fish-bearing and does not require mitigation to sustain rainbow trout or offsetting measures to address potential loss of fish production (**Figure 1-3**).

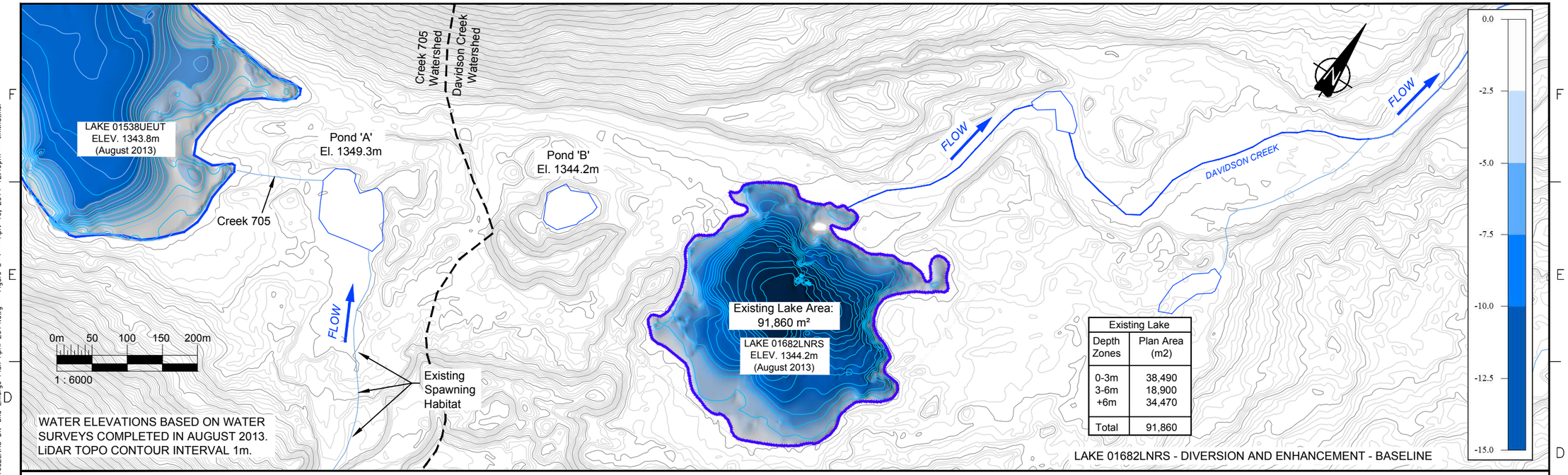
Habitat in the upper reaches of Creek 668328 and Creek 704454 supports juvenile rainbow trout, but does not provide sufficient spawning or overwintering habitat to sustain populations of trout once the Site D TSF, West Waste Rock Dump, and ore-processing facilities are built. Other than fish salvage, there are no mitigation measures possible to prevent the extirpation of rainbow trout from these headwater streams. This habitat will require offsetting to address this loss of rainbow trout production.

As indicated in **Section 3.0**, a resident rainbow trout population exists in Lake 1682LNRS. The sustainability of this population relies on small pockets of spawning habitat in Reach 11 of Davidson Creek downstream of the lake (9 m^2 in total) and in one small headwater tributary that enters the lake along its southern shoreline (18 m^2 in total). This is because the steep cascade that exists at the bottom of Reach 11 acts as a partial barrier to immigration of rainbow trout to Lake 01682LNRS from lower reaches of Davidson Creek.

Spawning habitat in Reach 11 of Davidson Creek will be lost under footprints of TSF Site C and the TSF Site C West dam. Spawning habitat will remain in the small inlet tributary when the lake is isolated from Davidson Creek. However, the combination of complete isolation from Davidson Creek due to TSF construction, and the reduction in spawning habitat availability reduces the long-term viability of the Lake 01682LNRS population. Therefore, it is conservatively assumed that the Lake 01682LNRS rainbow trout population will not persist in perpetuity, and that mitigation is therefore required to avoid a residual Project effect to fish and fish habitat.

Lake 01682LNRS Enlargement and Diversion Concept

To mitigate the potential effects to the Lake 01682LNRS rainbow trout population, Lake 01682LNRS will be connected to Lake 01538UEUT in the adjacent Creek 705 Watershed. This will be accomplished in two ways. First, a new dam will be constructed in Reach 12 of Davidson Creek upstream of the TSF Site C West Dam (**Figure 5-1** and **Figure 5-2**). This dam will back-flood Reach 12 of Davidson Creek, raising the water level in this reach to the existing level of Lake 01682LNRS (i.e., 1,344.2 masl).



Existing Lake	
Depth Zones	Plan Area (m2)
0-3m	38,490
3-6m	18,900
+6m	34,470
Total	91,860

REV	DSN	CHK	DR	APP	D/M/Y	REVISION
1			TH	BM	17/03/13	ISSUED FOR DRAFT REPORT

REF	NUMBER	REFERENCES

ISS	D/M/Y	APP	ISSUED FOR

Notes

1. Conceptual engineering detail only. Target water elevations of enlarged lake shall be based on existing mean annual water elevation of Lake 01682LNRS.
2. Lake Dam and Site 'C' Saddle Dam to be deteremined (TBD) by Knight and Piesold Ltd.

Data Sources:

1. Bathymetric lake surveys of existing lake performed by Ecofor, 2011 (Amec 2011-2012 Baseline Report - Fish and Aquatic Resources).
2. Freshwater Atlas Streams and Lakes - BC Government GEOBC Data Distribution.

newgold

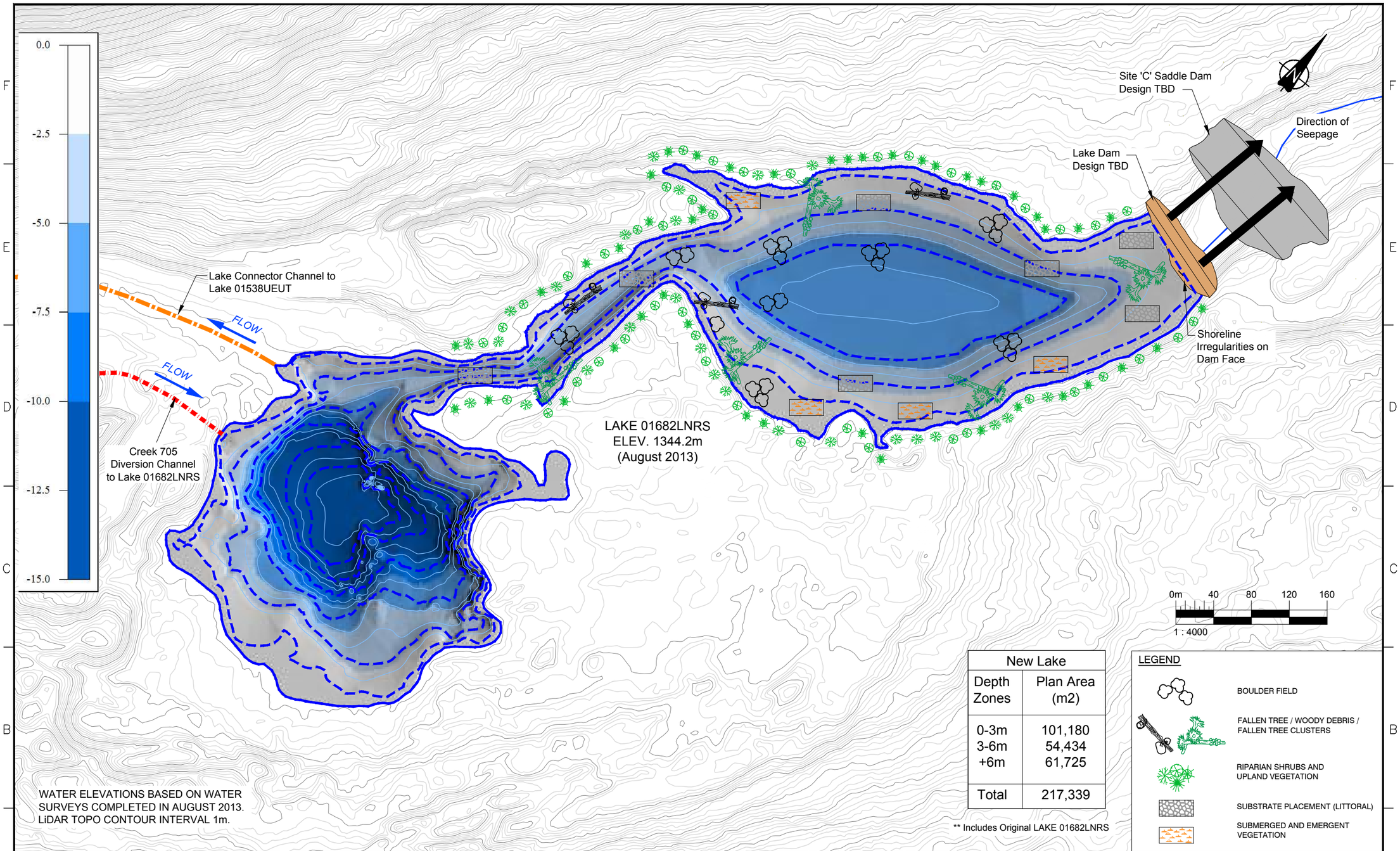
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BLACKWATER MINE PROJECT

Lake 01682LNRS
Diversion and Enlargement Plan

FILE NO: VE52277			DATE: APRIL 2014
PROJECTION: UTM Zone 10	DATUM: NAD 83		FIGURE: Figure 5-1
JOB NO: VE52277	REVISION NO: 1		

N:\Projects\52000\VE52200\VE52277 - New Gold - Blackwater EA 2013\7000 Compensation\Fish Habitat\04 Drawings and Maps\CAD Folder\NFigure 5-1 Lake-01682LNRS Div and Enlarge Plan April 2014.dwg - Figure 5-1 - Apr. 10, 2014 12:49pm - tim.hawker



WATER ELEVATIONS BASED ON WATER SURVEYS COMPLETED IN AUGUST 2013.
LiDAR TOPO CONTOUR INTERVAL 1m.

New Lake	
Depth Zones	Plan Area (m2)
0-3m	101,180
3-6m	54,434
+6m	61,725
Total	217,339

** Includes Original LAKE 01682LNRS

LEGEND

- BOULDER FIELD
- FALLEN TREE / WOODY DEBRIS / FALLEN TREE CLUSTERS
- RIPARIAN SHRUBS AND UPLAND VEGETATION
- SUBSTRATE PLACEMENT (LITTORAL)
- SUBMERGED AND EMERGENT VEGETATION

REV	DSN	CHK	DR	APP	D/M/Y	REVISION
1			TH	BM	17/03/13	ISSUED FOR DRAFT REPORT

REF	NUMBER	REFERENCES

ISS	D/M/Y	APP	ISSUED FOR

NOTES

1. Conceptual engineering detail only. Target water elevations of enlarged lake shall be based on existing mean annual water elevation of Lake 01682LNRS.
2. Distribution and type of littoral habitat classes, habitat features, and substates will be designed using natural analogues from local headwater lakes.

Data Sources:

1. Bathymetric lake surveys of existing lake performed by Ecofor, 2011 (Amec 2011-2012 Baseline Report - Fish and Aquatic Resources).

BLACKWATER MINE PROJECT

Lake 01682LNRS Diversion and Enlargement Concept Detail

FILE NO:	DATE:
VE52277	APRIL 2014
PROJECTION: UTM Zone 10	DATUM: NAD 83
JOB NO: VE52277	REVISION NO: 1
	FIGURE: Figure 5-2

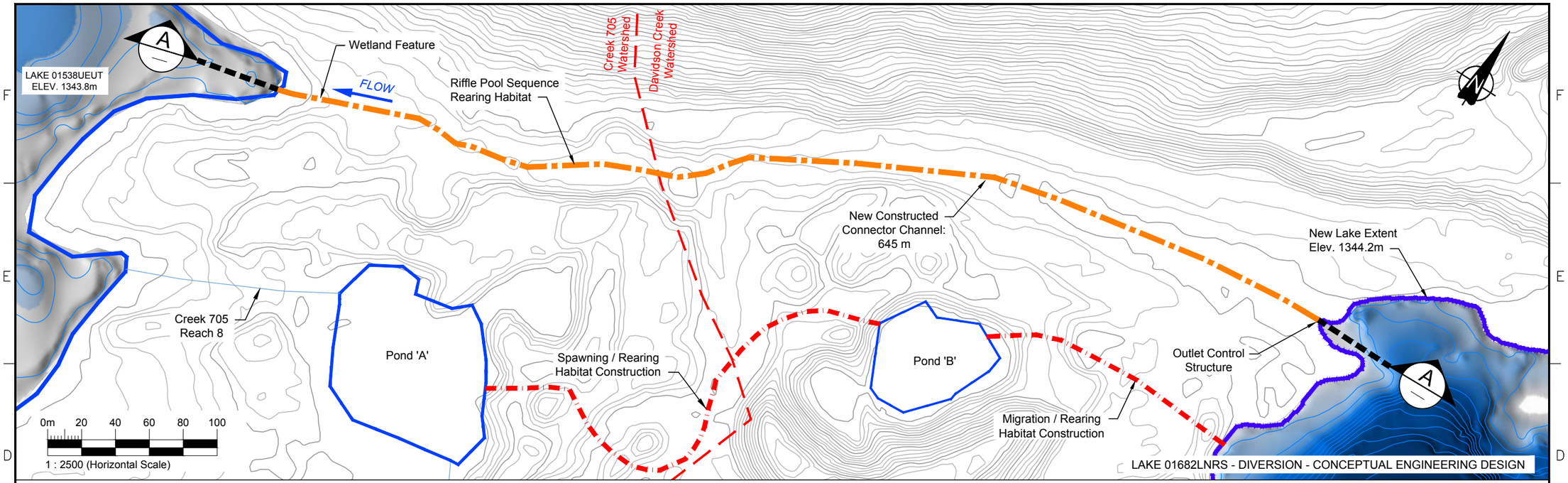
N:\Projects\52000\VE52200\VE52277 - New Gold - Blackwater EA 2013\7000 Compensation\Fish Habitat\04 Drawings and Maps\CAD Folder\NFigure 5-2 Lake-01682LNRS Div and Enlarge Details April 2014.dwg - Figure 5-2 - Apr. 10, 2014 2:22pm - tim.hawker

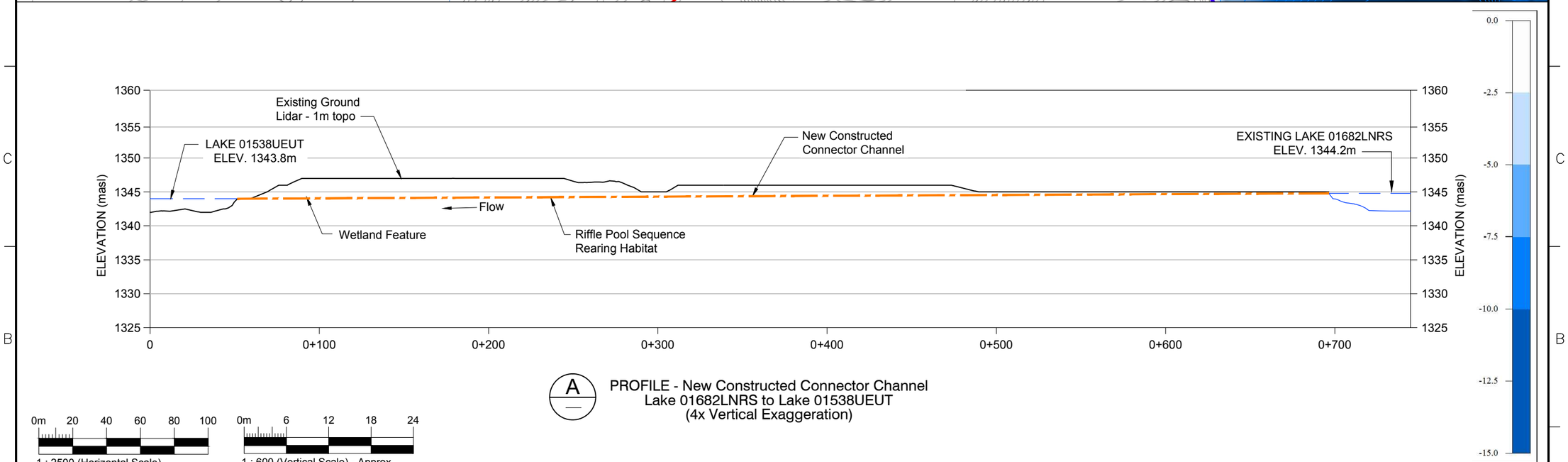
This dam will cause water that previously flowed out of the lake through Reach 12 to flow towards Lake 01538UEUT instead. Lake 01682LNRS is 0.4 m higher in elevation than Lake 01538UEUT. Thus, a hydraulic gradient naturally exists between the two lakes and, because the height of the divide between the two lakes is low, the height of the dam built in Reach 12 needs only to be high enough to back-flood Reach 12 to the existing Lake 01682LNRS water level elevation. The height of Lake 01682LNRS itself will not need to be raised to force water to flow towards Lake 01538UEUT. This minimizes or eliminates two potential ancillary effects to fish in the new lake: 1) it limits the amount of upland area flooded by the new dam, thereby minimizing the amount of mercury that may be released to the aquatic food web; and 2) it avoid the flooding of existing lake shoreline habitat and of spawning habitat in the one small tributary that enters Lake 01682LNRS on its southern shoreline. The dam will also increase the area of Lake 01682LNRS by approximately 125,500 m^2; this increase in lake area will be used to offset unavoidable impacts to fish and fish habitat that occur elsewhere on the Project site. The offsetting component of the lake enlargement and diversion plan is addressed in **Section 7**.

Second, a channel will be constructed between Lake 01682LNRS and Lake 01538UEUT (**Figure 5-3**). This connector channel will be approximately 650 m long and will likely vary between 2 m to 4 m wide. The design will not be finalized until the permitting phase, but besides conveying water between the two lakes, this channel could include habitat features that will benefit rainbow trout. Depending on the final channel gradient and flow volume, these features could include spawning riffles and glides, deep pools for juvenile and fry rearing, and large woody debris and boulder clusters to increase habitat diversity and cover (**Figure 5-4**).

Riffle-pool sequences will be incorporated as gradient permits. Wetland features may be created in widened sections of the channel to replicate natural conditions in low gradient streams. Stream banks will be vegetated with native plant species and rock-lined where necessary to prevent erosion, and will replicate bank conditions in local headwater streams. Woody debris, cobbles/boulders, deep pools, and riparian plantings will be incorporated to create summer rearing habitat for fry and juvenile rainbow trout. An engineered or impervious clay layer may be required in this connector channel to avoid water losses and keep the stream channel from going dry in summer and winter.

The final mitigation measure required for the Lake 01682LNRS diversion will be replacement of 9 m^2 of spawning habitat lost under the TSF Site C footprint in Reach 11 of Davidson Creek. Replacement is required because this spawning habitat is assumed to support the long-term sustainability of the lake's rainbow trout population. This spawning habitat will be replaced by constructing a new channel between a headwater pond that naturally drains towards Lake 01538UEUT (i.e., "Pond A") and a headwater pond that naturally drains towards Lake 01682LNRS (i.e., "Pond B") (**Figure 5-1**). The rationale for selection of this channel route between three other alternative routes is provided in **Annex B**. Once constructed, this channel will divert the Lake 01538UEUT headwater tributary to Lake 01682LNRS. This diversion will not result in a loss of inflow to Lake 01538UEUT because this watershed area will remain connected to Lake 01538UEUT via the channel constructed from Lake 01682LNRS.





A

PROFILE - New Constructed Connector Channel
Lake 01682LNRS to Lake 01538UEUT
(4x Vertical Exaggeration)

0m 20 40 60 80 100
1 : 2500 (Horizontal Scale)

0m 6 12 18 24
1 : 600 (Vertical Scale) - Approx.

REV	DSN	CHK	DR	APP	D/M/Y	REVISION
1			TH	BM	17/03/13	ISSUED FOR DRAFT REPORT

REF	NUMBER	REFERENCES

ISS	D/M/Y	APP	ISSUED FOR

NOTES

1. Conceptual engineering detail only. Channel sinuosity and location/layout of riffle-pool sequences and wetland features pending further investigations, including topographical surveys and soils/goundwater surveys between the two lakes.

Data Sources:

1. Bathymetric lake surveys performed by Ecofor, 2011 (Amec 2011-2012 Baseline Report - Fish and Aquatic Resources).
2. Freshwater Atlas Streams and Lakes - BC Government GEOBC Data Distribution.

newgold

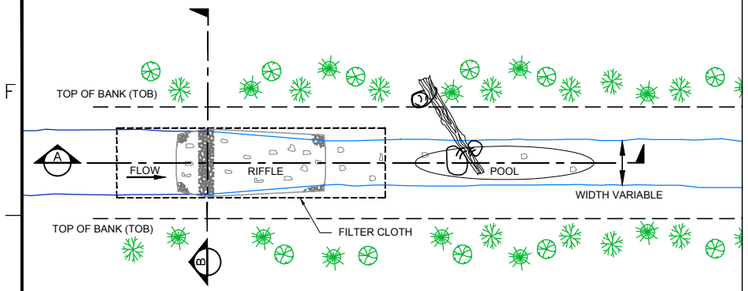
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BLACKWATER MINE PROJECT

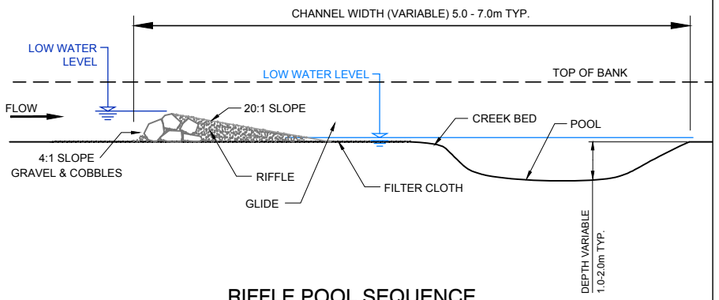
Lake 01682LNRS Connector and Channel Diversion Details and Profile

FILE NO: VE52277		DATE: APRIL 2014	
PROJECTION: UTM Zone 10	DATUM: NAD 83	FIGURE: Figure 5-3	
JOB NO: VE52277	REVISION NO: 1		

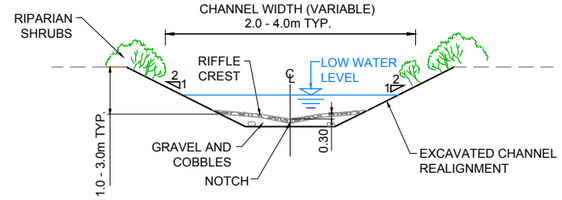
N:\Projects\52000\VE52200\VE52277 – New Gold – Blackwater EA 2013\7000 Compensation\Fish Habitat\04 Drawings and Maps\CAD Folder\[Figure 5-3 Lake-01682LNRS Connector and Channel Div Details April 2014.dwg – Figure 5-3 – Apr. 10, 2014 12:50pm – tim.hawker



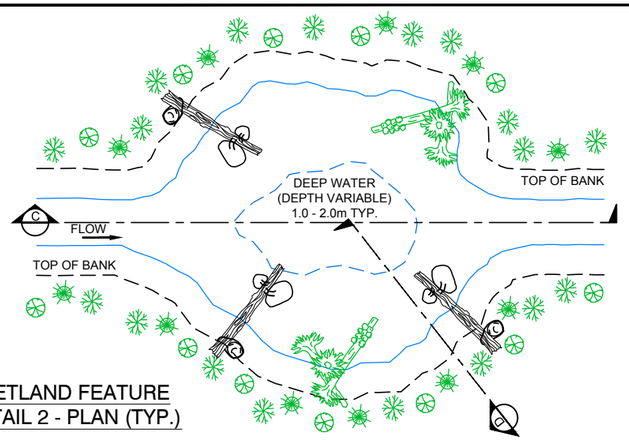
RIFFLE POOL SEQUENCE
DETAIL 1 - PLAN (TYP.)



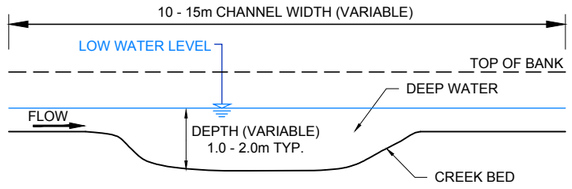
RIFFLE POOL SEQUENCE
SECTION A (TYP.)



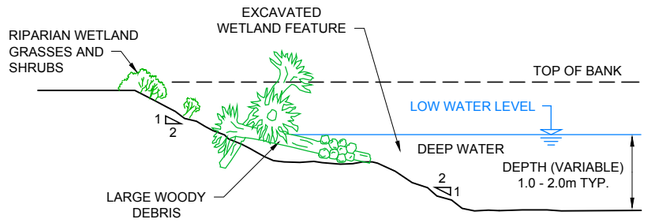
SECTION B - RIFFLE (TYP.)



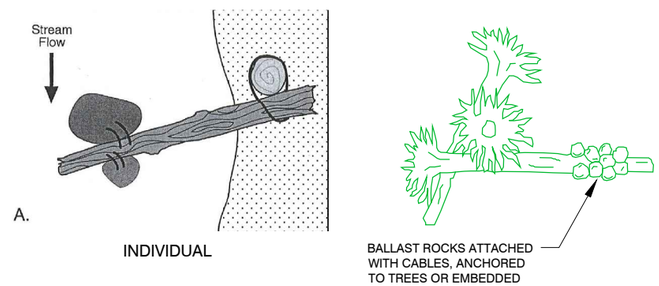
WETLAND FEATURE
DETAIL 2 - PLAN (TYP.)



WETLAND FEATURE
SECTION C (TYP.)



WETLAND FEATURE
SECTION D (TYP.)



LWD TYPICAL SPECIFICATIONS
- 30-60 cm DIAMETER
- UP TO 5 m LENGTH
- NATIVE PINE OR SPRUCE WITH BRANCHES AND ROOT WADS
- WOOD PIECES CABLED TOGETHER FOR STABILITY

LARGE WOODY DEBRIS TYPICALS
CHANNEL AND WETLAND

LEGEND:

- RIPARIAN WETLAND GRASSES AND SHRUBS
- LARGE WOODY DEBRIS INDIVIDUAL
- LARGE WOODY DEBRIS CLUSTER

NOTES:

1. Conceptual engineering detail only. Channel sinuosity and location/layout of riffle-pool sequences and wetland features are pending further investigations, including topographical surveys and soils/goundwater surveys between the two lakes.
2. New diversion channel shall be constructed using instream isolaton techniques to prevent sediment mobilization and transport to lakes. Site-specific environmental management plans shall be developed to address best management practices for instream construction, work-site isolation, erosion and sediment control, water management, riparian management and other environmental concerns.

REV	DSN	CHK	DR	APP	D/M/Y	REVISION
1			TH	BM	17/03/13	ISSUED FOR DRAFT REPORT

REF	NUMBER	REFERENCES

ISS	D/M/Y	APP	ISSUED FOR

Data Sources:
1. Riffle design guidelines based on Newbury et.al 1997.

newgold

amec

BLACKWATER MINE PROJECT

Lake 01682LNRS
Connector Channel Design Details

FILE NO:		DATE:
VE52277		APRIL 2014
PROJECTION: UTM Zone 10	DATUM: NAD 83	FIGURE: Figure 5-4
JOB NO: VE52277	REVISION NO: 1	

N:\Projects\52000\VE52200\VE52277 - New Gold - Blackwater EA 2013\7000 Compensation\Fish Habitat\04 Drawings and Maps\CAD Folder\VNFigure 5-4 Lake-01682LNRS Connector Channel Design Details April 2014.dwg - Figure 5-4 - Apr. 10, 2014 12:51pm - tim.hawker

The size, route, and design features of this new diversion channel will be finalized during the permitting phase. However, the distance and gradient between the two headwater ponds is sufficiently large, approximately 230 m and 2% respectively, that the channel can incorporate rainbow trout spawning, fry rearing and juvenile rearing habitat, and potentially overwintering habitat. If it is conservatively assumed that the new channel will be 230 m long and 1 m wide but only 25% of the channel will be designed to provide spawning habitat, approximately 60 m^2 of new spawning habitat will be created. This will be more than six times the amount of spawning habitat lost in Reach 11 downstream of Lake 01682LNRS, although some of this habitat will be required to support offset habitat created in the expanded Lake 01682LNRS (**Section 7**).

Potential Ancillary Impacts to Fish and Fish Habitat

Potential ancillary effects of enlargement of Lake 01682LNRS are addressed in **Section 7**.

Connection of Lake 01682LNRS and Lake 01538UEUT will allow the mixing of rainbow trout populations in the Davidson Creek and Creek 705 watersheds. Microsatellite DNA analysis of rainbow trout captured in Davidson Creek and in Fawnie Creek indicated that there were significant genetic similarities between the two watersheds (**Appendix 5.1.2.6A** of the Application). This is not unexpected given the close proximity of the two watersheds and the low relief between the two headwater lakes. For these reasons, mixing of rainbow trout from Lake 01682LNRS is not expected to have any negative effects on the genetic make-up of rainbow trout in Lake 01538UEUT or the Creek 705 and Fawnie Creek watersheds downstream.

Connection of Lake 01682LNRS to Lake 01538UEUT will also increase the watershed area of Lake 01538UEUT by approximately 50%. This will increase monthly run-off volumes at the Lake 01538UEUT outlet by between 40% and 70% depending on the season (**Section 5.3.2** of the Application). This increase in flow, could affect habitat in Creek 705.

Potential flow effects on fish and fish habitat were considered for two sections of Creek 705: the lower reaches near Fawnie Creek and reaches immediately downstream of Lake 01538UEUT. Flow/habitat models were constructed for Reaches 1 and 2 of Creek 705, upstream of the confluence with Fawnie Creek (**Section 5.3.9** of the Application). Results predicted no significant changes in fish habitat due to changes in flow, and no residual effects to fish and fish habitat in the lower reaches of Creek 705 are anticipated. Flow increases immediately downstream of Lake 01538UEUT will be proportionally larger than in lower reaches. Flow/habitat models were not constructed for stream sections immediately downstream of Lake 01538UEUT because the channel in these reaches is small and, therefore, not conducive to flow/habitat modelling and because flow/habitat models do not address any physical changes that may occur to the channel and stream banks as a result of increased flow. The channel immediately downstream of Lake 01538UEUT is expected to adjust in response to the increased flows, with most of these physical changes occurring during the spring freshets that immediately follow diversion.

The most likely effects to habitat downstream of the lake will be channel widening and bank erosion at locations where the channel is narrow and steep, and banks are soft. The 250 m of immediately downstream of Lake 01538UEUT is low gradient (1.5%) and largely unconfined. Habitat is predominantly pools, separated by short riffle and glide sections with large cobble

substrates. There is also a larger fen and wetland complex created by a beaver dam. While some bank erosion and channel widening may occur at riffle and glide sections, minimal changes to most habitat in this reach are expected, particularly in the fen and wetland complex due to low gradient and dissipation of energy in the deeper, wider habitats. Further downstream, the channel steepens (3% gradient) and becomes occasionally confined for approximately 800 m. Habitat is dominated by cobble riffles and cobble/gravel glides with cobble-armoured banks. Physical changes in this reach are expected to be minor due to the larger substrates and armouring of the channel and banks. Channel gradient drops to 1% below this point and the channel becomes largely unconfined over a length of 2,400 m, to the confluence with the stream draining Lake 01428UEUT. Habitat is comprised of beaver-impounded wetlands separated by riffles and glides with cobble substrates. Stream banks are largely comprised of erodible gravels and fines. Physical changes in this reach are expected to occur in the riffles and runs where the channel narrows. However, no change is expected in pools or wetlands where greater depths and unconfined channels will dissipate the energy from the higher flows.

Given these physical attributes, it is expected that the channel will adjust to accommodate increased flows after one or two consecutive spring freshets. These changes are expected to be limited to the few places where steeper riffles and glides with soft banks exist, to be restricted to the section of Creek 705 upstream of the confluence with the stream draining Lake 01428UEUT, and are unlikely to alter the availability or suitability of existing rearing or spawning habitat. The effects to fish production in this section of Creek 705 are expected to be negligible. Increased suspended solids from eroded banks will be temporary and will occur during spring when sediment concentrations are naturally high. Increased spring flows may increase the availability of spawning habitat downstream of Lake 01538UEUT by removing accumulated sediments in riffles and glides. For these reasons, no significant adverse effects to fish or fish habitat are anticipated due to diversion of flows from Lake 01682LNRS to Lake 01538UEUT, and no further mitigation is deemed necessary

5.2.2.4 Mitigation of Direct Mortality of Fish under and Upstream of Mine Site Facilities

Direct mortality of fish in stream reaches that will be lost during construction of site infrastructure, open pit, waste rock dumps, TSFs, ore-processing area, wetlands and water management system, and borrow areas will be minimized by salvaging fish prior to commencement of any construction activities in these streams. This will likely involve isolating the habitat with stop nets or fencing and, depending on the size of streams, using a combination of baited minnow traps and backpack electrofishing to capture fish. The stop nets and fencing will be required to prevent fish from entering the streams while the fish salvages were being conducted.

All fish captured will be identified, enumerated, measured and then released into lower reaches of the same watershed they were captured in. A preliminary fish salvage plan is described in **Section 12.2.1.18.4.21**), and a detailed plan will be prepared in consultation with regulatory agencies.

5.2.3 Mitigation for Freshwater Supply System

Mitigation measures for construction, operation, and closure of the FSS are those that will minimize or eliminate the direct mortality of fish in Tatelkuz Lake, at streams crossed by the pipeline and access road, and within the footprint of the freshwater reservoir in Davidson Creek and indirect effects to fish growth, survival and recruitment due to increases in TSS concentrations or interruption of fish migrations along the pipeline ROW and changes in water temperatures in Davidson Creek below the freshwater reservoir. A summary of mitigation measures that will be implemented for the FSS and other linear developments required for the Project is provided in **Table 5-2**.

Direct mortality of fish by the FSS will be mitigated by:

- Installing appropriately sized mesh screens over the ends of the FSS intake pipes in Tatelkuz Lake. These screens will be designed to meet DFO's *Freshwater Intake End-of-Pipe Fish Screen Guidelines* (DFO, 1995, 2013) and will therefore minimize the number of fish impinged on the screens and entrained in the pumps. Additional mitigation measures to reduce mortality of fish at these intake pipes includes:
  - Extending intake pipes sufficiently far out into the lake to prevent entrainment of sediment and aquatic organisms associated with the bottom;
  - Installing a manifold to ensure even velocity distribution across the screen surface;
  - Regularly removing, inspecting, and cleaning the screens; and
  - Shutting down pumps when fish screens are removed for inspection and cleaning.
- Timing pipeline and access road stream crossing construction so that it occurs during the "Reduced Risk Timing Windows" for rainbow trout (15 July to 15 April of the following year) for rainbow trout in the Omineca Region 7 (BC MWLAP, 2004). Doing so will eliminate potential interruption of spawning migrations, description of fish eggs and the detrimental effects of sedimentation of fish and fish eggs downstream;
- Five of six pipeline stream crossings will be over clear span bridges, eliminating the need for instream work and reducing potential effects to fish habitat;
- One of the six pipeline stream crossings will be trenched. At this site, the work area will be isolated and water diverted around the site during construction to minimize sedimentation downstream. A fish salvage will be conducted within the isolated area prior to dewatering; and
- Isolating the freshwater reservoir construction area in Davidson Creek and conducting fish salvage within it prior to dewatering.

Table 5-2: Summary of Mitigation Measures to Reduce or Eliminate Potential Serious Harm to due to Linear Developments Required for the Project

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Mitigation Measure	Likely Effectiveness
Construction	Mine Access Road	Site clearing, grading and topsoil salvage, road and lay-down area construction including transfer and placement of granular materials and stream crossings. Transportation of workforce and materials	**Direct Effects**:) alteration or destruction of fish habitat at access road stream crossings; 2) mortality of fish during construction of access road stream crossings; 3) mortality of fish due to spills of hydrocarbons and hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	1. Erosion and sediment control plans 2. Follow BC MOF (2012) "*Fish-Stream Crossing Guidebook*" and DFO (2013c) "*Measures for Avoiding Causing Harm to Fish and Fish Habitat*" 3. Construction during Reduced Risk Timing Windows for rainbow trout 4. Minimize ford crossings	High
	Kluskus-Ootsa FSR	Road upgrades. Transportation of workforce and materials	**Direct Effects**: 1) alteration or destruction of fish habitat at stream crossings; 2) mortality of fish during construction of stream crossings; 3) mortality of fish due to spills of hydrocarbons and hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	1. Erosion and sediment control plans 2. Follow BC MOF (2012) "*Fish-Stream Crossing Guidebook*" and DFO (2013c) "*Measures for Avoiding Causing Harm to Fish and Fish Habitat*" 3. Construction during Reduced Risk Timing Windows for rainbow trout 4. Minimize ford crossings	High
	FSS	ROW clearing and grading, timber salvage and soil management, facilities construction (pump-house, water intake, electrical hook-up), road construction, installation of water pipeline and fresh water reservoir. Transportation of workforce and materials	**Direct Effects**: 1) permanent loss of fish habitat under freshwater reservoir dam; 2) permanent alteration of fish habitat within freshwater reservoir pond; 3) temporary alteration of fish habitat at pipeline and access road stream crossings; 4) mortality of fish within the freshwater reservoir dam and pond work area; 5) mortality of fish stranded immediately downstream of the freshwater reservoir dam and pond work area **Indirect Effects:** 1) interruption of fish passage at stream crossings along pipeline route; 2) interruption of fish passage in Davidson Creek above freshwater reservoir dam; 3) change in downstream water quality below freshwater reservoir dam; 4) change in downstream water quality at stream crossings along pipeline and access road;	1. Construction during Reduced Risk Timing Windows 2. Isolation of instream work areas 3. Fish salvages in isolated works areas prior to construction 4. Erosion and sediment control plans 5. Emergency spill response plans	High
	Airstrip	Site clearing and grading, timber and soil salvage, construction of runway and construction of airstrip ancillary facilities (service road installation and site infrastructure). Transportation of workforce and materials	**Direct Effects**: 1) alteration or destruction of fish habitat at access road stream crossings; 2) mortality of fish during ford crossings by heavy machinery or during construction of access road stream crossings; 3) mortality of fish due to spills of hydrocarbons and hazardous materials **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	1. Erosion and sediment control plans 2. Follow BC MOF (2012) "*Fish-Stream Crossing Guidebook*" and DFO (2013c) "*Measures for Avoiding Causing Harm to Fish and Fish Habitat*" 3. Construction during Reduced Risk Timing Windows for rainbow trout 4. Minimize ford crossings	High
	Transmission Line	ROW clearing and preparation, vegetation clearing, construction of access roads, installation of power line (pole foundations, poles and cable stringing). Transportation of workforce and materials	**Direct Effects**: 1) temporary alteration of fish habitat at ford crossings; 2) alteration or destruction of fish habitat at access road stream crossings; 3) mortality of fish during ford crossings by heavy machinery or during construction of access road stream crossings; 4) mortality of fish due to spills of hydrocarbons **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) decrease in shade, cover, nutrient additions due to management of riparian vegetation; 3) alteration of fish passage due to temporary ford crossings or during stream crossing construction	1. Erosion and sediment control plans 2. Follow BC MOF (2012) "*Fish-Stream Crossing Guidebook*" and DFO (2013c) "*Measures for Avoiding Causing Harm to Fish and Fish Habitat*" 3. Construction during Reduced Risk Timing Windows for rainbow trout, Arctic grayling, bull trout, kokanee, or mountain whitefish as required 4. Minimize ford crossings 5. Optimize use of existing ROWs and watercourse crossings 6. Approved Work Practices for Riparian Vegetation Management	High

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Mitigation Measure	Likely Effectiveness
Operations	Mine Access Road	Transportation of workforce and materials and maintenance	**Direct Effects**: mortality of fish due to spills of hydrocarbons or hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	1. Provincial road maintenance guidelines 2. Emergency spill response plans	High
	Kluskus-Ootsa FSR	Maintenance and transportation of workforce and material	**Direct Effects**: mortality of fish due to spills of hydrocarbons or hazardous materials **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) changes in downstream water quality due to spills of hydrocarbons and hazardous materials	3. Provincial road maintenance guidelines 4. Emergency spill response plans	High
	FSS	Pumping of water and maintenance of system	**Direct Effects**: 1) mortality of fish impinged on intake screens or entrained in pumps and pipeline; 2) permanent loss of fish habitat under freshwater reservoir dam; 3) permanent alteration of fish habitat within freshwater reservoir pond; 4) temporary alteration of fish habitat at pipeline and access road stream crossings **Indirect Effects:** 1) draw-down of Tatelkuz Lake levels and subsequent loss of littoral habitat area; 2) interruption of fish passage at stream crossings along pipeline route; 3) change in downstream water quality at stream crossings along pipeline and access road; 4) change in water temperature and water chemistry in Davidson Creek due to water releases from freshwater reservoir; 5) maintenance of flows in Davidson Creek	1. Installation of appropriately sized screens on intake pipes 2. Shutting down pumps during maintenance 3. Manifold to ensure even water velocity distribution across screens 4. Water extraction below thermocline 5. Storage of water in freshwater reservoir before release to Davidson Creek	**Direct mortality** effects: High **Indirect effects (stream crossings):** High **Indirect effects (Tatelkuz Lake):** Moderate **Indirect effects (Davidson Creek flows):** High **Indirect effects (Davidson Creek water quality and temperature)**: low
	Airstrip	Maintenance only. No regular scheduled flights	**Direct Effects**: none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	Provincial road maintenance guidelines	High
	Transmission Line	Maintenance	**Direct Effects**: none **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) decrease in shade, cover, nutrient additions due to management of riparian vegetation	1. Provincial road maintenance guidelines 2. Approved Work Practices for Riparian Vegetation Management	High
Closure	Mine Access Road	Maintenance	**Direct Effects**: none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	Provincial road maintenance guidelines consistent with road use agreement	High
	Kluskus-Ootsa FSR	Maintenance	**Direct Effects**: none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	Provincial road maintenance guidelines consistent with road use agreement	High
	FSS	Pumping of water and maintenance of system, decommissioning of fresh water reservoir	**Direct Effects**: 1) mortality of fish impinged on intake screens or entrained in pumps and pipeline; 2) permanent loss of fish habitat under freshwater reservoir dam; 3) permanent alteration of fish habitat within freshwater reservoir pond; 4) permanent alteration of fish habitat at pipeline and access road stream crossings **Indirect Effects:** 1) draw-down of Tatelkuz Lake levels and subsequent loss of littoral habitat area; 2) interruption of fish passage at stream crossings along pipeline route; 3) change in downstream water quality at stream crossings along pipeline and access road; 4) change in water temperature and water chemistry in Davidson Creek due to water releases from freshwater reservoir; 5) maintenance of flows in Davidson Creek	1. Installation of appropriately sized screens on intake pipes 2. Shutting down pumps during maintenance 3. Manifold to ensure even water velocity distribution across screens 4. Water extraction below thermocline 5. Storage of water in freshwater reservoir before release to Davidson Creek	**Direct mortality** effects: High **Indirect effects (stream crossings):** High **Indirect effects (Tatelkuz Lake):** Moderate **Indirect effects (Davidson Creek flows):** High **Indirect effects (Davidson Creek water quality and temperature)**: low
	Airstrip	Maintenance; No regular scheduled flights	**Direct Effects**: none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	Provincial road maintenance guidelines	High

Phase	Mine Site Component	Proposed Work, Undertaking or Activity	Potential Effects	Mitigation Measure	Likely Effectiveness
	Transmission Line	Decommissioning and removal of cables and poles, implement reclamation plan (re-contouring and revegetation)	**Direct Effects**: none **Indirect Effects:** 1) changes in downstream water quality due to erosion and sedimentation; 2) improvement of riparian vegetation growth and subsequent increases in shade, cover, nutrient additions, and decreases in sediment.	Erosion and sediment control plans	High
Post-closure	Mine Access Road	Maintenance and occasional transportation of people	**Direct Effects**: none **Indirect Effects:** changes in downstream water quality due to erosion and sedimentation	Provincial road maintenance guidelines	High
	Kluskus-Ootsa FSR	Occasional transportation of people	**Direct Effects**: none **Indirect Effects:** none	None	n/a
	Fresh Water Supply System	None	**Direct Effects**: none **Indirect Effects:** none	None	n/a
	Airstrip	None	**Direct Effects**: none **Indirect Effects:** none	None	n/a
	Transmission Line	None	**Direct Effects**: none **Indirect Effects:** none	None	n/a

Potential temperature changes in Davidson Creek, and subsequent indirect effects to the growth, survival, and reproductive success of rainbow trout and kokanee, may occur due to water withdrawals from Tatelkuz Lake. Water will be withdrawn from between 8 and 12 m deep in Tatelkuz Lake. This depth range was chosen because it is typically below the thermocline that develops in the lake in summer and, therefore, avoids water temperatures above this thermocline that occasionally exceed the upper incipient lethal temperatures for rainbow trout (≥25°C) and, more frequently, exceed the upper temperature preference for rainbow trout (≥20°C).

The current thermal regime of Davidson Creek follows a bell-shaped curve typical of northern Canadian streams over the course of the year: a relatively constant temperature between December and March near 0°C, a summer peak temperature approaching 20°C by July or August, and increasing spring (April to June) temperatures and decreasing fall (September to November) temperatures separating winter and summer extremes. Daily water temperature fluctuations occur in response to diel cycles while weekly water temperature fluctuations occur in response to short-term weather patterns. Operation of the FSS during the operations and closure phases will cause the thermal regime of Davidson Creek to be much less variable in a daily, weekly, and seasonal basis.

The potential residual effects to fish from this altered thermal regime include: 1) faster development of rainbow trout embryos in spring and earlier emergence of fry; 2) slower growth of juvenile rainbow trout in summer; and 3) faster embryo development of kokanee in winter. **Section 5.3.8** of the Application provides a more detailed assessment of the effects on fish of temperature changes in Davidson Creek.

5.2.4 Mitigation for the Mine Access Road

Mitigation measures to reduce or eliminate potential effects to fish and fish habitat at the streams crossings on the new mine access road are those that will reduce erosion and downstream sedimentation, minimize the amount of fish habitat temporarily or permanently altered or destroyed, and prevent potential obstructions to upstream and downstream fish migrations. Mitigation measures that will be implemented at these stream crossings include those set out in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012) including:

- Use of existing disturbed areas (e.g., cut-blocks) and the same corridors as the transmission line to the extent possible;
- Use of erosion and sediment control measures such as riprap armouring, erosion control matting, and hydro seeding to protect erodible soils on stream banks;
- Installation of closed-bottom culverts only on non-fish-bearing streams;
- Construction of clear-span bridges or open-bottom culverts on fish-bearing streams in accordance with the guidelines and mitigation measures outlined in the *Fish-Stream Crossing Guidebook* (BC MOF, 2012) and DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013c) including:
    - Placement of abutments above the high water levels of each stream;

  - Design and construction of road approaches such that they are perpendicular to the watercourse to minimize loss or disturbance to riparian vegetation; and
  - Avoidance of stream crossings at meander bends, braided areas, alluvial fans, active floodplains or any other area that is inherently unstable and could result in erosion and scouring of the stream bed or compromise the integrity of the crossing structures;
- Construction will be timed so that instream works will be completed within "Reduced Risk Timing Windows" for rainbow trout (15 July to 15 April of the following year) in the Omineca Region 7 (BC MOE, 2004);
- Cross drains will be placed in seepage zones and in areas of low relief to minimize disruption of local drainage patterns;
- Use of ford crossings will be minimized but, where required, will be carried out in accordance with DFO's *Measures to Avoid Causing Harm to Fish and Fish Habitat* (DFO, 2013c) including:
  - Limiting machinery fording of any watercourse to a one-time event and only if not alternative crossing method is available; and
  - If repeated crossings are required or if the watercourse has steep of highly-erodible banks, construct a temporary crossing structure;
- Road surfaces will be monitored for increased erosion and sedimentation and repairs will be made if needed; and
- Following emergency spill response plans that will be developed prior to construction.

All of these mitigation measures are commonly and widely used in British Columbia during road construction. None of these measures is unique nor are they unsuitable for the streams to be crossed by the new mine access road. For these reasons, all of these mitigation measures are anticipated to be effective for eliminating any potential serious harm to fish in streams along the mine access road.

5.2.5 Mitigation for the Kluskus-Ootsa FSR Upgrade

Mitigation measures for construction and operations of the realigned section of the Kluskus-Ootsa FSR are the same as those proposed for the mine access road. Due to the small size of the two streams that will be crossed by this new section of road, one of which is non-fish-bearing, and the likely effectiveness of the mitigation measures listed above, potential serious harm to fish from the Kluskus-Ootsa FSR upgrade is highly unlikely.

5.2.6 Mitigation for the Airstrip

There are no streams or lakes in the immediate vicinity of the proposed airstrip location. Therefore, besides those measures required for reducing or eliminating potential effects to upland vegetation and wildlife, no additional mitigation measures are required to reduce or

eliminate potential effects to fish or fish habitat from construction, operation, or closure of the airstrip.

Mitigation measures for construction, operations, and closure of the airstrip access road are the same as those proposed for the mine access road. Due to the small size of the three streams that will need to be crossed by this road and the likely effectiveness of the mitigation measures listed above, potential serious harm to fish from the airstrip access road is highly unlikely.

5.2.7 Mitigation for the Transmission Line

Mitigation measures to minimize or eliminate potential effects to fish and fish habitat due to construction, operation, and closure of the transmission line and its access roads are essentially the same as those that will be used for the mine access road, the Kluskus-Ootsa FSR upgrade and the airstrip. The only additional mitigation measures that will be implemented for the transmission line and transmission line access roads are:

- Optimizing the use of existing access roads and existing ROWs. This will include sharing ROWs with the Kluskus and Kluskus-Ootsa FSRs and the mine access road where they over-lap. It will also include using existing stream crossings on the Stellako and Nechako rivers and the majority of other named watercourses along the route. By doing so, only 35 of the 143 streams and rivers along the transmission line ROW will require new temporary or permanent crossing structures;
- Beginning and ending construction within the "Reduced Risk Timing Windows" for the different fish species that are known to exist in each of the streams that will require new stream crossings. In addition to the rainbow trout reduced risk timing window described above, these could also include (BC MOE, 2004):
    - Arctic grayling (July 15 to March 31);
    - Bull trout (June 15 to August 15);
    - Dolly Varden (July 15 to August 31);
    - Kokanee (June 1 to August 31); and
    - Mountain whitefish (June 1 to September 15);
- Managing riparian vegetation in accordance with "*Approved Work Practices for Managing Riparian Vegetation*" (BC Hydro et al., 2003). This will include retaining a 15 m or 30 m buffer strip on either side of the watercourse, depending on the size of the stream or river.

5.2.8 Summary of Mitigated Habitat

Total mitigated habitat from the diversion of Lake 01682LNRS to the Creek 705 Watershed is estimated to be 92,000 m^2 (**Table 5-3**). This is 100% of Lake 01682LNRS area. It also includes 100% of 9 m^2 of spawning habitat lost in Reach 11 of Davidson Creek that will be mitigated by providing spawning habitat in the new diversion channel created between "Pond A" and "Pond B". This is included in the mitigated habitat category because this spawning habitat is assumed to be necessary for the rainbow trout population in Lake 01682LNRS to persist and, therefore,

needs to be replaced to keep the population viable. In total, all mitigated habitat represents 79% of the total pre-mine habitat area in the upper Davidson Creek Watershed isolated upstream of the TSF.

Fish habitat in Reach 12 of Davidson Creek and its small headwater tributary (totalling 2,340 m^2) will not be mitigated since this habitat will be inundated by the enlarged lake. Fish habitat in headwater streams that connect to Davidson Creek in Reaches 8, 9, and 10, and isolated upstream of the TSF will not be mitigated because these small tributaries will not be connected to fish habitat downstream once the TSF is built. Habitat not mitigated was included in the total that must be offset due to Project effects.

Table 5-3: Estimate of Total Habitat Area Mitigated by Diversion of Lake 01682LNRS in Upper Davidson Creek

Spatial Extent	Pre-Mine Scenario All Habitat (m^2)	Remaining Habitat without Mitigation (m^2)	Lake Diversion Total Mitigated Habitat (m^2)	Pre-Mine Habitat Mitigated (%)
Davidson Creek Reach 12	1,872	0	9[(1)]	<1%
Tributary to Reach 12 of Davidson Creek	468	0	0	0
Davidson Creek tributaries (Reaches 8, 9, 10)	22,329	0	0	0
Lake 01682LNRS	91,860	0	91,860	100%
Estimated Total Area	**116,529**	**0**	**91,869**	**79%**

Note: [(1)] Spawning habitat lost under TSF Site C pond in Reach 11.

In total, operation of the FSS to provide instream flow requirements during mine operations and closure phases will mitigate the potential loss of approximately 280,000 m^2 of habitat in the lower Davidson Creek Watershed (**Table 5-4**). In terms of area, most of this mitigated habitat is in tributaries to Davidson Creek that would be inaccessible to fish without the maintenance of flows in Davidson Creek. These tributaries contribute approximately 75% of the total mitigated habitat area. However, much of this habitat area is open water wetlands which, although important sources of nutrients, water, and benthic invertebrate drift, have much lower habitat quality for rainbow trout spawning, rearing, foraging and overwintering life stages and no direct value for kokanee. Regardless, with operation of the FSS, 100% of the habitat in these tributaries will be maintained.

Table 5-4: Total Area Mitigated Below the TSF from Pipeline Flow Maintenance in Lower Davidson Creek

Spatial Extent	Pre-Mine Scenario - All Habitat[1] (m^2)	Unmitigated Scenario - Remaining Habitat[2] (m^2)	Total Mitigated Habitat[3] (m^2)	Percent Pre-Mine Habitat Mitigated by FSS[4] (%)	Relative Value of Mitigation[5] (%)
Davidson Creek (Reaches 1 to 6)	68,424	37,404	68,424[6]	100	45
Davidson Creek Tributaries	214,087	24,981	214,087	100	88
Total	**282,511**	**62,385**	**282,511**	**100**	**78**

Note: [1] Habitat in all tributaries connecting to Reaches 1 to 6 considered in the pre-mine scenario.
[2] Without mitigation some functional habitat remains in lower Davidson Creek and in tributaries to Reaches 1 to 3 (i.e., access is not eliminated to tributaries connected to these reaches). Elimination of access assumed to be a potential effect to tributaries connecting to Reaches 4 to 6.
[3] Estimate of total habitat with mitigation using the water supply pipeline to maintain conservation flows in Davidson Creek.
[4] Mitigated scenario habitat area divided by pre-mine habitat area.
[5] Difference between mitigated and unmitigated scenario habitat area, divided by pre-mine habitat area.
[6] Habitat area in Reaches 1 to 6 will be reduced by approximately 2,095 m^2 compared to baseline over the 15 year time period modeled. However, because at least 90% of the weighted useable area for all rainbow trout and kokanee life stages will remain with operation of the FSS, it was assumed that no residual effect to the production of rainbow trout or kokanee in Davidson Creek will occur and, therefore, no residual loss of fish habitat will occur either.

Mitigated habitat in the mainstem of Davidson Creek is based on flow/habitat models described. Provision of the conservation flows defined using the *Instream Flow Study* is assumed to provide 100% mitigation for potential Project effects on downstream habitat.

By providing all instream flow requirements for each biological stanza for each rainbow trout and kokanee life stage, operation of the FSS during mine operations and closure phases will mitigate all potential losses of habitat in the lower six reaches of Davidson Creek and tributaries to these reaches. This includes rainbow trout and kokanee spawning habitat potentially lost as well as rainbow trout fry and juvenile summer rearing habitat potentially lost. As a result of mitigation, no residual effect to rainbow trout or kokanee is expected to occur downstream of the Project.

6.0 RESIDUAL SERIOUS HARM TO FISH

Project design and mitigation efforts substantially limit the overall "serious harm to fish." Nevertheless, unavoidable potential effects to fish and fish habitat remain. Habitat that will be impacted was quantified so that appropriate offsetting measures could be developed. Provided below is an overview of the quantification method and results of the anticipated residual "serious harm to fish" that will occur due to construction, operation, and closure of the Project.

6.1 Calculating Habitat Losses and Gains

The objective of habitat offsetting is to ensure that any Project-related reduction in fish production due to the permanent alteration or destruction of habitat is offset by habitat created, enhanced, or restored. Assessing whether the offsetting objective can be achieved requires a method that compares the amount of habitat lost and gained. However, because all habitats do not produce fish equally, the method must also account for the quality of different habitats lost and gained. Accounting for both habitat quality and habitat quantity ensures that the net change in a suitable habitat metric is a reasonable surrogate for determining offsetting success.

Two metrics were used to quantify the residual serious harm to fish: the strict areal extent of habitat affected (m^2) and a metric integrating habitat quality and quantity. This latter metric used a method developed by the U.S. Fish and Wildlife Service (US FWS) called the Habitat Evaluation Procedures (HEP) to develop Habitat Units (HUs) (US FWS, 1981). The use of total habitat area is straightforward, but does not incorporate an index of productivity related to habitat quality.

The HEP method relied on data collected during baseline field programs, including fish distribution and habitat use by different life stages of fish. Using existing literature and baseline field data, site-specific Habitat Suitability Index (HSI) models were developed to characterize semi-quantitative relationships between habitat variables and rainbow trout and kokanee life stages. These models and their application to stream habitat present in Davidson Creek and Creek 661 are provided in **Annex C**. That annex also described how HSI values were validated with site-specific observations of the distribution of rainbow trout by habitat types. This allowed evaluation of residual serious harm to fish in terms of both species and their different life stages. The method is particularly useful when a life stage has been identified as a likely bottleneck in adult fish production (i.e., the ultimate resource of a fishery).

Discussions with regulatory agencies during the development of this FMOP have confirmed that this habitat-based HEP method is suitable for determining the residual serious harm to fish and is consistent with recent changes to the *Fisheries Act* that came into effect in November 2013.

6.1.1 Quantification of Instream Habitat Area

Stream channel measurements collected during baseline field programs, and spatial analysis using Geographical Information Systems (GIS) software, were used to quantify the total area of instream habitat affected by the Project. GIS software was used to overlay the mine site footprint

over the BC standard 1:20,000 scale Freshwater Atlas stream and waterbody network coverage. The mine site facilities and TSF footprints at post-closure were used for this analysis because this phase represents the maximum footprint of all mine site facilities over the life of the Project. This includes all diversion channels, spillways, and post-closure drainage patterns. Quantification of habitat area in streams (i.e., length times average channel width) and lakes affected by the Project used the surface area of these features. These results form the basis of the areal extent of habitat affected and was also used in the HEP evaluation.

Each stream segment and water body affected was delineated and categorized by the Freshwater Atlas Code, stream order, reach number, stream classification, type of impact, and fish presence/absence data. Stream segment lengths were measured using GIS software. Total instream habitat area for each stream segment was determined using the length multiplied by average channel measurements obtained from field data collected during baseline field programs. Surveys of fish habitat of the LSA were comprehensive, as shown in **Figures 5.1.2.6-5** and **5.1.2.6-6**, and included first-to third-order streams and small ponds and wetlands connected to stream habitat. Surface water area for water bodies and lakes were derived using GIS software and was verified using shoreline perimeter data collected during bathymetric surveys conducted during the 2011, 2012, or 2013 baseline field programs.

Channel measurements were obtained from two main sources:

- Average active channel and wetted widths for different meso-habitat types surveyed during baseline field programs using BC standard FHAP protocol) (Johnston and Slaney, 1996); and
- Average active channel and wetted widths collected from baseline or historical Reconnaissance (1:20,000) fish and fish habitat inventories (RISC, 2001).

A conservative approach was used for selecting channel measurements to derive total instream habitat area calculations for stream habitat. For example, to account for habitat provided by undercut banks, average wetted widths[11] were used when they were greater than active channel widths[12]. Data on active channel or wetted widths for some smaller stream segments were not available. For these stream segments, active channel or wetted widths were inferred by using the average channel width[13] for measured stream segments of the same stream order or by conservatively using widths from wider downstream reaches.

6.1.2 Habitat Evaluation Procedure

The HEP procedure derives a dimensionless Habitat Unit (HU) by multiplying affected area (m^2) by a habitat, species and life stage-specific HSI value, which is a habitat quality rating on a scale

[11] Wetted width is the width measured between the water's edge on both stream banks. This can be greater than active channel width for stream channels with undercut banks.
[12] Active channel width is the width measured between the point on both stream banks where rooted riparian vegetation begins, and represents the width and depth at which the channel is typically filled during a 1:2 average year flood
[13] Channel width is the width measured between the top of banks on both sides of the stream

from 0 (unusable) to 1 (ideal). HU values were generated for habitat that will be affected as well as habitat to be created and/or enhanced by offsetting measures. Thus, the same accounting system was used for both sides of the habitat/productivity balance sheet and hence the approach provides an unbiased comparison between losses due to the Project and gains produced by offsetting projects.

A review of the final HU values for each combination of habitat type and species life stage affected by the Project was also completed to determine if potential habitat-based bottlenecks to productivity existed. Where bottlenecks were identified, strategic offsetting measures were developed to provide benefit to recreational and Aboriginal fisheries by reducing the bottleneck.

6.1.2.1 Fish Species and Life Stage Selection

Rainbow trout were selected as the key indicator fish species to evaluate residual serious harm to fish due to the Project. This fish species was targeted because of their high abundance and dominance of the fish community in area lakes and streams, their importance and relevance to local recreational and Aboriginal fisheries, and because of their presence under, upstream and downstream of the Project footprint. Kokanee were also identified by local aboriginal groups as being important for Aboriginal fisheries. However, based on baseline field surveys, kokanee do not reside under or upstream of the Project footprint and are only found downstream of the Project within Tatelkuz Lake and in the lower reaches of Davidson Creek and Creek 661. Therefore, it is assumed that kokanee populations, and the habitat they use, will be protected by the mitigation measures described in **Section 5.2**. This will include the construction and operation of the FSS to maintain flows in lower Davidson Creek. For this reason, kokanee were not included in the calculation of habitat losses and gains in this FMOP.

Life stages of rainbow trout that will be affected by the Project were selected based on findings from the baseline field programs (**Appendix 5.1.2.6A** and **Appendix 5.1.2.6B** of the Application) and included all five rainbow trout life stages (spawning/egg incubation, fry summer rearing, juvenile summer rearing, adult summer foraging, and overwintering). These same life stages were used to develop and assess offsetting measures.

6.1.2.2 Habitat Classification System

A habitat classification system was developed to support the application of HSI models. This section describes the various meso-habitat types present in the Davidson and Creek 661 Watersheds and the specific habitat classed assigned within these habitat types. This hierarchical subdivision was necessary to assign HSI suitability scores to the wide diversity of stream habitats present under, upstream and downstream of the Project.

6.1.2.3 Habitat Types

Seven habitat types were defined (**Table 6-1**). Stream habitat types included the four commonly used meso-habitat types: cascades, riffles, glides, and pools. They also included a “Tributary” category used to define small first-, second-, and third-order tributaries to mainstem creeks. Two

additional habitat types were defined to incorporate all habitat types present into the classification system: “Other” and “Lake.” The “Other” category characterizes fish habitat provided by open water wetlands, beaver ponds, and off-channel areas not represented by the major stream meso-habitat types, while the “Lake” habitat type characterizes lake environments.

Each of the seven habitat types was sub-divided into classes to represent the range of variability within each type. Nineteen habitat classes were included in the classification system and represent all fluvial and lacustrine habitats within watersheds near the Project area. They also include all habitats that will be protected, created, enhanced, or restored as part of the mitigation and offsetting measures. **Figure 6-1** shows the distribution of the habitat classes within the watersheds of Davidson Creek and Creek 661 affected by the Project.

Delineation of habitats using these categories is appropriate for quantifying and qualifying fish habitat for the Project since they are:

- Aligned with standard data collection methods and habitat definitions used during the baseline field programs (i.e., FHAP and Reconnaissance 1:20,000 Fish and Fish Habitat Inventory) and are the habitat definitions widely recognized in BC;
- Consistent with published literature on life history requirements and habitat selection by salmonid fish species in stream and lake environments; and
- Representative of all habitat types/classes within the watersheds near the Project, including those used by different life stages of rainbow trout.

Table 6-1: Habitat Types and Class Definitions

Habitat Type	Class	Definition and Habitat Variables
Cascade	1	Steep, stepped riffles of bedrock or emergent cobbles/boulders, fast-flowing water, turbulent, shallow, gradients >4%
Riffle	1	Turbulent, fast-flowing water, shallow, moderate gradient, spawning gravels extensive, dominant substrate are gravels, low cover and habitat complexity
	2	Turbulent, fast-flowing water, shallow, moderate gradient, pockets of spawning gravels, dominant substrates are cobbles or boulders, moderate cover and habitat complexity
	3	Turbulent, fast-flowing water, shallow, moderate gradient, no spawning gravels, dominate substrates are cobbles or boulders, high cover and habitat complexity
Glide	1	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, spawning gravels extensive, dominant substrates are gravels, low cover and habitat complexity
	2	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, pockets of spawning gravels, dominant substrates are cobbles or boulders, moderate cover and habitat complexity
	3	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, no spawning gravels, dominant substrates are cobbles or boulders, high cover and habitat complexity or areas of slow flowing, deep water with fine substrates
Pool	1	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, good pool depth (>0.50 m), abundant cover, high LWD and overhead cover
	2	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, moderate pool depth (0.3 to 0.5 m), moderate cover, moderate LWD and overhead cover
	3	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, low pool depth (<0.3 m), low cover, low LWD and overhead cover
Other	1	Off-channel habitat, >2 m deep, abundant cover, high LWD and overhead cover abundance, substrates widely variable
	2	Beaver dams, open water wetland complexes, shallow <2 m, low gradient, fine substrates, variable cover
Tributary Streams	1	Second or third-order headwater streams or tributaries with riffle-pool morphology, variable cover, juvenile rearing habitat only
	2	First-order headwater streams or tributaries with riffle-pool morphology, variable cover, juvenile rearing habitat only
	3	First- or second-order headwater streams or tributaries, or small third-order tributaries (lower valley) with large channel morphology, low gradient wetland habitats, intermittent channel features, fine substrates, juvenile rearing habitat only
	4	Ephemeral, headwater or tributary streams, NVC and NCD, non fish-bearing
Lake	1	Shallow littoral habitat, <3 m deep, greatest light penetration, high productivity (benthic and aquatic macrophyte communities), juvenile rearing and adult foraging habitat
	2	Deep littoral habitat, 3 m to 6 m deep, low light penetration, moderate to low productivity, juvenile rearing and adult foraging habitat
	3	Pelagic habitat, deep water habitat >6 m deep, low productivity, juvenile rearing and adult foraging habitat

Note: m = metres, LWD = large woody debris, NVC = no visible channel, NCD = non-classified drainage

360000 370000 380000 390000

5910000 5900000 5890000

Chedakuz Creek
Proposed Transmission Line (Mills Ranch Reroute)
Proposed Transmission Line
Turtle Creek
Kluskus-Ootsa FSR
Fawnie Creek
Creek 700
Davidson Creek
Creek 314094
Creek 226858
Tatelkuz Lake
Proposed Mine Access Road
Proposed Fresh Water Pipeline
Snake Lake
Top Lake
Creek 428973
Creek 636713
Creek 688328
Creek 543585
Creek 661
Lake 01428UEUT
Lake 01682LNRS
Lake 01538UEUT
Creek 705
Creek 505659
Creek 704456
Kuyakuz Lake
Mathews Creek

N

Legend

- Reach Break
- Kluskus-Ootsa FSR
- Stream
- Waterbody

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site

Habitat Type/Classes

- Mainstem Habitats
- Tributary Stream (Class 1)
- Tributary Stream (Class 2)
- Tributary Stream (Class 3)
- Tributary Stream (Class 4)
- Lake (Classes 1-3)

Fish and Aquatic Resources

- Local Study Area

Scale:1:110,000

0 1 2 4 6

Kilometres

Reference

BC Government GeoBC Data Distribution
1996-2006 - Reconaissance 1:20,000 Fish and Fish Habitat Inventories
FISS - Fisheries Information Summary System
AMEC 2013 Baseline Report Fish & Aquatic Resource

CLIENT: newgold

PROJECT: Blackwater Gold Project

Habitat Type/Classes in the Davidson Creek and Creek 661 Watersheds

DATE: April, 2014	ANALYST: KA	**Figure** 6-1
JOB No: VE52277	QA/QC: BM	PDF FILE: 10-100-146_habitatClass_v2.pdf
GIS FILE: 10-100-146_habitatClass_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_BlackwaterMapping\10_fisheries-aquatics\EIA\10-100-146_habitatClass_v2.mxd

6.1.2.4 Assigning Habitat Classes

Each discrete habitat type (i.e., cascades, riffles, glides, and pools) and class in each reach of Davidson Creek and Creek 661 was delineated in a GIS from geo-referenced habitat data collected during baseline FHAP surveys. Habitat parameters measured during field programs were used to assign appropriate habitat type and class. This procedure was also applied to reaches of two Davidson Creek tributaries (Creek 688328 and Creek 704454) and of one 661 tributary (Creek 505659). Results of this analysis are presented in **Table 6-2**. The approach was also applied to Mathews Creek, one of the streams that will be enhanced as part of the offsetting plan (described in **Section 7**).

Table 6-2: Dominant Habitat Classes, by Habitat Type, in Each Reach in the Davidson Creek and Creek 661 Watersheds

Stream Name	Reach #	Habitat Type			
		Cascade	Riffle	Glide	Pool
Davidson Creek	1	-	1	1	1
Davidson Creek	2	-	1	1	1
Davidson Creek	3	-	1	1	1
Davidson Creek	4	-	2	2	1
Davidson Creek	5	-	2	2	1
Davidson Creek	6	-	2	2	1
Davidson Creek	7	-	3	3	2
Davidson Creek	7.1	3	2	2	2
Davidson Creek	8	-	2	2	1
Davidson Creek	9	3	2	2	1
Davidson Creek	10	3	1	1	1
Davidson Creek	11	3	3	3	2
Davidson Creek	12	-	3	3	3
Creek 688328	1	-	2	2	2
Creek 688328	2	-	2	2	3
Creek 704454	1	3	3	2	2
Creek 704454	2	3	2	2	2
Creek 704454	3	3	2	2	2
Creek 704454	4	3	3	3	2
Creek 704454	5	-	2	2	2
Creek 661	1	-	2	2	1
Creek 661	2	-	2	1	1
Creek 661	3	-	3	1	1
Creek 661	4	-	1	2	2
Creek 661	5	-	3	3	2
Creek 505659	1	-	1	1	-
Creek 505659	2	-	1	1	1
Creek 505659	3	-	2	2	-

This analysis classified each habitat type class present with respect to specific habitat requirements for each rainbow trout life stage. This permitted accurate and transparent application of habitat suitability ratings to each habitat type and class and provided finer resolution than if a single suitability rating had been applied to the broader cascade, riffle, glide, and pool habitat types assigned during the FHAP surveys.

6.1.2.5 Habitat Suitability Index Models

Habitat Suitability Index (HSI) models describe habitat suitability based on the habitat variables that most influence the habitat selection of different life stages of fish (i.e., young-of-year, juveniles, adults, spawners). They use semi-quantitative relationships, based on published literature and modified with site-specific data, to describe how these variables influence habitat quality for each life stage. The models describe relative suitability of different physical habitats for different life stages of fish on a scale from 0 (unsuitable) to 1 (optimal). The underlying assumption is that a positive relationship exists between the index and the habitat's carrying capacity for fish (US FWS, 1981). The same HSI models were used to characterize the suitability of habitats lost or altered due to the Project and habitat gains due to offsetting.

Establishing HSI values for each habitat class was the fundamental step in applying HEP. The approach to developing site-specific rainbow trout HSI models and depth-velocity-substrate suitability curves is summarized here but is further described in the "*Habitat Suitability Ratings and Supporting Information*" memorandum included in **Annex C**. A five-point habitat suitability rating system was used, ranging from 0 (unsuitable) to 1 (optimal) (**Table 6-3**). Shifts in habitat suitability were represented by increments of 0.25. This level of precision is defensible given the overall ability to predict and measure responses in the productive capacity of fish habitat and the plasticity of rainbow trout to use various habitats.

Table 6-3: Habitat Suitability Ratings and Definitions

Habitat Suitability Rating	Definition
0.00	Unsuitable
0.25	Below Average Quality
0.50	Average Quality
0.75	Above Average Quality
1.00	Optimal

Table 6-4 provides the Habitat Suitability Ratings for all habitat types and classes for each life stage of rainbow trout potentially affected by the Project and for each life stage of rainbow trout potentially benefiting from offsetting projects. Assigning habitat suitability ratings to the different habitat types and classes was based on professional judgement using knowledge of the species life histories provided by existing literature and knowledge of site-specific habitat use and fish densities gained from the baseline studies.

Table 6-4: Habitat Suitability Ratings for Different Life Stages of Rainbow Trout

Fish Species		Rainbow Trout					
Habitat Type	**Class**	**Spawning/Egg Incubation**	**Fry Summer Rearing**	**Juvenile Summer Rearing**	**Adult Summer Foraging**	**Overwintering**	**Food & Nutrient Production**
Cascade	1	0.00	0.00	0.00	0.00	0.00	0.50
Riffle	1	0.50	0.50	0.00	0.00	0.00	0.75
	2	0.25	0.75	0.25	0.00	0.25	1.00
	3	0.00	0.50	0.75	0.00	0.25	1.00
Glide	1	1.00	0.25	0.00	0.00	0.00	0.50
	2	0.50	0.50	0.25	0.00	0.25	0.75
	3	0.00	0.25	0.50	0.00	0.25	0.75
Pool	1	0.00	0.25	1.00	0.00	0.75	0.25
	2	0.00	0.25	0.75	0.00	0.25	0.25
	3	0.00	0.25	0.25	0.00	0.00	0.25
Other	1	0.00	0.25	1.00	0.00	1.00	0.25
	2	0.00	0.25	0.25	0.00	0.25	0.25
Tributary Streams	1	0.00	0.00	0.50	0.00	0.00	0.25
	2	0.00	0.00	0.25	0.00	0.00	0.25
	3	0.00	0.00	0.25	0.00	0.00	0.25
	4	0.00	0.00	0.00	0.00	0.00	0.25
Lake	1	0.00	0.00	0.75	0.50	0.75	0.75
	2	0.00	0.00	0.75	0.75	1.00	0.25
	3	0.00	0.00	0.50	0.75	1.00	0.00

The HSI model has no *a priori* weighting for any particular habitat type or life stage of fish. Spawning habitat was not given any more importance than rearing habitat, overwintering habitat, or foraging habitat. However, different habitats were rated differently for spawning, rearing, foraging, or overwintering based on their unique habitat characteristics and how suitable these characteristics were for different life stages of fish. These are objectively calculated from baseline data however, not subjectively weighted according to perceived limiting habitats.

The food and nutrient HSI is the only HSI that is not based on a life history stage of rainbow trout. It was added to the HSI model to specifically address the contribution of such variables as water, nutrients, riparian inputs and benthic invertebrate drift that are difficult to quantify. **Annex C** describes the reasons for the HSI values assigned to each habitat type and rainbow trout life history class. The food and nutrient HSI generates a large number of HU relative to the other five HSI for rainbow trout life stages. As shown in **Table 5.1.2.6-8**, the food and nutrient HU contributes 29.6% of the total number of stream habitat HU in the five watersheds of the aquatics LSA. That is the single largest contribution of any HSI. The numbers of HU generated by the food and nutrient HSI are consistently the largest single item in each of the habitat budgets shown in this plan (e.g. **Tables 6-6** and **7-1**).

6.1.2.6 Determining Total Instream Habitat Units

Habitat suitability ratings for all life stages of rainbow trout were applied to total habitat areas for each habitat types/classes potentially affected by the Project. This was also completed for all habitats enhanced or created by offsetting measures. Total HUs lost by habitat type/class and rainbow trout life stage was calculated for four potential impact types:

- *Inside TIAs* – Losses to fish habitat inside, but not including, the physical footprint of tailings dams, where mining effluent, tailings, and waste rock will be deposited. Habitat in this category will require designation as a TIA by amending Schedule 2 of the MMER;
- *Upstream Habitat Isolation* – Habitat upstream of the mine site facilities or TSF footprint where fish will be isolated from habitat downstream that is necessary for their continued existence. Habitat in this category is part of the Section 35(2) *Fisheries Authorization*;
- *Mine Site Facilities Footprint* – Losses to fish habitat under the physical footprint of mine site facilities. Infrastructure considered under this category included the open pit, the low-grade ore stockpile, tailings dams (including the Site C West Dam, the Site C Dam, and the Site D TSF Dam), associated TSF dam spillways, diversion channels, ECD, freshwater reservoir and dam, treatment wetlands (outside the TSF), the construction and operations camps, the plant site, and construction and operations lay-down areas. Habitat in this category is part of the Section 35(2) *Fisheries Authorization*; and
- *Downstream Flow Reductions* – Losses to fish habitat as a result of downstream flow reductions have been mitigated in Davidson Creek with the design of the FSS. However, flow reductions within the Creek 661 Watershed will remain. These reductions will be a result of project infrastructure such as diversion channels to control run off and the plant site, and construction and operations camps footprint. Habitat in this category is part of the Section 35(2) *Fisheries Authorization*.

This approach allows a clear understanding of the sources of potential effects to fish habitat and allows segregation of fish habitat offsetting requirements between the *Fisheries Act* authorization and Schedule 2 amendment of the MMER, the two permits required to permanently alter or destroy fish habitat under the federal *Fisheries Act*.

6.2 Summary of Residual Fish Habitat Losses

As described in **Sections 4** and **5**, construction and operation of mine pit, mine site facilities, the TSF and associated infrastructure will result in unavoidable serious harm to fish, including the permanent alteration or destruction of fish habitat in the Davidson Creek and Creek 661 watersheds. Most of this habitat is located in the upper reaches of Davidson Creek (i.e., reaches 6 to 10) and its headwater tributaries (**Figure 4-1**). These tributaries include Creek 636713, Creek 688328, and Creek 704454. It also includes, to a smaller extent, habitat located in headwater tributaries to Creek 661 (Creek 543585, Creek 146920, and Creek 505659) (**Figure 4-1**). Most of the potential permanent alteration or destruction of fish habitat in headwater tributaries to Creek 661 is due to flow reductions downstream of mine infrastructure.

Summaries of potential permanent alteration or destructions of fish habitat in the Davidson Creek and Creek 661 watersheds inside the TIAs will require offsetting as part of the Schedule 2 amendment of the MMER and permanent alteration or destructions of fish habitat upstream, under, and downstream of the mine site infrastructure that will require a Section 35(2) *Fisheries Act* authorization from DFO are provided in the sections below. Both areal extent (m^2) and HUs are presented.

6.2.1 Section 27.1 MMER

The total habitat area permanently altered or destroyed habitat inside the TIAs subject to the deposit of deleterious substances from mine tailings and waste rock, including habitat within the TSF and under the east and west waste rock dumps and low grade ore stockpile, is approximately 60,150 m^2 (**Table 6-5**). The majority of this habitat is within the Davidson Creek Watershed (58,130 m^2), while approximately 2,000 m^2 is within upper tributaries of Creek 661.

Class 1 glides and Class 2 tributaries are the types subject to the largest total habitat area losses inside the TIAs (approximately 11,000 m^2, or 19%, for each). Class 1 glides are found exclusively in Davidson Creek; most of the tributary habitat lost under TIAs is also in the Davidson Creek Watershed. Class 1, 2, and 3 “Tributaries” were the only habitat type and class permanently altered or destroyed in the Creek 661 Watershed. The amount of fish-bearing habitat in each class was small in comparison to fish-bearing habitat losses inside the TIAs in the Davison Creek watershed.

The total HUs for rainbow trout for the habitat areas permanently altered or lost inside the TIAs and under the waste rock dumps is approximately 92,400 HUs (**Table 6-6**). The majority of the rainbow trout HUs lost (99%) are in the Davidson Creek Watershed. This is because most of the fish habitat lost inside the TIAs will be in the Davidson Creek Watershed, and because the Davidson Creek habitat has higher value for rainbow trout spawning, rearing, and overwintering

than the small first- and second-order headwater tributaries lost in the Creek 661 Watershed under the east waste rock dump.

The largest impact in terms of rainbow trout life stage affected inside the TIAs in the two watersheds is associated with food and nutrient production (35%; 32,200 HUs). This is because, by design, tailings facilities and waste rock dumps are located in the upper headwaters of the Davidson Creek and Creek 661 Watersheds were the majority of streams are non-fish-bearing first- or second-order tributaries. However, all streams, regardless of size or of fish-bearing status, provide some value to fish in terms of food and nutrient production.

The remainder of rainbow trout HUs lost due to the permanent alteration or destruction of fish habitat inside the TIAs are for spawning/egg incubation (18% of total), fry summer rearing (18%), juvenile rearing (20%), and overwintering (8%).

Table 6-5: Habitat Area Permanently Altered or Destroyed, by Habitat Type/Class and, in the Davidson Creek and Creek 661 Watersheds

Watershed		Davidson Creek			Creek 661		
Permit Requirement		Fisheries Act 35(2)			Fisheries Act 35(2)		
Impact Type		Upstream Habitat Isolation (m^2)	Mine Site Facilities Footprint (m^2)	MMER Inside TIAs (m^2)	Downstream Flow Changes (m^2)	Mine Site Facilities Footprint (m^2)	MMER Inside TIAs (m^2)
Habitat Type	Class						
Cascade	1	1,509	1,509	1,714	0	0	0
Riffle	1	38	38	2,186	588	0	0
	2	13,850	13,850	9,035	1,914	0	0
	3	2,081	2,081	4,741	0	0	0
Glide	1	200	200	11,429	2,168	0	0
	2	9,148	9,148	4,199	1,230	0	0
	3	725	725	760	0	0	0
Pool	1	2,059	2,059	2,996	529	0	0
	2	1,319	1,319	2,622	0	0	0
	3	28	28	205	0	0	0
Other	1	0	0	0	0	0	0
	2	14,131	14,131	0	0	0	0
Tributary	1	2,183	2,183	5,878	2,218	4,761	129
	2	4,005	4,005	10,200	3,676	6,632	950
	3	1,006	1,006	2,162	0	0	938
	4	0	0	0	0	0	0
Lake	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	0	0	0	0	0	0
Total by Impact Type (m^2)		**25,076**	**52,283**	**58,129**	**12,322**	**11,393**	**2,016**
Total by Permit Type (m^2)		**77,359**		**58,129**	**23,715**		**2,016**
Total by Watershed (m^2)				**135,487**			**25,731**
						Fisheries Act 35(2) (m^2)	**101,073**
						Section 27.1 MMER (m^2)	**60,145**
						Grand Total	**161,218**

Note: MMER = Metal Mining Effluent Regulation, TIA = Tailings Impoundment Area, m^2 = square metres

Table 6-6: Habitat Units (HUs) Lost for Different Life Stages of Rainbow Trout due to Permanent Alteration or Destruction of Fish Habitat in the Davidson Creek and Creek 661 Watersheds

Permit Requirement			Fisheries Act 35(2)			MMER
Impact Type			Upstream Habitat Isolation HUs	Downstream Flow Changes HUs	Mine Site Facilities Footprint HUs	Inside TIAs HUs
Watershed	Fish Species	Life Stages				
Davidson Creek	Rainbow Trout	Spawning/Egg Incubation	1,251	0	8,256	16,881
		Fry Summer Rearing	2,680	0	20,637	16,842
		Juvenile Summer Rearing	6,592	0	16,529	18,288
		Adult Summer Foraging	0	0	0	0
		Overwintering	1,134	0	11,858	7,586
	Food & Nutrient Production		8,894	0	30,402	31,723
	Watershed Subtotal		20,651	0	87,683	91,320
Creek 661	Rainbow Trout	Spawning/Egg Incubation	0	3,555	0	0
		Fry Summer Rearing	0	3,018	0	0
		Juvenile Summer Rearing	0	3,343	4,038	536
		Adult Summer Foraging	0	0	0	0
		Overwintering	0	1,182	0	0
	Food & Nutrient Production		0	5,967	2,848	504
	Watershed Subtotal		0	17,065	6,887	1,040
Fisheries Act 35(2) (HUs)				**132,285**		
Section 27.1 MMER (HUs)						**92,360**
Grand Total						**224,645**

Note: MMER = Metal Mining Effluent Regulation, TSF = tailing storage facility, HUs = habitat units.

6.2.2 Section 35(2) *Fisheries Act Authorization*

The total habitat area permanently altered or destroyed upstream, under, and downstream of the mine site infrastructure, excluding habitat inside the TIAs, is approximately 101,100 m^2 (**Table 6-5**). The majority (77%) of this habitat is located in the Davidson Creek Watershed (77,350 m^2).

The total habitat located directly under the mine site facilities is approximately 63,700 m^2 (**Table 6-5**). Most (52,300 m^2, 82%) of this habitat is located within the Davidson Creek Watershed under the TSF dams and embankment fills, the open pit, low-grade stockpile, and construction lay-down areas. The remaining 18% is located in the Creek 661 Watershed, under the plant site, and construction and operations camps, and totals approximately 11,400 m^2.

Of all habitat lost under the mine pit and mine site facility footprints in the Davidson Creek and Creek 661 Watersheds, most is lower quality habitat including 18,600 m^2 (29%) of small headwater tributary streams and 14,100 m^2 (22%) of beaver ponds and wetland complexes. Potential spawning habitat and higher quality rearing habitat for fry and juvenile rainbow trout lost under the mine pit and mine site facility footprints includes 13,900 m^2 of Class 2 riffle and

9,200 m^2 of Class 2 glide. Together, these two habitat types/classes comprise 36% of the total habitat permanently altered or destroyed under the mine site footprint.

A total of 25,100 m^2 of fish habitat will be lost upstream of the mine site footprint in the Davidson Creek Watershed. This will include habitat in Reach 12 of Davidson Creek that will be flooded due to enlargement and diversion of Lake 1682LNRS and habitat that will be isolated upstream of the TSF Site C and D, the low-grade stockpile, and the West Waste Rock Dump. The majority (66%) of this upstream habitat is "Tributary" Class 2, first-order streams that provide juvenile rearing habitat in summer only.

Finally, approximately 12,300 m^2 of fish habitat in the Creek 661 Watershed will be permanently altered or destroyed due to reduced flows downstream of the construction and operations camps, the East Waste Rock Dump, and the Plant Site. These flow reductions will be caused by diversion of runoff to the TSF. Flow reductions downstream of these mine site facilities are expected in Creek 543585, Creek 146920, and Creek 505659, all headwater tributaries of Creek 661. Flow reductions, although not expected to dewater these tributaries, are considered sufficient to significantly reduce the suitability of these streams for rainbow trout. These streams are therefore included in the residual loss totals.

A total of 132,300 HUs for rainbow trout will be permanently altered or destroyed under, upstream, and downstream of the Project (**Table 6-6**) and will require a Section 35(2) Authorization. These include approximately 94,600 HUs under the mine site footprint, 20,600 HUs upstream of the footprint, and 17,100 HUs downstream of the footprint. The majority (36%) are associated with food and nutrient production (48,200 HUs). The remaining HUs, in order of abundance, are associated with juvenile rearing (30,500 HUs; 23%), summer fry rearing (26,400; 20%), overwintering (14,200 HUs; 11%); and spawning/egg incubation (13,000 HUs; 10%). None of this habitat is suitable for adult rainbow trout foraging; field investigations indicate that adults migrate into larger waterbodies (**Table 6-4**). The value of the habitat permanently altered or destroyed under, downstream, and upstream of the mine site facilities for juvenile and summer fry rearing compared to spawning/egg incubation, overwintering, and adult summer foraging is a reflection of the small size and depth of these headwater streams, the relative paucity fish overwintering habitat, and the limited quantity gravels suitable for rainbow trout spawning.

7.0 OFFSETTING PLAN

Provided below are the preferred options for offsetting the predicted serious permanent harm to fisheries within the project area outlined in **Section 6**.

7.1 General Approach

The Proponent recognizes the importance of early planning, engagement, and transparency in developing the FMOP for the Project. The offset planning process is iterative, relying on continuous advancement of project designs, cooperation between mine engineers and environmental professionals, and ongoing input from regulatory agencies, stakeholders, and First Nations through effective consultation.

With this in mind, the Proponent used the following approaches during offset planning:

- **Avoid and Mitigate** – As described in **Section 5**, the Proponent has considered all possible measures for avoiding and mitigating potential "serious harm to fish." This has included minimizing the size of the Project footprint, concentrating mine infrastructure in headwater areas with lower habitat value to fish, eliminating mine effluent discharge during operations, maintaining flows for fish in Davidson Creek throughout the Project, and eliminating isolation of headwater lakes;
- **Early Planning** – Mitigation and offset planning was initiated during early mine planning stages. Early engagement and ongoing collaboration between fish biologists, water resource engineers, and mine planners addressed water management and environment concerns during planning and design. Guiding principles for mine planning emphasized impact avoidance as outlined in DFO's former habitat conservation and protection policy (DFO, 1998a, 1998b) and DFO's new *Fisheries Investment Policy: A Proponent's Guide to Offsetting* (DFO, 2013b);
- **Options Compilation and Assessments** – Offset options were compiled, investigated, and assessed to rank options considering biological, regulatory, stakeholder, and technical perspectives. This was accomplished through a two-phase process including a preliminary screening assessment; and more detailed evaluations of the lowest risk/highest benefit options. The goal was to identify and select offsetting measures that are biologically relevant (i.e., address limiting factors), are technically feasible and durable, focus on fish species and populations directly affected by the Project and of greatest value to people, and offer the highest probability of success. the Proponent's target is to build new or enhanced habitat that is highly likely to provide long-term benefits for fish, and that successfully balance losses to fish populations in the geographic areas that are being affected;
- **Contingency Offsetting Measures** – As with all biological offsetting or rehabilitation programs, natural variability and environmental conditions add uncertainty. This has been recognized by the Proponent and as a result, a series of contingency options have been compiled such that additional offsetting measures are available, should they be required. Each has received a preliminary assessment to determine that options are

feasible and biologically meaningful. While contingencies have been prepared, there is no expectation at this time that they will be required. If development of contingency options is required, additional analysis will be necessary prior to implementation;

- **Approach to *Fisheries Act* Amendments** – The Project will result in permanent harm to fish that support recreational and Aboriginal fisheries, as defined under the amended *Fisheries Act*. Measuring the net change in the productive capacity of fish habitat to contribute to these fisheries used a habitat-based approach. the Proponent recognizes that changes to guidelines and policy for managing fish offsets (formerly fish habitat compensation) under the amended *Fisheries Act* have occurred and has continued close collaboration with regulatory agencies to address these changes. Based on this consultation, no changes are anticipated in the method used to measure net change in productive capacity;
- **Regulatory, Stakeholder, and First Nations Consultations** – Consultations with regulatory agencies, stakeholders, and First Nations are ongoing and will continue into the post-filing phases of the Project. This is important to ensure consistency with provincial, federal, and First Nations fisheries management objectives. Continuous feedback and input on proposed mitigation and offsetting strategies is considered key to overall success and acceptability;
- **Best Practices and Standards** – The Proponent will use BMP's to minimize potential adverse effects from the construction and operation of the mine access road, airstrip access road, transmission line, and water supply pipeline. These infrastructure components are not anticipated to result in serious, permanent harm to fish (i.e., no death to fish or permanent alteration to, or destruction of, fish habitat) that are part of a commercial, recreational, or Aboriginal fishery. Under the revised *Fisheries Act*, a review of all final crossing and infrastructure designs will be completed (known as self-assessment) and any that do not meet measures to avoid harm, will be submitted to DFO for review. DFO operational statements, standard mitigations and best practices will be followed during construction and operation of stream crossings;
- **Future Segregation of Offsetting Plan** – An amendment to Schedule 2 of the MMER will be required for tailings disposal in waters frequented by fish. If required by DFO and Environment Canada, two separate FMOPs will be developed and submitted during the permitting stage; one to address offsetting requirements under section 35 of the *Fisheries Act*, and a second to meet requirements under Schedule 2 of the MMER for the release of deleterious substances into the proposed TSF; and
- **Early Construction of Offsetting Measures** – The Proponent plans to construct mitigation and offsetting measures as early as possible following approval of the Project. This may include construction of some offsetting measures prior to construction of the mine. This initiative is intended to reduce the time lag between any serious, permanent harm to fish and when offsets become fully functional, thereby reducing uncertainty and risk.

7.1.1 Guiding Principles

The approach for planning and designing the Project described in **Section 5** incorporates environmental design criteria and guiding principles intended to avoid or minimize potential serious, permanent harm to fish. In addition to the Proponent's guiding principles for developing and applying offsetting measures, the new guiding principles from DFO's "*Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting*" (DFO, 2013b) were considered during offset measures assessment (**Section 7.2**). A summary of DFO's guiding principles is provided below:

Principle 1: *Offsetting measures must support fisheries management objectives or local restoration priorities.* Offsets should be designed so they contribute to the objectives identified in fisheries management plans, where such plans exist. Where such objectives do not exist or where they do not describe restoration priorities, fisheries managers, Aboriginal groups, local organizations and stakeholders may help to identify areas that require restoration or improvement.

In situations where offsets are realized away from the project site, a robust rationale is required and should be communicated to potentially affected parties.

Principle 2: *Benefits from offsetting measures must balance project impacts*. Offsets should be scaled such that they are proportional to the impacts caused by the project. Offsets are more likely to successfully balance losses when they benefit the specific fish populations in the geographic areas that are affected by a proposed development project or activity.

Principle 3: *Offsetting measures should provide additional benefits to the fishery*. Proposed offsets should provide additional benefits to fisheries productivity. This means that benefits to the fishery are caused by offset actions and not by other factors. Fisheries benefits that are being or will be provided by other programs or activities should not be considered offsets.

Principle 4: *Offsetting measures must generate self-sustaining benefits over the long term*. Offsets should strive to generate self-sustaining benefits to fisheries productivity. The offset benefits to the fisheries should last at least as long as the impacts from the development project.

7.1.2 Consultations with Regulators, Stakeholders, and First Nations

The Proponent has undertaken a range of regulatory, public, stakeholder and First Nations engagement initiatives regarding the Project. Feedback and input on the direction of mitigation and offsetting measures is considered important to ensure consistency with provincial, federal, and First Nations fisheries management objectives. The Proponent recognizes the consultation process as a key element to success and acceptability of the final FMOPs that will be submitted with the EA and project application. All input received through consultations continue to be considered in development and final design of mitigation and offsets for the Project. Consultations with groups are ongoing and will continue throughout the pre-application period into the post-filing phases of the Project. Regulatory consultations relevant to the development of the offsetting plan are summarized in **Annex D**.

Consultations on the project designs, fish, and aquatic resources baseline surveys, water management, permitting and mitigation/offsetting planning have been conducted throughout the design process. In April 2012, a meeting was held between the Proponent and BC FLNRO, BC MOE, and the BC Ministry of Energy and Mines (BC MEM) to discuss the environmental work plan for the project. In January 2013, a meeting was held with representatives from DFO, CEAA, BC MOE, BC EAO, and BC MFLNRO to discuss the Project, results of the fish and aquatic resource baseline field programs conducted in 2011 and 2012, and obtain input into mitigation and offsetting strategies. In August 2013, meetings were held with DFO to discuss permitting and offsetting. Topics included the baseline program, mitigation measures, offsetting concepts and offsetting ratios. As a follow up to this meeting, a site tour was completed with representatives from DFO, BC MOE and BC MFLNRO. The project site toured by helicopter and on the ground. In November 2013, the proponent met with DFO to discuss changes to the *Fisheries Act* legislation and the implications for the Project. In December 2013, a meeting including DFO, CEAA, BC EAO, BC MOE and BC MFLNRO to discuss fish habitat evaluation, water management and instream flow. Topics discussed during the meeting also included habitat losses and gains. Issues identified and feedback obtained from meeting participants have been incorporated into this document.

Interviews with First Nations and traditional use studies have been initiated to define the location and extent of Aboriginal fisheries near the proposed project area. Meetings with First Nations were initiated in 2011 and have been ongoing. Further consultations and community meetings with First Nations are planned to gain input and discuss mitigation and offsetting options. Information on mitigation and offsetting measures will also be presented in upcoming open houses and community meetings to solicit feedback. In September 2013, offsetting measure options were discussed with the Saik'uz First Nation. Discussion included possible projects that are of interest in the Saik'uz First Nation.

7.1.3 Alignment with Fisheries Management Objectives

The Provincial government manages fisheries in BC with the aim of a naturally rich and sustainable freshwater resource supporting diverse uses for all British Columbians (BC MOE, 2007). Management objectives focus on improving fish stocks and habitat to increase production of sport fish species such as rainbow trout, kokanee, and whitefish.

Based on various management objectives summarized from federal, provincial, and regional government sources (**Annex E**), two broad fisheries management objectives were used to assess potential offsetting measures:

- Protect and increase freshwater fish stocks supporting recreational and aboriginal fisheries; and
- Rehabilitate habitat used by freshwater fish that contribute to a recreational or aboriginal fishery.

Maintaining and increasing the productive capacity of fisheries is the primary management goal at all levels, resulting in increased/enhanced fisheries for resource users. Rehabilitation of

habitat can be achieved by restoration projects on stream areas that have been impacted by land use activities such as agriculture or forestry.

7.1.4 Target Species and Limiting Factors

Physical works to offset serious, permanent harm target the creation of fish habitat for rainbow trout, the species principally affected by the Project. Rainbow trout is an important recreational fish species in BC and are culturally important to Aboriginal people and thus fit the intent of the recent changes in the *Fisheries Act*. Populations that use Davidson Creek and Creek 661 support recreational and Aboriginal fisheries in Tatelkuz Lake and Chedakuz Creek. Rainbow trout are also the most abundant and widely distributed fish species in the watersheds potentially affected by the Project.

As shown in **Sections 5 and 6**, design and mitigation activities will reduce the overall offsets required. Residual effects to fish habitat will be caused by the mine site facilities and TSF footprints in the upper Davidson Creek and Creek 661 Watersheds. While the overall habitat area and HUs affected are important to ensure that populations will persist, the residual serious, permanent harm will be offset with physical measures that consider factors limiting rainbow trout populations in the Project area. **Table 7-1** provides a summary of the habitat areas and HUs of each fish population in the project area, as well as factors limiting the production of adult fish. As noted in **Section 6**, the generally low quantity and quality of overwintering habitat reflects the limited distribution of this habitat type within Davidson Creek and Creek 661.

Table 7-1: Summary of Habitat Loss by Life Stage for each Fish Population within the Project Area

Fish Population	Brief Population Description	Life Stages	Serious Harm S35(2) Fisheries Act		Serious Harm S27.1 MMER		Potential Limiting Factor
			(m^2)	(HUs)	(m^2)	(HUs)	
Davidson Creek (Project Footprint)	Rainbow trout adults reside in Tatelkuz Lake but migrate into Davidson Creek to spawn. Fry and juveniles reside within the creek for up to three years before migrating back to the lake	Spawning/Egg Incubation		9,507		16,881	Adult rearing is within Tatelkuz Lake (i.e., not limiting) but overwintering of fry and juveniles within Davidson Creek is most likely limiting juvenile survival and therefore outmigration to the adult population
		Fry Summer Rearing		22,703		16,480	
		Juvenile Summer Rearing		22,022		17,675	
		Adult Summer Foraging		0		0	
		Overwintering		12,631		7,350	
		Food and Nutrient Production		37,935		30,850	
		Sub-Total	74,801	104,799	57,056	89,236	
Davidson Creek Headwaters (Isolated Populations)	Rainbow trout population resides in Lake 01682LNRS upstream of partial barrier in lower Reach 11. Self-sustaining with no or limited immigration from lower Davidson Creek population	Spawning/Egg Incubation		0		0	Adults appear to be using Lake 01682LNRS for rearing (i.e., not limiting), however, the loss of stream habitat and isolation of the headwater system will require additional stream spawning and rearing habitat in order to maintain self-sustaining population.
		Fry Summer Rearing		614		363	
		Juvenile Summer Rearing		1,099		613	
		Adult Summer Foraging		0		0	
		Overwintering		360		236	
		Food and Nutrient Production		1,461		872	
		Sub-Total	2,558	3,535	1,073	2084	
Creek 661	Similar to Davidson Creek rainbow trout, adults reside in Tatelkuz Lake but migrate into Creek 661 to spawn. Fry and juveniles reside within the creek for up to three years before migrating back to the lake	Spawning/Egg Incubation		3,555		0	Adult rearing is within Tatelkuz Lake (i.e., not limiting) but overwintering of fry and juveniles within Creek 661 is most likely limiting juvenile survival and therefore outmigration to the adult population
		Fry Summer Rearing		3,018		0	
		Juvenile Summer Rearing		7,381		536	
		Adult Summer Foraging		0		0	
		Overwintering		1,182		0	
		Food and Nutrient Production		8,815		504	
		Sub-Total	23,715	23,951	2,016	1040	
Estimated Total Area and Habitat Units			**101,073**	**132,285**	**60,145**	**92,360**	

Note: HUs = habitat units

7.2 Options Identification and Evaluation

7.2.1 On-Site Options

On-site options were investigated during baseline field programs and by dedicated field trips conducted by water resource engineers and fisheries specialists through 2011, 2012 and 2013. These trips focused on all options available in the watersheds near the Project area, including Davidson Creek, Creek 661, Turtle Creek, Creek 705, and Chedakuz Creek. Field and aerial surveys were also completed within the larger, regional Chedakuz Creek and Fawnie Creek watersheds, including:

- Chedakuz Creek from the Nechako Reservoir to the top of Kuyakuz Lake;
- All tributaries of Tatelkuz and Kuyakuz Lakes; and
- Fawnie Creek.

A total of 19 potential offsetting projects were identified within local watersheds near the Project area. These were considered on-site options and were included in the evaluation process (**Figure 7-1**).

7.2.2 Off-Site Options

Twelve potential off-site offsetting opportunities within the Vanderhoof and Fort St. James regions were identified using desktop reviews by subcontractors with local knowledge (Avison, 2012; Ecofor, 2012). Information on potential off-site opportunities was compiled using literature searches, local knowledge, and experience working with non-governmental organizations, provincial regulators, and First Nations within these regions. **Figure 7-2** shows the location of potential off-site offsetting options identified.

Of these twelve offsite projects, two distinct project types were identified: traditional offsetting projects involving enhancement and/or rehabilitation of existing habitat; and partnership or funding opportunities with regional fisheries initiatives and conservation or stewardship groups. All twelve off-site opportunities target the creation, restoration, or enhancement of fish habitat and the recovery of sensitive fish species, and are recognized by the community, local First Nations, and/or government agencies as regionally important.

370000 375000 380000 385000 390000

5910000 5905000 5900000 5895000

Chedakuz Creek
Dykam Ranch
11
10
12
Mills Ranch
17
Creek 505659
TATELKUS LAKE RESERVE 28
9
Turtle Creek
Tatelkuz Lake Ranch Resort
NECHAKO RANGE
Kluskus-Ootsa FSR
Turtle Creek
7
8
6
Davidson Creek
Creek 226858
Creek 314089
Tatelkuz Lake
Creek 700
13
19
Snake Lake
Top Lake
FAWNIE RANGE
5
4
Creek 428073
15
Creek 638713
18
14
3
Creek 688328
Davidson Creek
16
Creek 661
Lake 01428UEUT
Creek 704454
Creek 505659
Creek 543585
Creek 146920
Chedakuz Creek
1
2
Lake 01538UEUT
Creek 705
Lake 01682LNRS
Kuyakuz Lake

N

Legend

- Recreation Lodge
- Homestead
- Airstrip
- Kluskus-Ootsa FSR
- Stream
- Lake
- Indian Reserve
- Private land

Project Components

- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site
- Proposed Mine Footprint

Potential Stream Creation/Enhancement

- Potential Stream Creation/Enhancement
- Potential Pond or Lake Creation/Enhancement

Potential On-Site Offsetting Options

- **1 Lake 01682LNRS Enlargement**
- **2 Lake 01682LNRS Diversion**
- 3 Creek 688328 Pond
- 4 Upper Creek 700 Pond
- 5 Creek 700 Enhancement and Surge Pond
- 6 Upper Turtle Creek Pond
- 7 Mid Turtle Creek Pond
- 8 Mid Turtle Creek Pond
- 9 Lower Turtle Creek Pond
- 10 Lower Turtle Creek Channel Enhancement
- 11 Dykam Ranch Rehabilitation
- 12 Kokanee Spawning Channel
- **13 Creek 420873 Pond**
- 14 Three Ponds - Creek 661
- 15 Three Ponds Water Storage Complex
- **16 Creek 505659 Pond**
- 17 Mills Ranch Rehabilitation
- 18 Upper Davidson Creek Diversion
- 19 Snake Lake Diversion

Scale: 1:80,000

0 0.5 1 2 3

Kilometres

Notes

Preferred options are bolded

Reference

BC Government GeoBC Data Distribution

Knight Pieshold 'Year 17' Drawing May 24, 2013

CLIENT: newgold

PROJECT: Blackwater Gold Project

Potential On-Site Offsetting Options

DATE: April, 2014	ANALYST: WR	**Figure** 7-1
JOB No: VE52277	QA/QC: BM	PDF FILE: 10-100-021_OnSiteComp_v12.pdf
GIS FILE: 10-100-021_OnSiteComp_v12.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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320000 360000 400000 440000 480000

6000000 5960000 5920000 5880000

Vanderhoof Inset

Fort St. James Forest District

Vanderhoof Forest District

NECHAKO FLOODPLAINS

SAVORY RIDGE

NECHAKO RANGE

FAWNIE RANGE

NULKI HILLS

NAGLICO HILLS

Fort St. James
Nak'azdli
Dog Creek
Endako
Fraser Lake
Stellako
Nadleh Whuten
Fort Fraser
Vanderhoof
Weneez
Sinkut River
Saik'uz
Nulki
Mapes
Colleymount
François Lake
McDonalds Landing
Nee-Tahi-Buhn
Cheslatta Carrier
Danskin
Tatalrose
Skin Tyee
Ootsa Lake
Nukko Lake
Reid Lake
Isle Pierre
Telachick
Mud River
Punchaw
Blackwater
Nazko
Kluskus
Nechako Canyon Protected Area
Meridian Road (Vanderhoof) Ecological Reserve
Chilako River Ecological Reserve
Finger Lake
Uncha Mountains Red Hills Park
Francois Lake Park
Stuart River Park
Finger Tatuk Park
Kluskoil Lake Park
Entiako Park
Natalkuz Lake (Nechako Reservoir)
Proposed Blackwater Gold Project Site

Legend

- Populated Place
- Highway
- Kluskus FSR
- Kluskus-Ootsa FSR
- Kluskus-Blue FSR
- Other FSRs
- Railway
- Existing Transmission Line
- Stream
- Waterbody
- Parks and Protected Areas
- Forest Districts
- NEWSS Project Boundary

Potential Off-Site Offsetting Options

1. Enhancement of Finger-Tatuk Watershed Habitats
2. Creation and Maintenance of Sutherland River Watershed Habitats
3. Murray Creek Rehabilitation Project
4. Nechako Environment and Water Stewardship Society (NEWSS)
5. Nechako White Sturgeon Recovery Initiative
6. Restoration of Fish Passage in Fort St. James Forest District
7. Nechako Fisheries Conservation Program
8. Nulki - Tachik Watershed Restoration Program
9. Restoration of Fish Passage in the Vanderhoof Forest District
10. Stoney Creek Rehabilitation Project
11. Matthews Creek Watershed Rehabilitation
12. Swanson Creek Watershed Rehabilitation

Scale: 1:675,000
0 5 10 20
Kilometres

Reference

BC Government GeoBC Data Distribution
NRCAN Geobase
Ministry of Forests, Lands and Natural Resource Operations

CLIENT: newgold

PROJECT: Blackwater Gold Project

Potential Off-Site Offsetting Options

DATE:	ANALYST:	Figure 7-2
April, 2014	WR	
JOB No: VE52277	QA/QC: MY	PDF FILE: 10-100-143_Offsite_comp_v5.pdf
GIS FILE: 10-100-143_Offsite_comp_v5.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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7.2.3 Evaluation Methods

All 19 on-site and 12 off-site options were evaluated against regulatory, biological, engineering, construction and socio-economic screening criteria to determine the options that provided the best combination of criteria values and the greatest likelihood of success and acceptance by regulatory agencies, First Nations, and other stakeholders (**Annex F**). Consultations with regulators, First Nations, and other stakeholders were incorporated into the assessment and selection of options. The evaluation of each option used a two-tiered approach:

- Preliminary screening, involving a desktop review and fatal flaw analysis against selected biological, technical, regulatory, and socioeconomic criteria; and
- Detailed evaluation of technical feasibility and biological relevance assessment, based on field studies and analysis of groundwater, hydrological, and biological data.

For the preliminary screening assessment, the following criteria were considered:

- Technical feasibility, including constructability and potential for ancillary impacts;
- Biological relevance and potential population benefits, in terms of target species and populations affected by the Project;
- Stability and permanence;
- DFO's preferences for offsetting as outlined in the "*Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting*" (DFO, 2013b);
- BC MOE's fisheries management objectives;
- Consistency with First Nations' traditional knowledge and land use; and
- Relative economic feasibility based on construction costs.

All efforts were made to select offsets at the highest levels of DFO's hierarchy of preferences, consistent with DFO's guiding principles, and with high probability of successfully providing stable, long-term offsets for the target species (DFO, 1986, 1998a, 1998b, 2007, 2012, 2013a, 2013b, 2013c). On-site offsets were given priority because these were considered more likely to provide direct benefits to the fisheries affected by the Project and to the people using these resources.

Technical feasibility was included as a screening criterion because each option has to be technically possible to construct and must avoid significant adverse effects to the surrounding environment. These constraints are often imposed by local conditions, including factors such as stability, surficial geology, hydrogeology, and hydrology. Further investigation of factors that affect technical feasibility was a key component of the detailed evaluation stage. For example, under some circumstances, field investigations and data analysis resulted in the rejection of an option, as no engineering solution was available or the risk of failure was considered too high.

Biological relevance was considered because the ultimate determinant of success is the ability of an offsetting measure to preserve or increase fish production. Biological relevance was

evaluated as *the likelihood of alleviating habitat bottlenecks, and the likelihood of increasing the productive capacity for targeted fish species*. These were evaluated based on the understanding of existing habitat and fish distribution combined with baseline data and interpretation of physical habitat features currently limiting fish production.

Each option was assessed for its stability and ability to provide long-term benefits to offset the predicted losses. Options that are known to reliably increase productive capacity in perpetuity were preferred to shorter-lived options or options prone to structural failures. Furthermore, options that require little to no maintenance or are easily accessed were preferred, as these options reduce the likelihood of structural failures or structural failures going undetected, therefore providing the Proponent and regulators with greater confidence.

The relative economic feasibility of mitigation and offsetting projects was also considered. Construction costs for each option are dependent on complexity, access, and site conditions. Options that maximize HU gains per unit cost were generally more attractive. However, cost was not intended to preclude more expensive offsetting measures, but rather to differentiate between various options with all other factors being equal.

7.2.4 Evaluation Results

Preliminary screening results for all offsetting options investigated are summarized in **Annex F**. Five options were determined to provide the best combination of the screening criteria described above and the quantity/quality necessary to meet the required offsets:

- Lake 01682LNS enlargement and spawning/rearing habitat increases;
- Construction of two overwintering and rearing ponds near the mid-reaches of Davidson Creek (Creek 428073 Pond and mid-Davidson Pond);
- Construction of one overwintering and rearing pond near the mid-reaches of Creek 661 (Upper Creek 661 Pond);
- Mathews Creek Watershed restoration; and
- Restoration of fish passage in the Vanderhoof Forest District.

Many of the identified options had limitations related to technical feasibility, biological relevance and/or stability and permanence. A summary of the rationale for exclusion of those measures no longer included in the offsetting plan is provided in **Annex G**. Several other stream rehabilitation projects have been identified in the Vanderhoof region. These projects provide opportunities to enhance degraded stream habitats for a variety of fish species, depending on their location. These options are not considered necessary to meet the offsetting requirements of the Project, but have been carried forward as contingency options in the event required.

7.3 General Enhancement / Creation Procedures

While each offsetting location will have specific requirements in terms of construction, timing, and access, many of the stream habitat enhancement measures for spawning, rearing and overwintering share common features which are described below. The design characteristics of any enhanced or created habitat will consider local flow characteristics to ensure that that high flows will be transported without excess erosion or damage.

7.3.1 Spawning and Rearing

This section outlines general habitat features that will be constructed at stream locations to increase spawning and rearing capacity for rainbow trout. Planned features have been designed to address identified bottlenecks limiting population productivity. Areas with gravels suitable for rainbow trout spawning will be incorporated in constructed sections with appropriate gradients. Rearing habitat will be constructed to support the fish production provided by new or enhanced spawning habitat. Additional fry production will also increase use of existing nearby habitats as fish disperse.

Constructed spawning and rearing habitat features will be a combination of run and riffle meso-habitats, with characteristics based on habitat preferences for rainbow trout outlined in **Annex C**. A deeper section of channel (i.e., the thalweg) will be excavated, where possible, and routed from side to side of the channel.

A gravel-rubble mixture will be the primary spawning substrate. Rainbow trout spawning substrates are typically comprised of material between 2 and 130 mm in size with less than 5% fines (Grant and Lee, 2004), with a minimum substrate layer thickness of 250 mm (Thompson, 1972; Raleigh et al., 1984). Material will range from rounded to sub-angular and will not be sourced from blasted rock. **Figure 7-3** presents the general gradation of suitable spawning substrate. The proportions of finer material (percentages less than 10 mm and 1 mm diameter) are consistent with spawning material compositions that produce high salmonid egg-to-fry survival (>60%) (Tappel and Bjornn, 1983) and that have be used in other spawning habitat improvement projects in BC. A geological assessment will be conducted to identify a suitable material source. Angular rock material such as rip-rap will be used to stabilize shorelines, if required. Rip-rap will typically range between 200 mm and 460 mm in size (Buchanan and Wade 1983; Lister et al., 1995), will be selected from pit run sources where available, will be non- acid generating and will be clean of debris and fine particles.

Spawning substrates will be applied in enhancement areas over an existing base layer of larger material. Cobble and gravel substrates will be blended and applied to the same locations. This will provide a range of substrates in concentrated locations rather than lower densities of suitable spawning material throughout. The thalweg and deeper portions will use similar material, but larger substrates may be added to slow water and maintain shelter and cover for juvenile rearing. In areas where a reduction in bottom slope or gravel stabilization are required, low-head barriers will be installed (**Figure 7-4**).

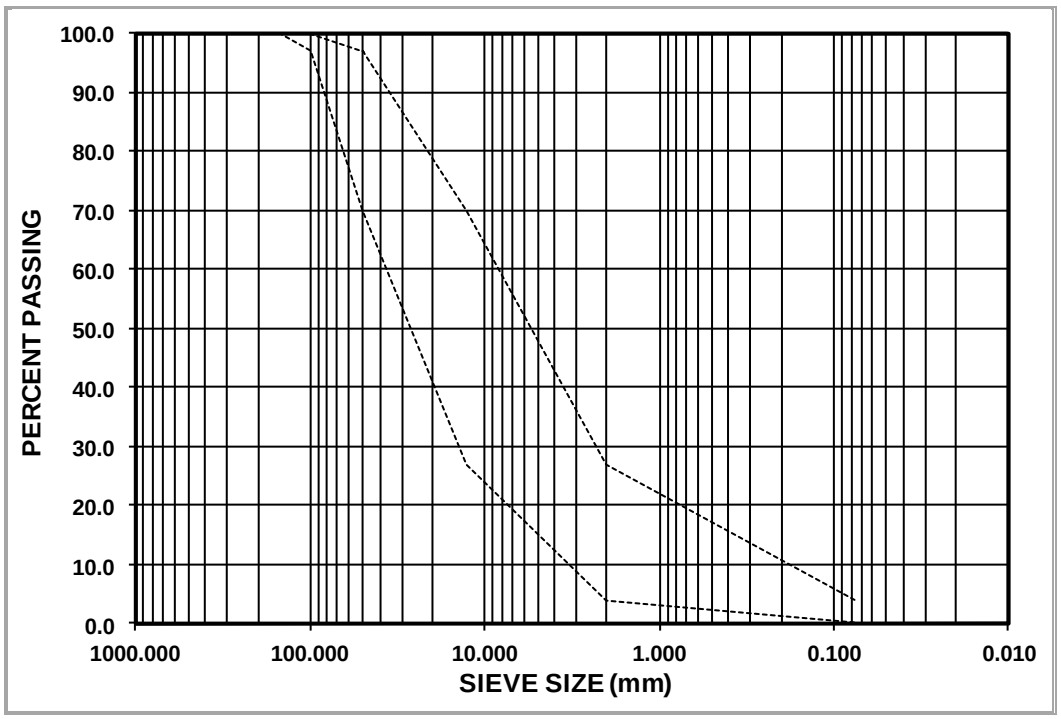


Figure 7-3: Typical Spawning Material Gradation

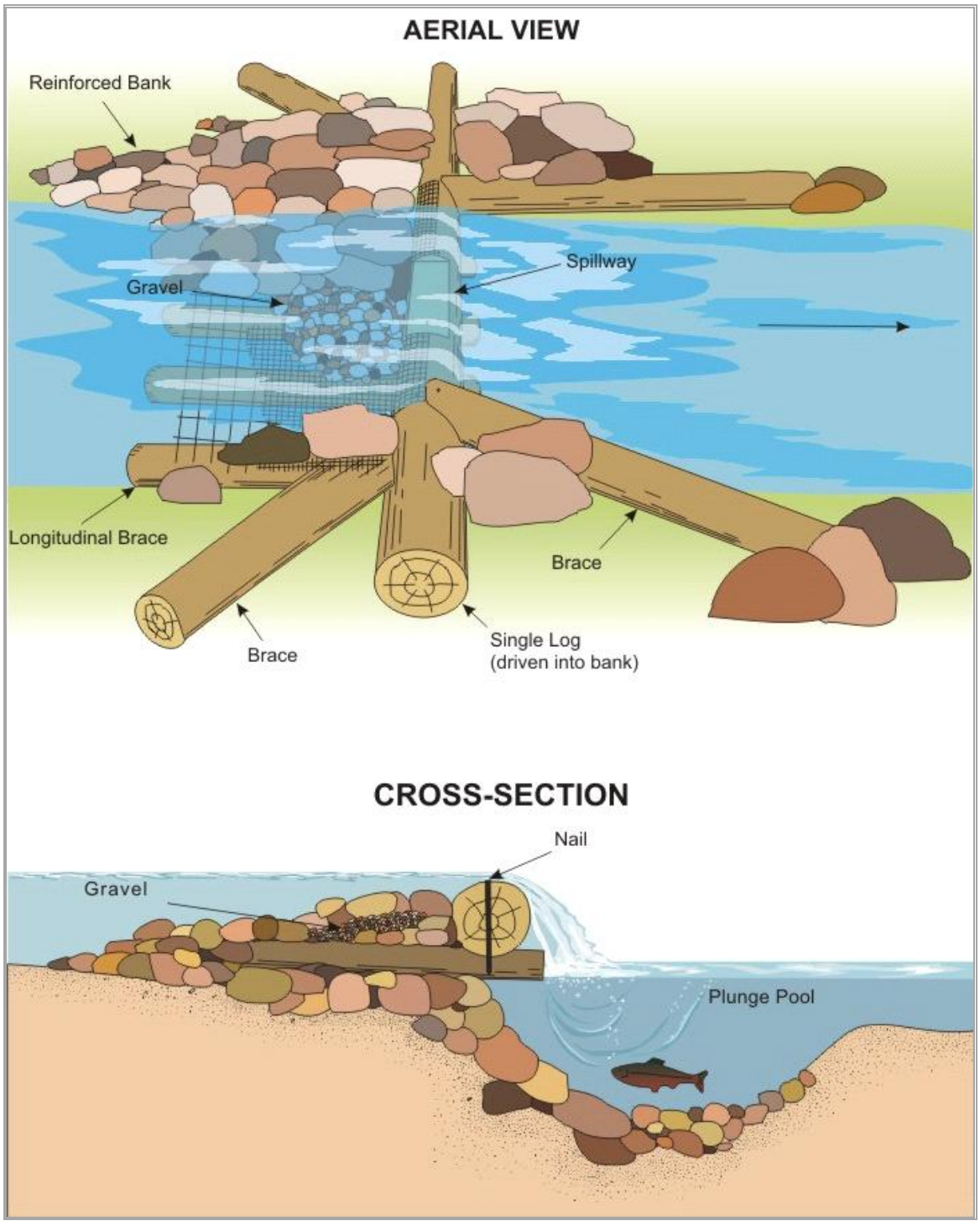


Figure 7-4: Typical Schematic of a Low-Head Barrier Installation

7.3.2 Pool Construction

Pool habitat provides a refuge for fish from high velocities associated with storm events and from low water levels during mid-summer and mid-winter. Refugia increase stream productivity. Constructed pools are a good addition to existing or constructed stream reaches, where limited refuge habitat is present and where bed load movement will not cause infilling. Off-channel ponds have proven an effective overwintering enhancement for rivers with limited deep pools or with flow dynamics that restrict the use of pools as refugia during winter months (Cunjak, 1996). For this offsetting plan, both in-channel and off-channel pool types will be constructed.

7.3.2.1 In-Channel Pools

In-channel pools are constructed within the existing active stream channel and are generally not more than 1 m deep at normal low flows. The overall extent of in-stream pool construction appropriate depends on the characteristics of each site, with final layout dependent on habitat requirements, access, ability to transport and dispose of excavated material, stability of shoreline material, ability to divert or retain the existing stream from the construction area, and availability new shoreline material.

In-channel pools are planned primarily within created channels, as pools assist creating spawning habitat structure (i.e., riffles or glides with suitable spawning material and pool habitat downstream (Roberge et al., 2002). Pools will be constructed in the dry prior to channel watering. Pools will be excavated to the appropriate depth and lined with larger material to increase stability and to provide cover for fish. Angular rock material such as rip-rap, as described above, will be used to stabilize pool shorelines if required.

7.3.2.2 Off-Channel Pools

Off-channel pools or ponds are generally larger, deeper bodies of water that are located just off the main stem of a stream, and provide slow, deep water with adequate cover for rearing and, in particular, overwintering. These are particularly important to rainbow trout populations where juveniles spend the first one or two years in streams, and where overwintering can become a limiting habitat bottleneck. Off-channel pools can be greater than 1 m in depth, particularly where thick ice cover is anticipated. A depth of 2 m is typically preferred. Because these features are built outside the natural watercourse, they can be isolated from the stream during construction. The overall extent, location and design of each off-channel pool constructed depends on site characteristics.

Off-channel pond options have been identified in the Davidson Creek and Creek 661 watersheds because they will provide overwintering habitat for Tatelkuz Lake rainbow trout populations. At each identified location, ponds will be constructed in the dry. Ponds will be excavated to the appropriate depth and lined with larger material to increase shoreline stability and to provide shoreline cover for fish. Large woody debris and other structures that improve overwinter habitat suitability will also be constructed. Angular rock material such as rip-rap will be used, if required, to stabilize pool shorelines. Once completed, ponds will slowly be filled with water from the mainstem (most likely via pumping directly into the created habitat) or via groundwater. This will

permit water levels to stabilize before pond connection to the main channel. Case-histories of juvenile rainbow trout use of off-channel overwintering ponds in northern Canada is presented in **Annex H**.

7.3.3 Riparian Revegetation

Upon completion of fish habitat construction, standard riparian contouring and revegetation will be completed to stabilize and re-colonize new and exposed shorelines and site access areas. This will be completed as machinery retreats from the area. Peat bog and mineral soil, from structure excavations, will be mixed on-site. If needed, soil will be placed on any exposed bank areas at a depth of 0.3 m to 0.6 m and graded to even grades. If required, lime and fertilizer may also be applied to the soil, followed by seeding for stabilization.

If riparian vegetation is disturbed, it will be rehabilitated immediately following completion of instream work. Initial riparian revegetation will consist of seeding (typical seed mix such as Canada No. 1 Ground Cover Mixture or a mix of clover and hay seed). Typically, local plant species will be used to stabilize habitats. Alder and willow are local, are successful colonizers and can be live-staked from local cuttings. Alder seed will be harvested in the fall and distributed in addition to live-staking. If required, local young trees such as willow, balsam fir, black spruce and alder will be transplanted into disturbed areas. All revegetation will be directed by an experienced botanist.

7.4 Environmental Protection

The Proponent has developed an Environmental Management Plan (EMP) that is applicable to all activities associated with Project construction. This EMP will be applicable to all fish offsetting works described in this document. This will eliminate or reduce the environmental effects of construction and operation activities on the aquatic environment. The protection measures applicable to freshwater fish habitat include, but are not limited to:

- Provide maximum protection to all streams and riparian habitat near fish offsetting measures, but not affected by the offset design;
- Implement a “no fishing policy for employees and contractors while traveling for work and while staying in accommodations provided by the Proponent;
- Design for no mine effluent discharge during mine operations and closure, and compliance with applicable discharge regulations;
- Consolidate sites and facilities to reduce areas of disturbance;
- Minimize, to the extent possible, alteration of surface water and groundwater patterns and flow;
- Control sediment during road construction and grading, blasting, excavation and dredging, and road de-icing;
- Educate and train personnel with regard to best practices to ensure protection of fish habitat;

- Adhere to applicable federal and provincial regulations and policies;
- Design diversion channels to control erosion and facilitate fish passage;
- Design stream crossings to reduce habitat alteration and facilitate fish passage;
- Limit and monitor construction and operation activities near waterways during sensitive periods for fish (e.g., avoidance of spawning/incubation);
- Include fish screens on water intakes as per DFO's *Freshwater Intake End-of-Pipe Fish Screen Guideline* (DFO, 1995); and
- Maintain flows downstream of all offsetting construction or enhancement sites such that no serious, permanent harm to fish will occur.

In addition, a Fish Recovery and Relocation Plan will be submitted to DFO prior to issuance of a S.35(2) *Fisheries Act Authorization*, and will describe measures to remove fish from areas of construction and/or dewatering.

7.5 Offsetting Measures for the Residual Serious Harm to Fish

Based on the preliminary screening, five options were selected to provide required Project offsets. Detailed evaluation of technical feasibility and biological relevance was completed for these options, based on field studies and analysis of groundwater, hydrological, and biological data. Sufficient survey data and design detail has been developed to ensure confidence with respect to feasibility and likelihood of success. Each option will be advanced to detailed design in the permitting/authorization phase of the Project.

7.5.1 Enlargement and Diversion of Lake 01682LNRS

Construction of the TSF Site C will isolate fish habitat, including Reach 12 of Davidson Creek and Lake 01682LNRS. To avoid the loss of the rainbow trout population in Lake 01682LNRS, mitigation measures will include a connection channel from Lake 01682LNRS to Lake 01538UEUT (**Section 5**). In addition to mitigation measures, Lake 01682LNRS will also be enlarged to as an offsetting measure that will to increase rainbow trout productivity. Additional spawning habitat will also be created to support increased productivity in the enlarged lake.

As indicated in **Section 3**, there are two separate lake-resident rainbow trout populations in the Davidson Creek Watershed; one population resides in Tatelkuz Lake and uses the lower to mid reaches of Davidson Creek for spawning and juvenile rearing and the second resides in Lake 01682LNRS and uses spawning and rearing habitats in the lake inlet and outlet streams. A steep cascade feature in Reach 11 of Davidson Creek obstructs upstream fish migration under most flows and effectively maintains these two separate populations.

To enlarge Lake 01682LNRS, water will impounded behind the Site C West dam. This action will inundate Reach 12 of Davidson Creek. The loss of this stream habitat is addressed in **Section 6** with regard to offset requirements. Mitigation for 9 m^2 of spawning habitat which supports the Lake 01682LNRS population, and which will be lost in Reach 11 of Davidson Creek, is

addressed in **Section 5**. The offsetting component of the Lake 01682LNRS enlargement project includes two separate aspects; lacustrine habitat creation and riverine creation/enhancement (**Figure 5-1**). Each is described below in terms of feasibility, targeted life stages, and anticipated success. To accomplish these objectives, the constructed offsets will consist of:

- Additional littoral and deep water habitats in a new lake area for resident rainbow trout productivity;
- New stream spawning, nursery and rearing habitats in the two diversion channels previously described in **Section 5**:
  - from Lake 01682LNRS to Lake 01538UEUT; and
  - from the headwater pond in the Creek 705 drainage ("Pond A"), to Lake 01682LNRS via "Pond B."

7.5.1.1 Lacustrine Habitat Creation

The main goal of the lake enlargement designs will be to increase the productivity of the lake in proportion to the increase in lake size (i.e., equivalent biomass per unit of habitat area). Aquatic habitat in Lake 01682LNRS is summarized in **Section 3.3.8**, based on detailed study described in **Section 5.1.2.6** and **Appendix 5.1.2.6A**. These habitat characteristics will be used as the template for creation of new lacustrine habitat. The design of the enlarged lake will replicate existing lake conditions and natural habitat analogues common to headwater lakes in the proposed Project area. These include the abundance and distribution of littoral habitats and physical habitat features such as substrates, cover features, and patterns of aquatic macrophyte colonization. Opportunities to enhance existing habitat conditions have been considered and integrated with natural shoreline features (i.e., bays, shoals, etc.) created by the enlarged lake area.

The proposed lacustrine habitat creation will increase the surface area of Lake 01682LNRS from approximately 9.2 ha to 21.7 ha. This increase in lacustrine habitat is expected to increase total biological production, which will increase the number of rainbow trout, although fish density (i.e., number/ha) is expected to remain the same. **Table 7-2** summarizes changes between the existing and enlarged lake areas. The ratio of littoral and pelagic habitats in the enlarged lake will be similar to the existing ratio.

Table 7-2: Summary of Characteristics in the Existing and Enlarged Lake 01682LNRS

Lake Characteristics	Unit	Existing Lake	Enlarged Lake Area[(1)]	Percent Change
Surface Area	(m^2)	91,860	217,339	237
Littoral Habitat Area (0-3 m)	(m^2)	38,490	101,180	263
Littoral Habitat Area (3-6 m)	(m^2)	18,900	54,434	288
Pelagic Habitat Area (6+ m)	(m^2)	34,470	61,725	179
Mean Depth	(m)	5.5	4.3	-22
Maximum Depth	(m)	16.3	16.3	0
Shoreline Length	(m)	1,667	5,430	326
Water Elevation	(masl)	1,345	1,346	-

Notes: [(1)] total including existing Lake 01682LNRS and constructed lake habitat.
masl = metres above sea level; m^2 = square metres; m = metres

The new lake area will be constructed in the dry. This will be done by installing a small cofferdam at the existing outlet of the lake and by first constructing the connector channel between Lake 01682LNRS and Lake 01538UEUT. The cofferdam will prevent water from flowing downstream into Davidson Creek and will cause water to flow towards Lake 01538UEUT through the connector channel. Fish salvage activities and construction of the new lake area will be tightly coordinated with construction of the TSF Site C West dam.

The enlarged lake will include a secondary basin adjacent to TSF Site C (**Figure 5-2**). A deep water connection (~5 m deep) between the new basin and the existing lake basin along the existing outlet alignment will be constructed to provide unrestricted fish migration between the two basins during low water and under thick winter ice. Habitat features that will be included in the enlarged lake area include:

- Shoreline features in shallow littoral habitats consisting of small angular rock, gravels, and LWD material to create near-shore cover and feeding opportunities for juvenile and adult fish;
- Shallow (0.50 m to 0.75 m average depth) shoals, littered with large boulder cover for juvenile and adult fish during open water season;
- Shoreline irregularities, including shoals, substrate complexity, and LWD along the dam face to support habitat use;
- Organic material placement in shallower sections (0 m to 3 m) and bays that are appropriate for aquatic macrophyte colonization and production;
- Randomly placed boulder fields positioned at varying depths throughout the enlarged lake area to provide additional cover and refuge throughout all seasons; and
- Moderately deep sections (3 m to 4 m on average) to provide overwintering refuge during periods of ice cover on the lake.

In general, the isolated area will first be stripped of all vegetation and topsoil material up to the expected high water line. Vegetation and soil stripping will facilitate installing habitat features and will mitigate potential effects from mercury bioaccumulation in the aquatic environment. Excavation of deep-water zones and fill placement will be required, including contouring and organic material placement in shallow water habitats and shoal areas. Shoreline and deep-water habitat elements will be installed once all excavation and contouring is complete. Whole and intact trees excavated during the stripping phase will be placed to provide LWD in the lake area.

Once all earthworks in the new lake area are complete and the diversion channel between "Pond A" in the Lake 01538UEUT watershed and "Pond B" in the Lake 01682LNRS watershed is complete (see **Section 7.5.1.2**), the new lake area will be filled by pumping water from Lake 01682LNRS around the coffer dam. The rate of pumping will be equal to the additional run-off provided to Lake 01682LNRS by the diversion channel. This will avoid any potential draw-down of Lake 01682LNRS while the new lake habitat fills with water. The filling time will be dependent on construction timing and the rate of inflow.

Once the new lake area is filled to the same water elevation as Lake 01682LNRS, the area will remain isolated from Lake 01682LNRS until water quality and habitat conditions stabilize. When the new lake area is demonstrated to be suitable for fish, the cofferdam at the existing outlet will be removed, and the new lake area connected to Lake 01682LNRS.

To minimize impacts to the rainbow trout spawning habitat in the inlet stream on the south side of Lake 01682LNRS, the lake enlargement design and construction will maintain the existing natural range of lake level elevations at all times. As described in **Section 5**, this will be accomplished during construction by pumping water at a rate equal to the additional inflow provided by the diversion channel and during operations by ensuring that the control elevation of the new outlet connector channel between the two lakes is similar to the natural outlet elevation. This will prevent disturbances to the existing lake shoreline, to littoral habitats and to spawning habitat within the lower sections of the inlet stream. This will protect 18 m^2 of existing spawning habitat in the inlet stream.

A site-specific EMP will be developed to support construction and will include BMPs for instream construction, erosion and sediment control, water management, and riparian management. Provisions to mitigate other potential environmental effects will be included such as protecting archaeological sites, rare plants or plant communities, wetlands, migratory birds, and other wildlife species.

7.5.1.2 Stream Habitat Creation/Enhancement

Rainbow trout productivity in Lake 01682LNRS is supported by stream habitat in the existing inlet and outlet. Habitat losses due to inundation of the outlet will be addressed via mitigation (**Section 5**). The lake enlargement concept involves increasing the surface area of Lake 01682LNRS from approximately 9.2 ha to 21.7 ha (i.e., 2.4 times the size of the existing lake). Assuming that other factors governing annual recruitment, survival, and growth (i.e., dissolved oxygen concentrations, predation rates, prey production) remain unchanged following lake enlargement, the larger lake will support and enlarged population of rainbow trout. New

spawning and rearing habitats will be required to support the new rainbow trout productivity in the enlarged lake. This habitat will be created in the two new channels created as part of the Lake 01682LNRS enlargement: rearing habitat in the connector channel between Lake 01682LNRS and Lake 01538UEUT; and spawning habitat in the diversion channel from the Lake 01538UEUT headwater tributary at "Pond A" to Lake 01682LNRS via "Pond B."

It is assumed that an increase in suitable spawning habitat area equivalent to the change in lake area will be required. Current production in Lake 01682LNRS is supported by 27 m^2 of spawning habitat. Therefore, it is estimated that a minimum of 65 m^2 (i.e., 27 m^2 x 2.4) of spawning habitat will be required to support the enlarged lake, including both mitigation (**Section 5**) and offset components. Given that 18 m^2 of spawning habitat in the inlet stream to Lake 01682LNRS will remain unaffected by the diversion and enlargement (**Section 5**), 47 m^2 of new spawning habitat will be required to maintain annual rainbow trout recruitment in the enlarged lake.

An EMP for stream habitat creation and enhancement will be developed to describe BMPs for instream construction, work-site isolation, erosion and sediment control, water management, riparian management, and other environmental concerns.

Connector Channel from Lake 01682LNRS to Lake 01538UEUT

This diversion will consist of a 650 m long connector channel constructed between Lake 01682LNRS and Lake 01538UEUT and described in **Section 5**. The channel will provide connectivity to Creek 705 to mitigate the isolation of Lake 01682LNRS and to maintain the viability of the offset population in the enlarged lake. In addition, the channel will be designed provide spawning and rearing habitat to the maximum extent practical.

As noted in **Section 5**, channel design will not be finalized until the permitting phase. **Figure 5-3** and **Figure 5-4** provide a conceptual overview of the layout and design. Riffle-pool sequences will be incorporated as gradient permits. Wetland features may be created in widened sections of the channel to replicate natural conditions in low gradient streams. Stream banks will be vegetated with native plant species and rock-lined where necessary to prevent erosion, and will replicate bank conditions in local headwater streams. Woody debris, cobbles/boulders, deep pools, and riparian plantings will be incorporated to create summer rearing habitat for fry and juvenile rainbow trout.

Inlet Channel Creation/Diversion

An additional offsetting measure will be the diversion of flows from the headwaters of Creek 705 to Lake 01682LNRS. The purpose is to construct new spawning habitat in a new inlet stream to Lake 01682LNRS. This diversion will also improve access to existing spawning habitat in Reaches 10 and 11 of Creek 705, an area currently used by longnose sucker and likely rainbow trout residing in Lake 01538UEUT (**Appendix 5.1.2.6B** of the Application).

Several routing options were investigated (**Annex B**); however, the preferred option offers the most direct route for migrating fish and the greatest potential for habitat creation. The channel will connect "Pond A" (Reach 9 of Creek 705) to "Pond B" by means of new 1.3 m wide channel.

This channel will be approximately 310 m in length, 403 m^2 in area, and have an average gradient of 1.7%. Where possible, a low gradient, riffle-pool type stream will be constructed. Based on typical design configurations for this type of channel, between 15% and 25% of the total channel area is expected to provide rainbow trout spawning habitat (i.e., creation of between 60 m^2 and 100 m^2 of suitable spawning habitat). “Pond B” will be connected to Lake 01682LNRS via a constructed low gradient channel. The gradient in this channel will be too low (<1%) to provide spawning habitat.

In addition to spawning habitat created in the diversion channel, spawning habitat that currently exists in the Lake 01538UEUT headwater tributary upstream of “Pond A” will be made available to fish in the enlarged Lake 01682LNRS. Habitat above this pond is divisible into two reaches: a 380 m long reach of higher quality spawning and rearing habitat characterized by cobble/gravel dominated glides and riffles, cobble dominated cascades, and pools with silt substrate, overhanging vegetation and small woody debris; and a 1,840 m reach of lower quality spawning and rearing habitat characterized by higher gradient (~9%), cobble/boulder cascades, isolated pockets of gravel riffles and instream vegetative cover. Potential use of this habitat by spawning rainbow trout from Lake 01538UEUT is unknown. Juvenile longnose sucker were observed in “Pond A” in summer 2013 (**Appendix 5.1.2.6B** of the Application). Although less reliant on upwelling than rainbow trout, longnose sucker typically use similar spawning habitat. This suggests that rainbow trout in the enlarged Lake 01682LNRS could also use this habitat once the diversion channel is built. Longnose sucker, and presumably rainbow trout, from Lake 01538UEUT will continue to be able to access this habitat via the connector channel.

The combination of 60 m^2 to 100 m^2 of new spawning habitat created in the channel between “Pond A” and “Pond B,” and improved access to spawning habitat upstream of “Pond A” will address the requirement for at least 47 m^2 of new spawning habitat to support the enlargement of Lake 01682LNRS. While spawning habitat is the focus of channel design, rearing habitat will also be incorporated in designs for channels connecting “Pond A” to “Pond B,” and “Pond B” to Lake 01682LNRS.

7.5.1.3 Potential Ancillary Impacts to Fish and Fish Habitat

Potential ancillary effects of increased flows in Creek 705 due to diversion of Lake 01682LNRS are addressed in **Section 5**.

Enlargement of Lake 01682LNRS will result in the flooding of upland and riparian areas and has the potential to release mercury stored in the surrounding soils. This mercury can then be methylated by naturally occurring bacteria. If this were to occur, methylmercury could bioaccumulate in the aquatic foodweb. Concentrations of methylmercury in tissues of aquatic organisms typically biomagnify with increasing trophic level, with the highest concentrations typically occurring in predatory fish.

This effect will be reduced by removing or burning vegetation in the area to be flooded and removing soil in the area. The anticipated magnitude of mercury bioaccumulation as a result of thse mitigation measures is low. Although mercury and methylmercury concentrations are may increase in tissues of rainbow trout, they are not expected to reach concentrations that could

significantly affect any aspect of rainbow trout growth, survival or reproduction. As reported by Azimuth (2012), there is very little evidence that the elevated mercury concentrations typically observed in tissue of fish resident in newly-created reservoirs has any effect on their ecology. The main scientific and social concern has always been for the health of humans, particularly pregnant women, who may consume large quantities of fish harvested from such reservoirs on a continuous basis over a long time period.

This is an unlikely scenario because the mine site will be off limits to the general public until the mine site is abandoned (i.e., the Mines Act Permit is closed) and First Nations are unlikely to fish the lake given its small size and greater distance from their communities in comparison to other, larger lakes and streams. Lakes 01682LNRS and 01538UEUT will not be accessible for food fishing until at least 18 years after mine closure or about 35 years total from mine opening. Typically, the period of elevated mercury concentrations in a new reservoir lasts for 30 to 40 years (Azimuth, 2012). Eventually all of the mercury that is mobilized by flooding of soil will be processed through the lake food chain and re-buried in an inert form in the lake sediments. This period corresponds to the Project life span.

Diversion of “Pond A” in the Creek 705 Watershed to “Pond B” will result in the loss of Reach 8 of Creek 705. This short reach (125 m) is characterised by riffle (72%) and glide (28%) habitat with cobble and fine substrates. Rainbow trout spawning habitat is poor due to the lack of spawning gravels. Despite good instream vegetation and LWD cover, rearing habitat is poor due to low water levels. There are no pools, so no overwintering habitat is available. Migration is rated as fair because there are no major obstructions that would prevent migration other than low water levels. The loss of this reach will be mitigated by new habitat created in the diversions between Lake 01682LNRS and Lake 01538UEUT and between “Pond A,” “Pond B” and Lake 01682LNRS.

7.5.1.4 Summary of Offset Gains

A summary of predicted offset gains created by the new Lake 01682LNRS enlargement, diversion channel, and inlet channel is provided in **Table 7-3**. Gains anticipated as a result of the proposed offsetting are 132,000 m^2. When habitat quality provided for different life stages of rainbow trout is considered, a total of over 339,350 HUs are created. The value of newly created habitat for longnose sucker resident in Lake 01538UEUT was not considered in this assessment.

Most of the offset gains for this option are juvenile summer rearing (89,500 HUs), adult summer foraging (78,500 HUs), and overwintering (111,500 HUs) habitats for rainbow trout. The high contribution of habitat for these life stages the quantity and quality of habitat provided in the enlarged lake area. The new diversion channel and inlet contribute approximately 70 HUs of spawning/egg incubation, 1,600 HUs of fry summer rearing and 2,250 HUs of juvenile summer rearing habitat for rainbow trout. These values consider habitat lost between “Pond A” and Lake 01538UEUT, and represent highly conservative estimates of the quantity of spawning habitat that can be created in the diversion channels. Total habitat area in the lake connector channel is 2,970 m^2. The inlet channel will 600 m^2 of new stream habitat, and access to 3,275 m^2 of previously isolated habitat in “Pond B.” Improved access to “Pond A” and to habitat upstream of “Pond A” was not included in the assessment. The new channel construction will improve access

to existing spawning habitat within the upper reaches of Creek 705, which appears under-utilized by rainbow trout.

Contribution to Fisheries Act and MMER Offset Requirements

Based on the overall areal extent and HU values associated with the Lake 01682LNRS diversion and enlargement option, it is determined that the enlargement component (i.e., the offsetting component) will offset a portion of the serious, permanent harm associated with the *Fisheries Act* 35(2) Authorization (i.e., for habitat effects associated with upstream habitat isolation, the mine facilities footprint and flow reductions in headwater tributaries to Creek 661). A complete summary of offset ratios relative to serious, permanent harm is provided in **Section 7.7**.

Table 7-3: Total Estimated Area and Habitat Unit Offsets from the Lake 01682LNRS Enlargement, Diversion Channel, and Inlet Channel Creation in Upper Davidson Creek

Compensation Component	Habitat Type	Class	Estimated Total Area (m^2)	Rainbow Trout Life Stages					Food & Nutrient Production HUs	Total by Habitat Type / Class HUs
				Spawning / Egg Incubation HUs	Fry Summer Rearing HUs	Juvenile Summer Rearing HUs	Adult Summer Foraging HUs	Overwintering HUs		
Lake Enlargement	Lake	1	62,690	0	0	47,018	31,345	47,018	47,018	172,398
		2	35,534	0	0	26,651	26,651	35,534	8,884	97,719
		3	27,255	0	0	13,628	20,441	27,255	0	61,324
Diversion Channel from "Pond A" to Lake 01682 LNRS1	Riffle	1	40	20	20	0	0	0	30	70
		2	10	2	7	2	0	2	10	25
		3	80	0	40	60	0	20	80	199
	Glide	1	40	40	10	0	0	0	20	70
		2	10	5	5	2	0	2	7	22
		3	235	0	59	117	0	59	176	411
	Pool	2	191	0	48	143	0	48	48	286
	Other	2	3,275	0	819	819	0	819	819	3,275
Lake Connector	Riffle	3	23	0	12	18	0	6	23	59
	Glide	3	679	0	170	339	0	170	509	1,188
	Pool	1	351	0	88	351	0	263	88	790
		2	117	0	29	88	0	29	29	176
	Other	2	1,800	0	450	450	0	450	450	1,800
Loss of Creek 705 Reach 8	Riffle	3	-136	0	-68	-102	0	-34	-136	-340
	Glide	3	-54	0	-14	-27	0	-14	-41	-95
Estimated Total Area and Habitat Units			**132,139**	**67**	**1,674**	**89,556**	**78,437**	**111,627**	**58,013**	**339,374**

Note: m^2 = square metres, HUs = habitat units
(1) Includes "Pond B"

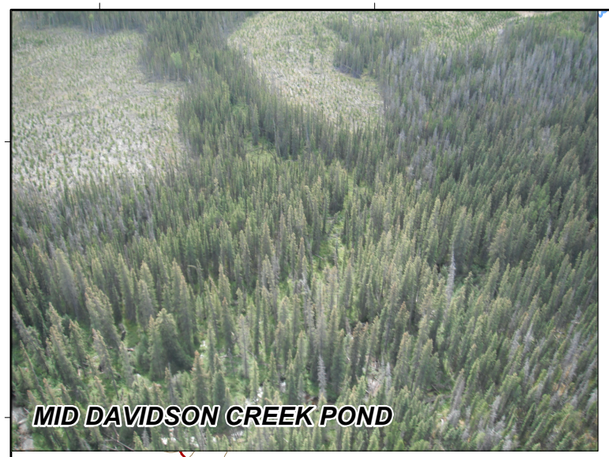
7.5.2 Off-Channel Overwintering Ponds in Selected Watersheds

Stream-dwelling salmonids undergo physiological and behavioural changes in winter in response to falling water temperatures. These changes include reduced swimming, metabolism and feeding, as well as depletion of lipid energy stores (Cunjak and Power, 1986; Riehle and Griffith, 1993; Cunjak, 1996; Simpkins et al., 2000). As a result of these changes, stream-dwelling salmonids like rainbow trout actively choose overwintering habitats that minimize energy expenditure while maximizing concealment and survival. Adequate overwintering habitat, rather than the amount of summer rearing habitat, can be the major factor limiting salmonid densities in some streams (Bustard and Narver, 1975).

Overwintering habitats generally have low water velocities, depths sufficient to provide protection from ice scour, cover from predators, and an accessible food supply (Anderson, 2002). Juveniles tend to hide in the interstitial spaces in the substrate (Bjornn and Reiser, 1991) and the interstitial spaces between larger substrates are preferred (Gregory and Griffith, 1996). DO in water is another important variable for overwintering salmonids. DO concentrations <3 mg/L are lethal for rainbow trout (Alabaster et al., 1957; Davis, 1975), growth and survival of rainbow trout increases significantly at DO concentrations >5 mg/L (Bjornn and Reiser, 1991; Raleigh et al., 1984), and DO concentrations >8 mg/L or near saturation are ideal. Sources of oxygenated water may be groundwater seepage or open water areas upstream (Anderson, 2002).

Winter cover and overwintering habitat quality are factors that likely limit the productive capacity of fish habitat in Davidson Creek, Creek 661, and Creek 705. Adult rainbow trout that spawn in these watersheds move to larger streams and lakes (i.e., Chedakuz Creek, Tatelkuz Lake, Lake 01628LNRS, Lake 01538UEUT) after spawning, and do not use overwintering habitats in streams. However, juvenile rainbow trout remain in the streams for several years to feed and grow, and are therefore dependent on stream overwintering habitats. Baseline surveys indicate that overwintering habitats are limited by thick ice cover, absence of larger substrates, low winter flows and/or lack of adequate groundwater inputs (**Appendix 5.1.2.6A** and **Appendix 5.1.2.6B** of the Application).

Opportunities to help alleviate the overwintering habitat bottleneck were identified at three locations within Project-area. Suitable sites for off-channel overwintering pond construction were found in the mid to upper reaches of Davidson Creek (two locations) and in Creek 661 (one location) (**Figure 7-5**). There are relatively few previous projects in the northern BC interior, which have constructed overwintering ponds to address rainbow trout habitat limitations (**Annex H**). However, such ponds have been successfully created at the recent, nearby Mount Milligan project, specifically to address rainbow trout overwintering habitat limitations. Successful rainbow trout overwintering ponds have also been developed in Alberta, and ponds for other salmonids are commonly developed on the BC coast. Site and design characteristics to maximise success are well understood (**Annex H**), and are available at the identified sites. Ideal overwintering habitats for rainbow trout are deep pools (>2 m) with cobble/boulder substrates, overhead cover, and a source of oxygenated water.







372000 375000 378000 381000 384000 387000 390000

5910000 5907000 5904000 5901000 5898000

N

Kluskus-Ootsa FSR

Turtle Creek

Davidson Creek

Mid Davidson Creek Pond

Creek 428073 Pond

Creek 505659 Pond

Creek 661

Kluskus-Messue FSR

Snake Lake

Tatelkuz Lake

Tatelkuz Lake Tributaries

NECHAKO RANGE

Legend

- Kluskus-Ootsa FSR
- Other FSRs
- Existing Road
- Stream
- Waterbody
- Watersheds

Project Components

- Exploration Road
- Proposed Mine Access Road
- Proposed Transmission Line
- Mills Ranch Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip Access Road
- Proposed Airstrip
- Proposed Mine Site
- Proposed Mine Footprint

Fish and Aquatic Resources

- Local Study Area

Scale: 1:65,000

0 1 2 3

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Off-Channel Overwintering Ponds - Proposed Site Locations

DATE: April, 2014	ANALYST: KA	**Figure** 7-5
JOB No: VE52277	QA/QC: MM	PDF FILE: 10-100-142_offchannel_OWP_v4.pdf
GIS FILE: 10-100-142_offchannel_OWP_v4.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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Design criteria for off-channel overwintering ponds target identified biological and physical requirements. Most off-channel ponds constructed in BC have similar design and engineering details, so provide a relatively simple, effective, and proven template to design and construct overwintering habitat at low risk. Each identified site meets these needs, and is located in a broad, low-relief floodplain or wetland area adjacent to the stream channel, where water tables are near surface. These areas provide a good source of groundwater or subsurface inflows, and options for various configurations including inlet or outlet channels. Determination of inlet/outlet channel configurations will depend on local site conditions, including mainstem sediment transport and deposition characteristics.

The locations and estimated sizes of planned off-channel overwintering ponds are summarized in **Table 7-4**. A total habitat area of approximately 21,560 m^2 can be created by constructing the three off-channel overwintering ponds. Additional pond habitat area may be realized depending on the final locations and layouts. Off-channel pond design targets increased overwintering habitat for juvenile rainbow trout, but created habitat will also be suitable for rainbow trout juvenile and fry summer rearing.

Table 7-4: Location and Potential Size of the Proposed Overwintering Ponds

Overwintering Pond	Watershed	Location	Estimated Area (m^2)
Creek 428073 Pond	Davidson Creek	Reach 1	7,500
Mid Davidson Creek Pond	Davidson Creek	Reach 5	6,030
Upper Creek 661 Pond	Creek 661	Reach 5	8,030
Total Pond Habitat Area			**21,560**

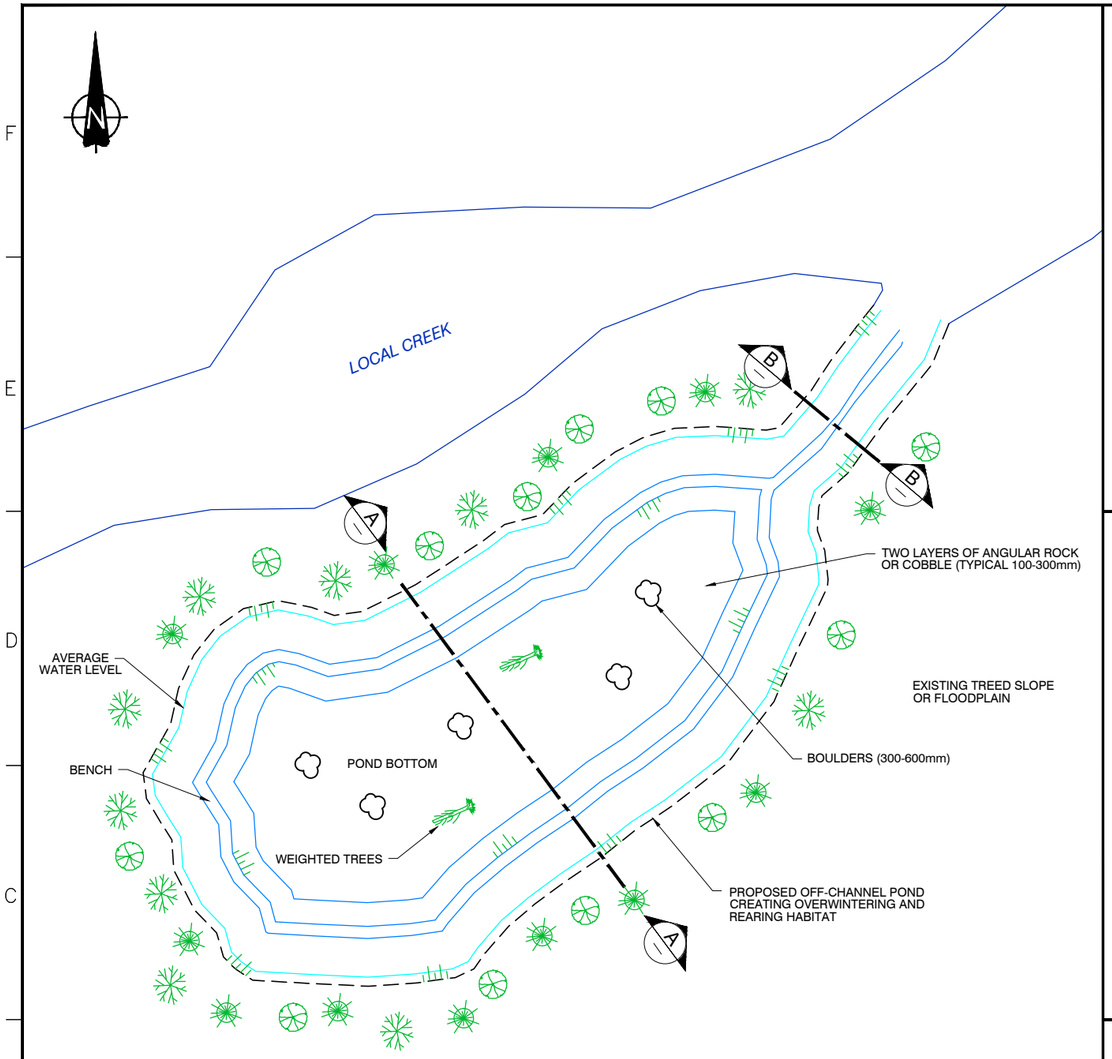
Engineering and fish habitat features that will be common to all proposed off-channel overwintering ponds include:

- Located close to the local stream (typically within 10 m to 20 m) within the floodplain or natural low-lying wetland area;
- Ideally located near a groundwater source that provides sufficient water quantity to eliminate the need for an inlet channel;
- Adequate depth (typically 2 m to 4 m) to prevent freezing to bottom during exceptionally cold winters and provide refuge for overwintering fish beneath the ice;
- Shallow water benches around the perimeter to allow for colonization by aquatic macrophytes, habitat complexity, and to increase instream cover for juvenile rearing;
- Shallow banks with 2:1 slopes to avoid slumping and sedimentation and minimize requirements for hard bank erosion protection;
- Constructed inlet and/or outlet channels that allow fish passage during all seasons; and
- Abundant instream and overhead cover (i.e., LWD, cobble/boulder substrates, depth, riparian vegetation) to provide cover during both overwintering and rearing periods.

Constructed off-channel overwintering ponds will range in size and will typically be oval. Minor variations in shape will be incorporated for increased habitat complexity, and will be influenced by local topography. **Figure 7-6** shows a plan and design detail for off-channel overwintering ponds. Designs will be adapted to the local site conditions to provide the greatest possible pond size relative to excavation and water source constraints.

Construction of off-channel overwintering ponds will involve excavating and contouring the pond area, including excavating inlet/outlet channels, placing substrates, rip-rap, and LWD. Construction will be scheduled during the winter when frozen ground conditions can support heavy machinery, and water management and site runoff concerns are reduced. All excavated materials will be transported and stored offsite, or at a suitable location outside the floodplain area. Access routes to and from each site will optimize the use of existing forestry roads and minimize additional clearing. To minimize the release of suspended sediments, construction will be completed under dry conditions by isolating the main excavation area from the natural stream channel. The inlet/outlet channels will be used as natural plugs, effectively isolating the main pond area, and will be removed when conditions stabilize. In the late spring immediately following construction, all disturbed areas and banks will be stabilized and planted using native vegetation. An EMP will be developed to describe BMPs for instream construction, work-site isolation, erosion and sediment control, water management, riparian management, and other environmental concerns.

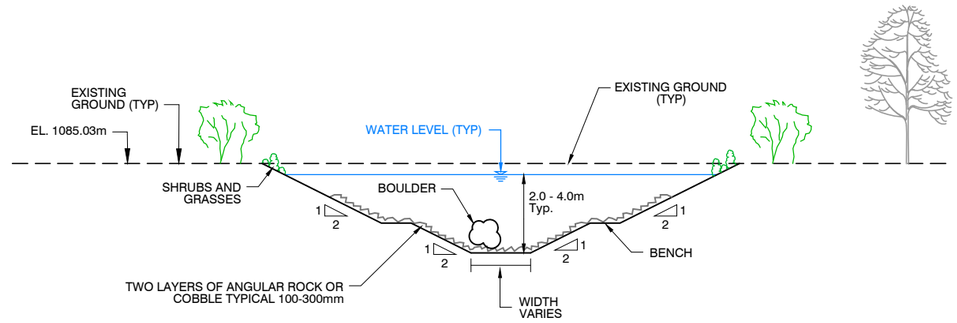
Early construction of overwintering ponds are planned to ensure that these habitats are available at approximately the same time that Project-related effects to fish habitats in Davidson Creek and Creek 661 occur.



OFF-CHANNEL OVERWINTERING POND PLAN - TYPICAL

0m 5 10 15 20

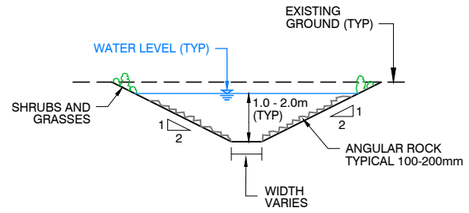
1 : 500



SECTION A-A

0m 2 4 6 8

1 : 200



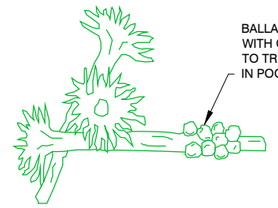
SECTION B-B

0m 2 4 6 8

1 : 200

LWD TYPICAL SPECIFICATIONS

- 30-60 cm DIAMETER
- UP TO 5 m LENGTH
- NATIVE PINE OR SPRUCE WITH BRANCHES AND ROOT WADS
- WOOD PIECES CABLED TOGETHER FOR STABLITY



LARGE WOODY DEBRIS DETAIL

SCALE: N.T.S

LEGEND

- LARGE WOODY DEBRIS CLUSTER
- RIPARIAN SHRUBS AND UPLAND VEGETATION
- BOULDERS

NOTES:

1. CONCEPTUAL ENGINEERING DETAIL ONLY. OFF-CHANNEL OVER-WINTERING PONDS ARE PENDING FURTHER INVESTIGATIONS AND DESIGN DEVELOPMENT.

2. CONSTRUCTION SHOULD BE COMPLETED IN THE WINTER UNDER FROZEN GROUND CONDITIONS USING IN-STREAM ISOLATION TECHNIQUES TO PREVENT SEDIMENT MOBILIZATION AND TRANSPORT TO THE NATURAL STREAM. SITE-SPECIFIC ENVIRONMENTAL MANAGEMENT PLANS SHALL BE DEVELOPED TO ADDRESS BEST MANAGEMENT PRACTICES FOR IN-STREAM CONSTRUCTION, WORK-SITE ISOLATION, EROSION AND SEDIMENT CONTROL, WATER MANAGEMENT, RIPARIAN MANAGEMENT AND OTHER ENVIRONMENTAL CONCERNS.

REV	DSN	CHK	DR	APP	D/M/Y	REVISION
1			TH	BM	17/03/13	ISSUED FOR DRAFT REPORT

REF	NUMBER	TITLE

REFERENCES

ISS	D/M/Y	APP	ISSUED FOR

NOTES

newgold

amec

BLACKWATER MINE PROJECT

OFF-CHANNEL OVERWINTERING POND PLAN AND DESIGN DETAIL

FILE NO:		DATE:
VE52277		JANUARY 2014
PROJECTION: UTM Zone 10	DATUM: NAD 83	
JOB NO: VE52277	REVISION NO: 1	7-6

N:\Projects\52000\VE52200\VE52277 - New Gold - Blackwater EA 2013\7000 Compensation\Fish Habitat\04 Drawings and Maps\CAD Folder\N5.4-6 Off-Channel Overwintering Pond Jan 2014.dwg - 5.4-6 - Jan. 14, 2014 10:50am - tim.hawker

7.5.2.1 Summary of Habitat Gains

Habitat gains created by the construction of off-channel overwintering ponds in the various watersheds are summarized in **Table 7-5**. A total of 21,560 m^2 of instream habitat area, or 47,411 HUs of rainbow trout habitat, can be created by off-channel overwintering ponds.

Fish habitat created by off-channel overwintering ponds has been focused on the identified overwintering habitat bottleneck (18,296 HUs); however, will also provide suitable habitat for rainbow trout juvenile summer rearing (18,311 HUs), fry summer rearing (5,390 HUs), and for food and nutrient production (5,414 HUs).

Contribution to Fisheries Act and MMER Offset Requirements

Based on the overall areal extent and HU values associated with this option, it is determined that construction of off-channel overwintering ponds will offset a portion of the requirements related to the *Fisheries Act* 35(2) Authorisation. A complete summary of offset ratios relative to serious, permanent harm is provided in **Section 7.7**.

Table 7-5: Total Estimated Area and Habitat Units from Constructing Off-Channel Overwintering Ponds in Various Watersheds

Off-Channel Pond Location	Habitat Type	Class	Estimated Total Area (m^2)	Rainbow Trout Life Stages					Food and Nutrient Production (HU)	Total by Habitat Type/Class (HU)
				Spawning/ Egg Incubation (HU)	Fry Summer Rearing (HU)	Juvenile Summer Rearing (HU)	Adult Summer Foraging (HU)	Overwintering (HU)		
Mid-Davidson Creek Pond	Other	1	4,800	0	1,200	4,800	0	4,800	1,200	12,000
		2	1,200	0	300	300	0	300	300	1,200
	Glide	3	24	0	6	12	0	6	18	42
	Pool	1	6	0	2	6	0	5	2	14
	Subtotal		6,030	0	1,508	5,118	0	5,111	1,520	13,256
Creek 428073 Pond	Other	1	6,000	0	1,500	6,000	0	6,000	1,500	15,000
		2	1,500	0	375	375	0	375	375	1,500
	Glide	3	0	0	0	0	0	0	0	0
	Pool	1	0	0	0	0	0	0	0	0
	Subtotal		7,500	0	1,875	6,375	0	6,375	1,875	16,500
Upper Creek 661 Pond	Other	1	6,400	0	1,600	6,400	0	6,400	1,600	16,000
		2	1,600	0	400	400	0	400	400	1,600
	Glide	3	24	0	6	12	0	6	18	42
	Pool	1	6	0	2	6	0	5	2	14
	Subtotal		8,060	0	2,008	6,818	0	6,811	2,020	17,656
Estimated Total Area and Habitat Units			**21,560**	**0**	**5,390**	**18,311**	**0**	**18,296**	**5,414**	**47,411**

Note: HU = habitat unit

7.5.3 Mathews Creek Watershed Restoration Project

7.5.3.1 Concept Overview and Rationale

Past agricultural activities in the Mathews Creek watershed, particularly adjacent to in the middle reaches of the Mathews Creek mainstem (Reaches 3, 4, and 5), has resulted in localized impacts to instream, riparian, and terrestrial habitats. These impacts are primarily the result of vegetation clearing, draining of the land with ditching to accommodate agricultural activity, cattle trampling of the floodplain and channel banks, and little to no maintenance of bridges which have collapsed and now pose obstructions to flow and fish passage (PECG, 2013). The most severe impacts are concentrated within the valley bottom along Reach 5, within two areas of private land (PECG, 2013). More detailed descriptions of the existing habitat conditions, fish community composition, relative abundance and distribution, and proposed habitat rehabilitation projects proposed in Mathews Creek is provided in PECG's Blackwater Project: Mathews Creek Watershed Fish and Fish Habitat Baseline Assessment and Offsetting Plan report (PECG, 2013) which is included in **Annex I**.

Mathews Creek has been identified as a valuable opportunity for off-site offsetting because of its history of ongoing agricultural impacts, its close proximity to the Blackwater Gold Project, and the presence of native rainbow trout in its watershed, the species most directly affected by the Project. Because of this, the Proponent recently purchased the private land adjacent to Reach 5 of Mathews and now intends to rehabilitate these degraded habitats as part of it offsetting requirements for the Project.

The objective of the Mathews Creek Watershed Rehabilitation Project is to restore and enhance instream, riparian and wetland habitat in Reach 5 of Mathews Creek. This restoration is intended to increase the productive capacity of habitat in Reach 5 of Mathews Creek for rainbow trout. Rainbow trout are an important recreational fish species in BC and restoration of degraded habitat in Reach 5 of Mathews Creek would increase the production of fisheries in Mathews Creek and in Laidman Lake at the mouth of Mathews Creek.

7.5.3.2 Description of Proposed Habitat Rehabilitation Projects

The focus of the Mathews Creek rehabilitation projects will be in Reach 5 where PECG documented the majority of fish habitat degradation in the Mathews Creek watershed. Efforts will target current habitat limitations for rainbow trout by improving existing habitat, creating new off-channel habitat, and improving access to existing high quality habitat upstream. These projects will provide new habitat or increase the suitability of existing habitat for juvenile summer rearing, adult summer foraging and overwintering habitat for rainbow trout. In addition, the proposed works will increase food and nutrient production within and downstream of Reach 5. Benefits to other fish species are also expected to occur as a result of the proposed works.

Four separate but complementary stream rehabilitation projects will be implemented in Reach 5 of Mathews Creek. These include:

- Mainstem channel and bank restoration and enhancement;
- Sinuous tributary restoration and enhancement;
- Creation of a new meandering tributary to Mathews Creek; and
- Wetland creation/restoration.

Mainstem channel and bank restoration and enhancement would improve approximately 15,380 m^2 of the most degraded habitat in Reach 5 of Mathews Creek **(Figure 7-7** to **Figure 7-13**). This would be done by:

- Removing unnatural, in-stream obstructions to flow, including collapsed and unmaintained bridges, haphazard blocks of collapsed, sandy banks, and isolated metal debris from agricultural vehicles from the channel;
- Regrading the stream banks to more stable slopes;
- stabilizing the stream banks with bioengineering techniques to accelerate natural stabilization and to allow the natural formation of undercut banks, an optimal attractant for rainbow trout; and
- re-establishing riparian vegetation with willows, shrubs and black spruce within a 15 m wide buffer zone along each stream bank.

Along runs, brush layers will be installed in the upper portions of the restored banks, at and just above the bankfull depth (Section B-B, **Figure 7-8**). Along pools, which most commonly exist near the apices of sharp meanders, root wads will be installed along the outer bank and anchored beneath anchor logs and buttressed by boulders (Section C-C, **Figure 7-8**).

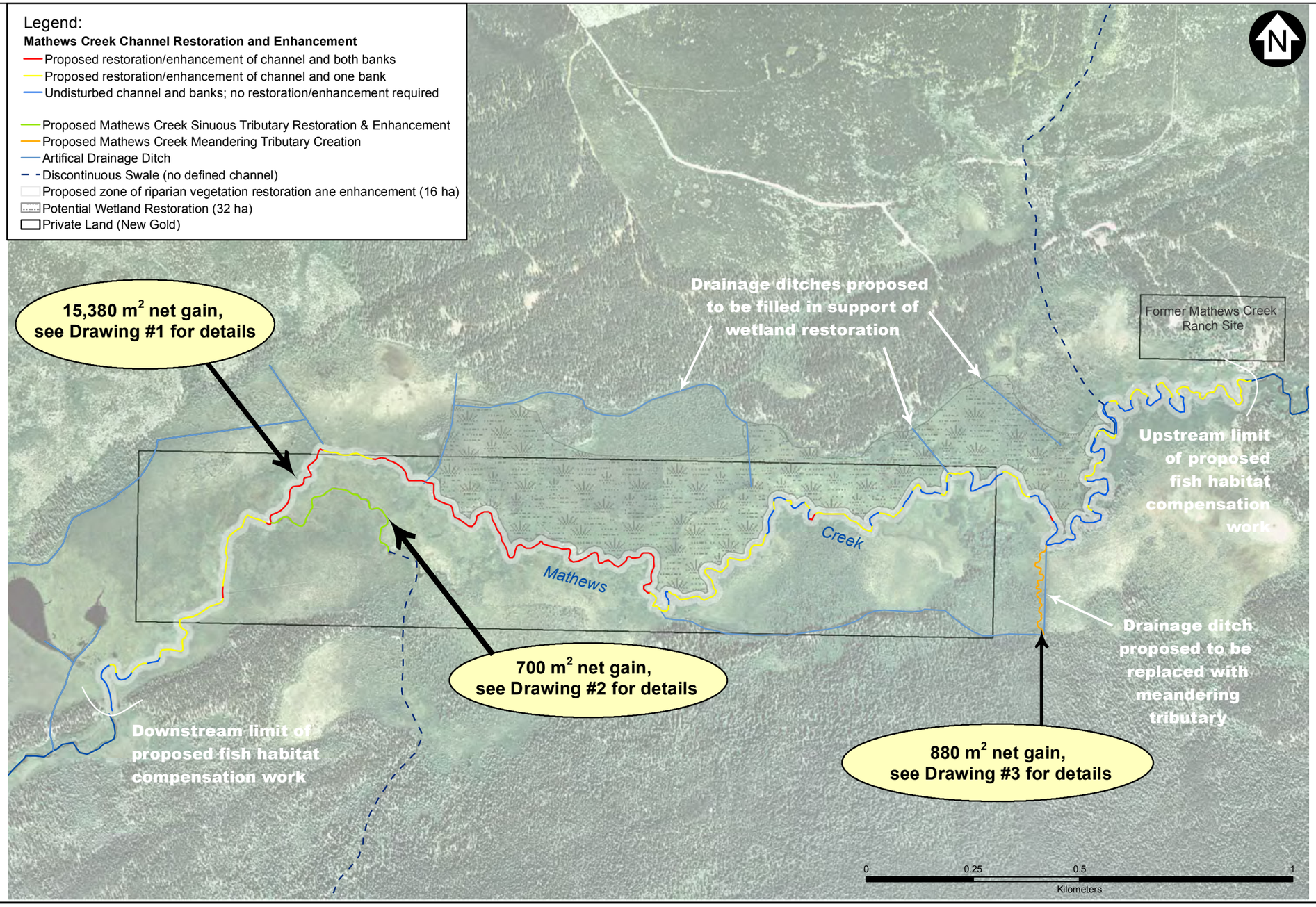
Live willow stakes will be inserted along the tops of banks and into the adjacent floodplain to promote rapid establishment of deeply rooted riparian vegetation. The stakes will be set-back slightly from the tops of the outer banks above pools, in order to allow channel migration to set up the formation of an undercut bank. Finally, clusters of boulders will be placed on the channel bed to provide in-stream cover and create microhabitats with widely varying, local flow velocities.

This project will increase the density and suitability of pool and run habitats for the benefit of juvenile and adult rainbow trout, increase food and nutrient production, decrease downstream sedimentation, and increase upstream fish passage. Regrading the banks will give riparian plantings the opportunity to grow and naturally stabilize the banks. Removed bank material will be used to reshape the banks or to build low mounds for planting black spruce saplings in the riparian zone. An estimated 16 ha of restored riparian vegetation will be created to replicate natural conditions prior to agricultural activity with this project.

Legend:

Mathews Creek Channel Restoration and Enhancement

- Proposed restoration/enhancement of channel and both banks
- Proposed restoration/enhancement of channel and one bank
- Undisturbed channel and banks; no restoration/enhancement required
- Proposed Mathews Creek Sinuous Tributary Restoration & Enhancement
- Proposed Mathews Creek Meandering Tributary Creation
- Artifical Drainage Ditch
- Discontinuous Swale (no defined channel)
- Proposed zone of riparian vegetation restoration ane enhancement (16 ha)
- Potential Wetland Restoration (32 ha)
- Private Land (New Gold)



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PROJECTION:	N/A
SCALE:	N/A

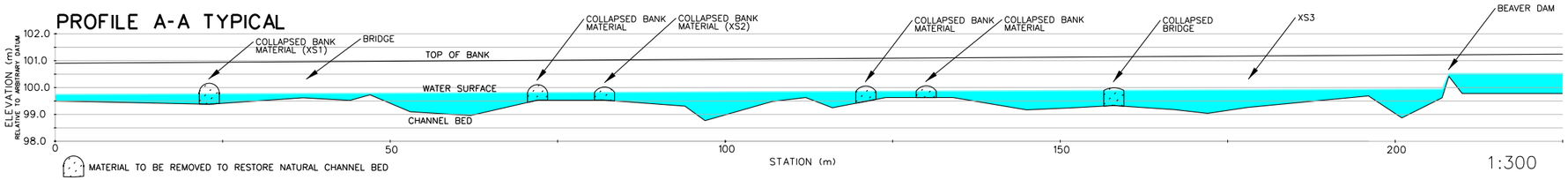
PROJECT: Blackwater Gold Project

TITLE: Locations and Extents of Proposed Fish Habitat Offsetting

DATE:	December 2013
PROJECT NO:	VE52277
REV. NO.:	A
FIGURE No.	7-7

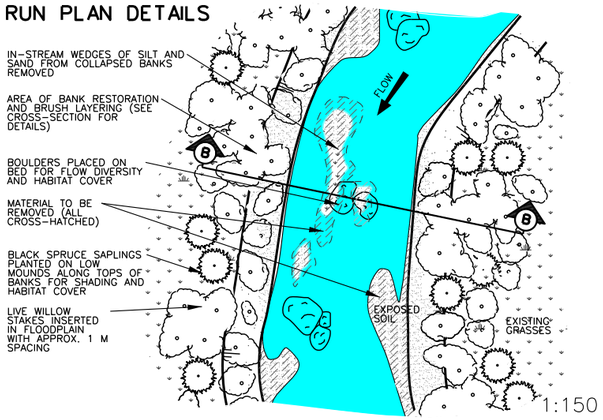
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PROFILE A-A TYPICAL



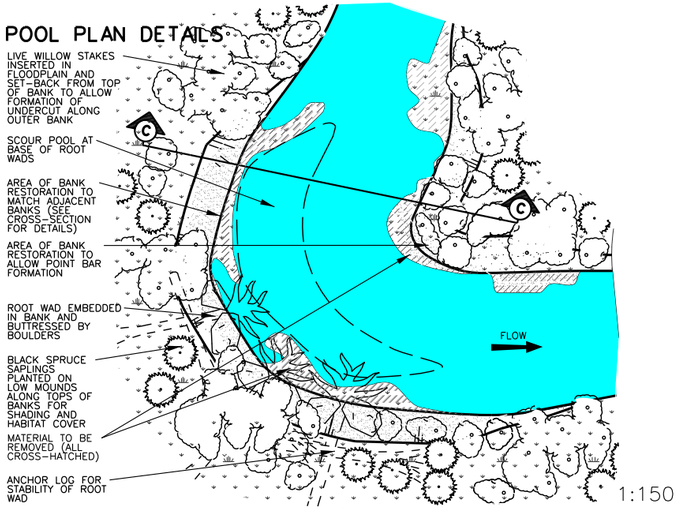
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RUN PLAN DETAILS



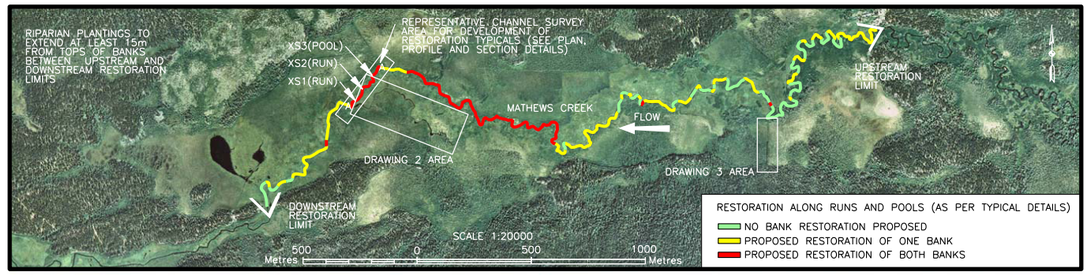
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POOL PLAN DETAILS



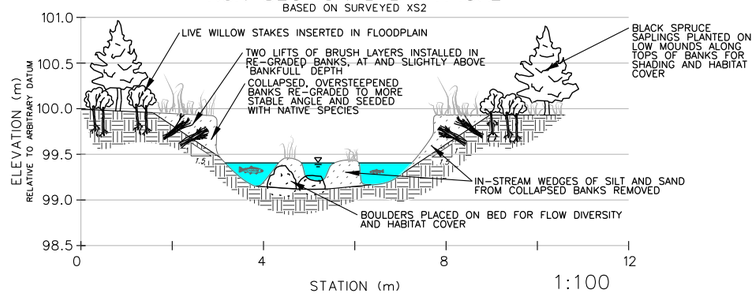
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MATHEWS CREEK PLAN OVERVIEW



RUN SECTION B-B TYPICAL

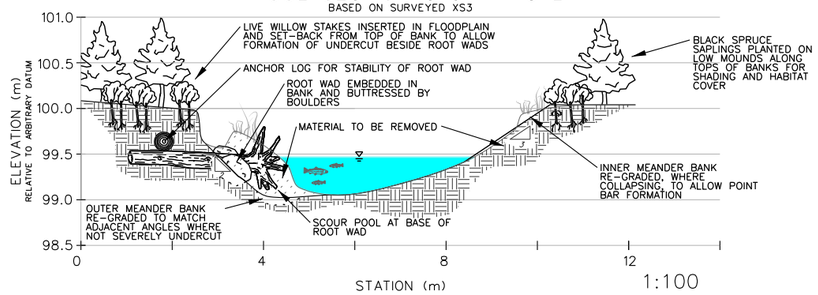
BASED ON SURVEYED XS2



1:100

POOL SECTION C-C TYPICAL

BASED ON SURVEYED XS3



1:100

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DATUM: N/A
PROJECTION: N/A
SCALE: N/A

PROJECT: Blackwater Gold Project

TITLE: Mathews Creek Channel Restoration and Enchancement Conceptual Design

DATE: December 2013
PROJECT NO: VE52277
REV. NO.: A
FIGURE No. 7-8

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Sinuous tributary restoration and enhancement involves deepening and narrowing the downstream two-thirds of the one natural tributary that enters Mathews Creek in Reach 5 (**Figure 7-9**). Unrestricted access to the lower two thirds of this tributary by livestock has caused the bed and banks of the channel to be severely degraded. As a result, the channel cross-section is unnaturally wide and shallow and excessive in-stream vegetation growth nearly obstructs flow. Although this tributary does not contribute large amounts of flow to Mathews Creek, it does provide valuable base flow during dry periods due to the presence of a slope-toe groundwater seep.

In addition to excavation of the channel, the following techniques will also be employed to improve the suitability of the tributary for rainbow trout and to improve the benefits the tributary provides to Mathews Creek downstream:

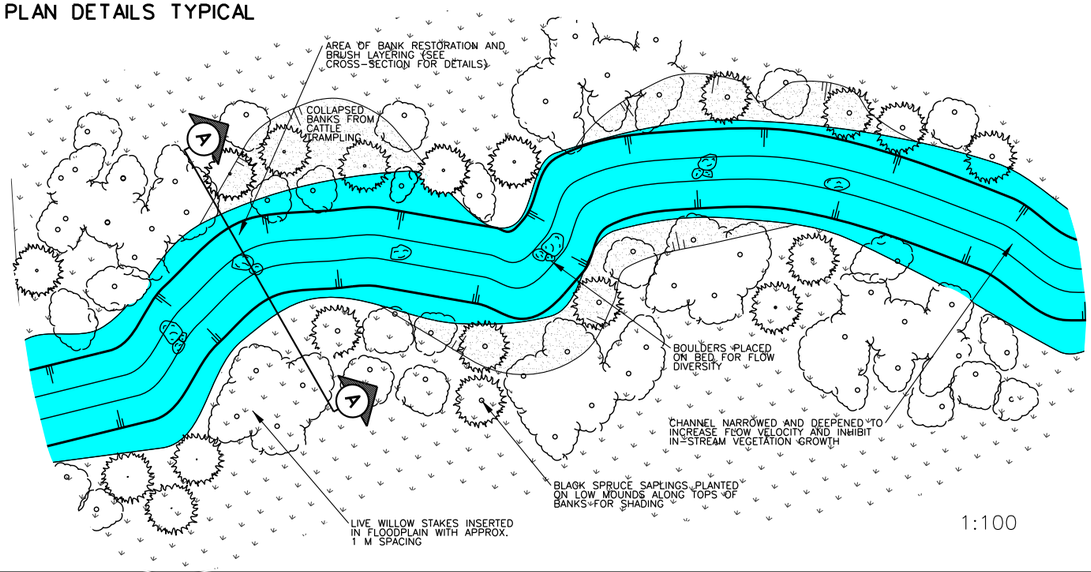
- Boulder clusters will be added to the channel at various locations to increase flow diversity and habitat complexity;
- Where necessary, the banks will be reshaped and/or re-sculpted using clean, native fill to make them stable;
- A single brush layer will be installed just below the tops of banks to help maintain a narrow, concentrated thalweg along the centerline of the channel. Once established, this overhanging vegetation will help shade the creek and provide important cover for fish;
- Live willow stakes will planted at 1 m spacing along the banks and in the adjacent floodplain to help shade the channel and provide important inputs of allochthonous materials; and
- Black spruce saplings will be planted on low mounds adjacent to the channel to provide additional soil stability, shading and riparian habitat.

Combined these techniques will restore a more natural channel morphology, decrease sedimentation by stabilizing and re-vegetating exposed soils and banks, improve water quality, decrease summer water temperatures, improve summer rearing and foraging habitat for rainbow trout, and ensure that the spring fed tributary continues to provide important summer base flow contributions for Mathews Creek. A plan view and representative cross-sections of this project are shown in **Figure 7-9**.

PLAN OVERVIEW



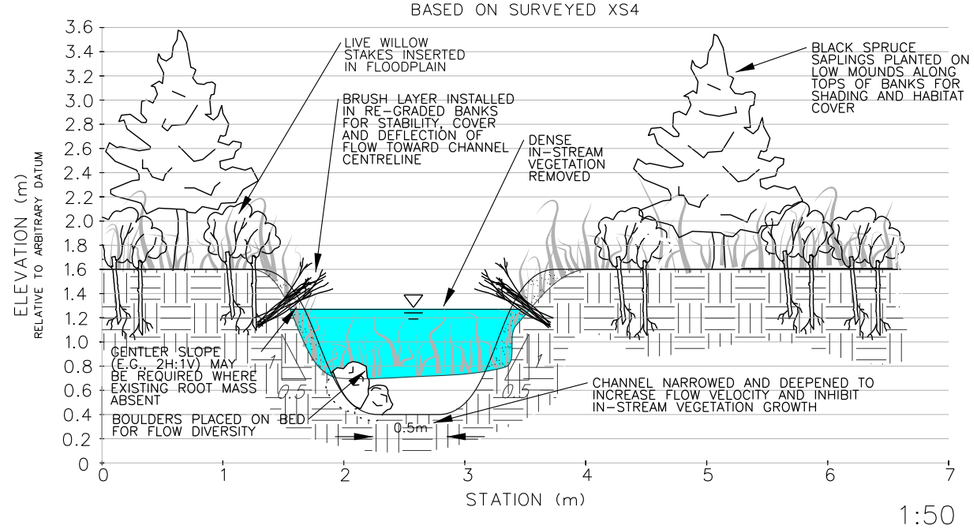
PLAN DETAILS TYPICAL



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SECTION A-A TYPICAL

BASED ON SURVEYED XS4



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PROJECTION:	N/A
SCALE:	N/A

PROJECT: Blackwater Gold Project

TITLE: Mathews Creek Sinuous Tributary Restoration and Enhancement Conceptual Design

DATE:	December 2013
PROJECT NO:	VE52277
REV. NO.:	A
FIGURE No.	7-9

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The meandering tributary creation component involves the creation of a new channel entering Mathews Creek in Reach 5 that would replace one of the existing drainage ditches that cuts straight across the Mathews Creek floodplain (**Figure 7-10**). This drainage ditch descends a gentle slope-toe apron and drains a naturally high groundwater table in the floodplain. Replacing this ditch with a more natural, meandering channel will create more off-channel habitat diversity for fish while maintaining the delivery of groundwater to Mathews Creek downstream.

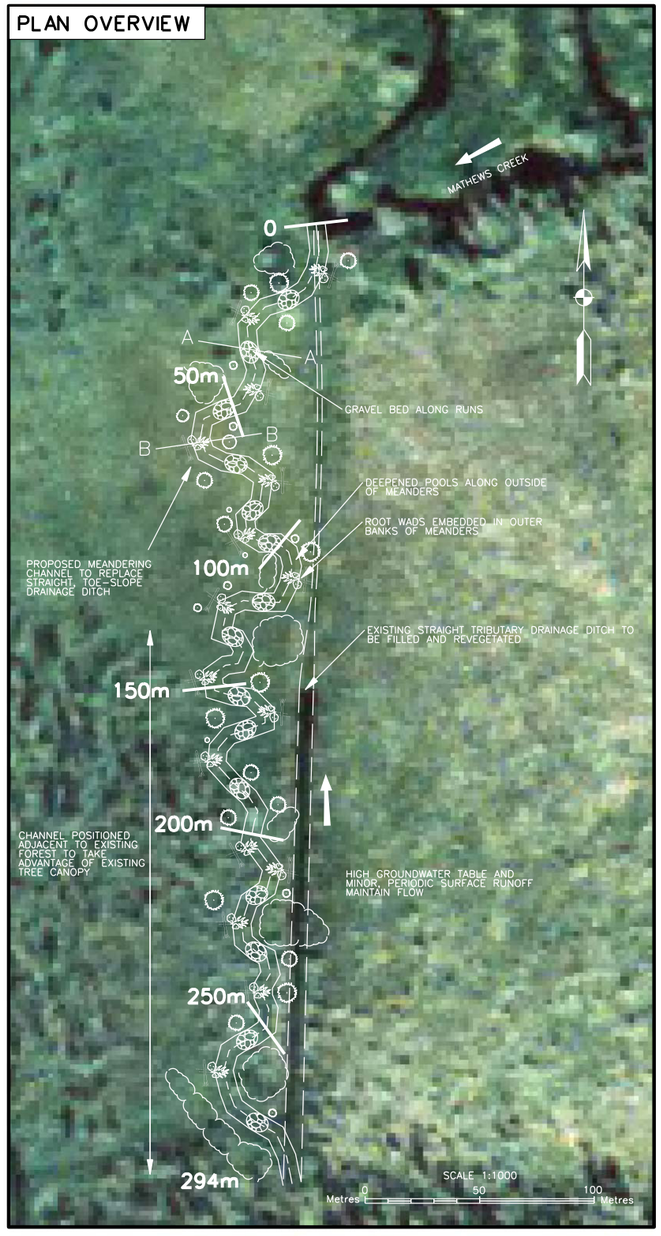
The proposed channel configuration will be based on the meander pattern of a natural tributary that descends a similarly gentle slope-toe apron just 1 km to the east of the project site. The channel will be approximately 294 m long and 3 m wide when completed. The creation of the meandering tributary channel will involve:

- Constructing both symmetric and asymmetric cross-sectional configurations and more closely replicate natural channel geometries. The symmetrical shaped cross sections will be located along the straight sections of channel between meander curves where run habitat will be located (Section A-A; **Figure 7-10**). The asymmetric cross-sections (i.e., steeper outer bank and a gentler inner bank) will be located at each of the meander bends where scour pools and point bars would naturally occur (Section B-B; **Figure 7-10**);
- A brush layer will be installed along both banks, at the bankfull level, to create habitat cover and provide additional bank stability;
- Gravel ranging from 50 mm to 150 mm in diameter will be placed along the bed to provide substrate diversity and to inhibit potential scour during the spring snowmelt, when surface contributions to flow will be highest;
- root wads, stabilized with anchor logs, will be embedded into the outer bank of each meander to provide erosion protection and to promote pool formation for rainbow trout;
- Live willow stakes will be planted immediately adjacent to the new channel in areas devoid of vegetative cover to help maintain bank stability and provide riparian habitat; and
- Black spruce saplings will be planted on low mounds to provide shading, over storey cover, allochthonous inputs and future sources of LWD.

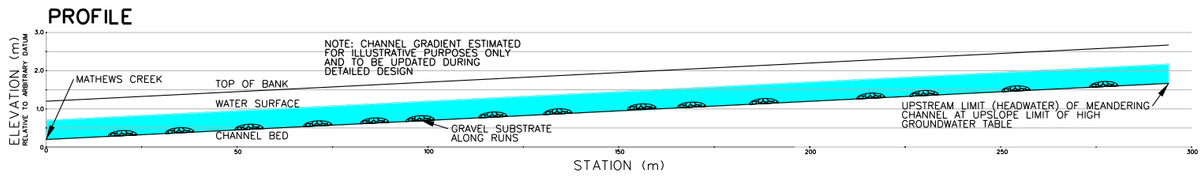
Wetland creation/restoration component of the Mathews Creek rehabilitation project will involve filling in several drainage ditches on the north side of the creek, excavating a shallow-sloped, 32 ha basin, and planting with native wetland vegetation. A mosaic of riparian habitat types will be created by planting willows, patches of black spruce on higher ground and herbaceous species in slightly depressed areas.

Once filled with water and connected to Mathews Creek, this wetland will improve water quality in Mathews Creek, help attenuate natural flood events, and will provide a food source for rainbow trout in the form of benthic macro-invertebrates. In addition, this wetland will provide habitat for amphibians, aquatic mammals and waterfowl. A more detailed description of the function and value of this wetland is provided in the Proponent's wetland compensation plan (**Section 12.2.1.18.4.3**).

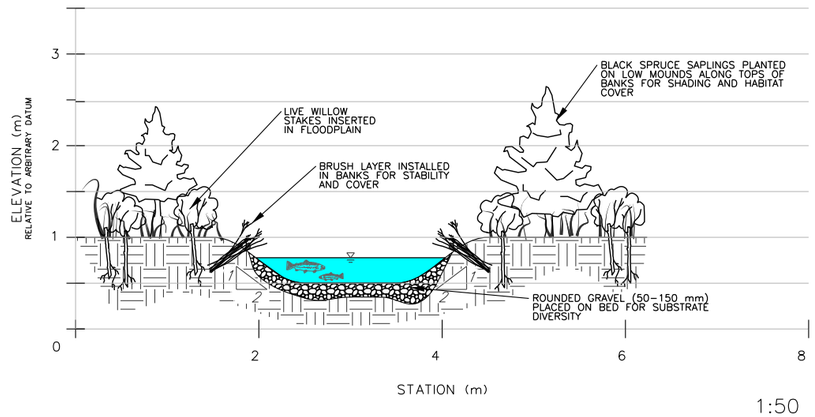
PLAN OVERVIEW



PROFILE

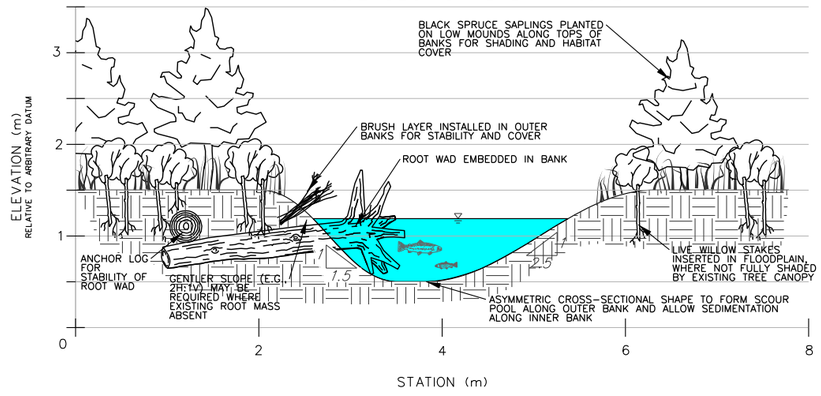


RUN SECTION A-A TYPICAL



1:50

POOL SECTION B-B TYPICAL



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SCALE:	N/A

PROJECT: Blackwater Gold Project

TITLE: Mathews Creek Meandering Tributary Creation Conceptual Design

DATE:	December 2013
PROJECT NO:	VE52277
REV. NO.:	A
FIGURE No.	7-10

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7.5.3.3 Constructability and Mitigation Measures

Construction of these projects will involve excavating within the active channels and floodplain areas using heavy machinery, removal of anthropogenic debris, installation of habitat complexing features and revegetation activities. Standard mitigation measures will be employed to prevent or minimize impacts including:

- adhering to appropriate fisheries timing windows to avoid impacting spawning fish, their incubating eggs and larval life stages;
- All channel works will be completed in the “dry” or under “frozen conditions” or by isolating the work from flowing water conditions;
- Fish salvages will be undertaken by a qualified fisheries biologist or technician prior to any in-water work in fish bearing waterbodies;
- Downstream flows will be maintained at all times during stream isolation or diversion works;
- All materials used to construct fish habitat including gravel, boulders and LWD will be cleaned of all loose dirt and debris prior to placing it in fish habitat; and
- An erosion and sediment control plan will be developed and will focus on controlling surface runoff and minimizing the extent and duration of exposed soils.

An Environmental Management Plan will be developed to describe Best Management Practices for in-stream and floodplain construction, work-site isolation, erosion and sediment control, water management, fish salvage protocols, riparian management, and planting criteria.

7.5.3.4 Summary of Habitat Gains

Approximately 64,690 m^2 of habitat will be created, enhanced or rehabilitated in Mathews Creek by these four projects (**Table 7-6**). The majority (74%) of this area is provided by the new wetland. The Maintem Channel and Bank enhancement and Rehabilitation Project would enhance a total of 15,380 m^2 of existing instream and riparian habitat in Reach 5 of Mathews Creek. This project component represents 24% of the total rehabilitated habitat area. The “Sinuous Tributary Enhancement and Rehabilitation” Project would enhance approximately 700 m^2 of existing off-channel habitat while the “Meandering Channel Creation” Project would create approximately 880 m^2 of new off-channel habitat. Together, these two project components provide 2% of the total rehabilitated habitat area.

In addition to the other services it provides to the Mathews Creek watershed, the newly created wetland is conservatively estimated to provide approximately 48,000 m^2 of open-water habitat useable by fish (~15% of the total constructed wetland area of 320,000 m^2). It is anticipated that this open-water habitat would provide a total of 24,000 habitat units for rainbow trout (Table 7-9). These habitat units are equally divided between fry summer rearing and food and nutrient production. This is approximately 57% of the total habitat units provided by the Mathews Creek Restoration Project.

Table 7-6: Total Estimated Area and Habitat Unit Offsets from Offsetting Measures within Mathews Creek

Offsetting Component	Habitat Type	Class	Estimated Total Area (m^2)	Rainbow Trout Life Stages					Food and Nutrient Production (HU)	Total by Habitat Type/Class (HU)
				Spawning/Egg Incubation (HU)	Fry Summer Rearing (HU)	Juvenile Summer Rearing (HU)	Adult Summer Foraging (HU)	Overwintering (HU)		
Bank and Riparian Restoration	Glide	3	6,306	0	0	1,576	1,576	0	1,576	4,729
	Pool	1	9,074	0	0	4,537	4,537	0	2,269	11,343
Sinuous Tributary	Tributary	3	700	0	0	175	175	0	175	525
Meandering Tributary Creation	Glide	3	572	0	0	286	143	143	429	1,001
	Pool	1	308	0	0	231	77	77	77	462
Wetland Restoration	Other	2	48,000	0	12,000	0	0	0	12,000	24,000
Estimated Total Area and Habitat Units			**64,960**	**0**	**12,000**	**6,805**	**6,508**	**220**	**16,526**	**42,059**

Note: m^2 = square metres, HU = habitat units

The enhanced mainstem channel and riparian areas along Reach 5 of Mathews Creek are anticipated to provide 16,072 habitat units for rainbow trout, or 38% of the total. Most of these habitat units are provided by the enhanced pools for juvenile and adult fish. The new meandering tributary is expected to provide 1,463 habitat units, or 3% of the total. Most of these habitat units are for juvenile rearing and food and nutrient production but adult foraging and overwintering habitat is also expected. The sinuous tributary enhancement is expected to provide 525 habitat units, or 1% of the total. These habitat units are equally divided between juvenile summer rearing, adult summer foraging, and food and nutrient production.

7.5.4 Fish Passage Restoration in the Vanderhoof Forest District

7.5.4.1 Concept Overview and Rationale

Improperly sized or installed culverts at road crossings frequently create barriers to upstream fish passage. These barriers may be due to vertical drops at the culvert outlet that are too high for fish to jump (i.e., perching), or to excessive turbulence and high water velocities, particularly during high flow periods, that exceed the swimming capabilities of fish (BC MoE 2011). Because of this, improperly sized or installed culverts may be impassable under all flow conditions or only during low or high flows. They also may be impassable to all fish species or only to certain fish species and life stages that have lower jumping or swimming abilities.

Freshwater fish species require a variety of habitats to complete their lifecycle and rely on migration to reach habitats used for feeding, refuge and spawning (Cunjak et al., 2005). In the absence of these potentially limiting habitats, individuals are forced to endure suboptimal conditions which can affect mortality, growth (Cunjak et al., 2005), population size and persistence and community structure (Perkin and Gido, 2012).

This longitudinal fragmentation of streams and watersheds by culverts increases genetic and reproductive isolation of fish populations upstream of these barriers (Schick and Lindley, 2007). This makes these populations more susceptible to extirpation from disease, climate extremes, predation, as well as natural (e.g., landslides) and anthropogenic (e.g., clear-cut forestry) disturbances. These barriers may also prevent fish from colonizing previously accessible areas after disturbance and restrict the species diversity and, therefore, stability of the upstream fish community structure (i.e., leading to community homogeneity). The cumulative effects on fish populations of many impassable structures along a river or in a watershed are often substantial, even when individual barriers have negligible impact.

Barriers to fish passage associated with improperly sized or installed culverts at road crossings have long been an identified problem in British Columbia. As early as 1976, the Province of British Columbia recognized that more needed to be done to study culverts and the capability of fish to move through them (Wightman and Taylor, 1976). In 2007, there was estimated to be between over 70,000 culverts in BC that are potential barriers to fish passage (Fish Passage Technical Working Group, 2014). The associated habitat fragmentation was the single biggest impact on fish habitat (Forest Practices Board, 2009). Further studies suggest that 90% of those located in important and critical habitat in BC present a risk to fish passage (Mount et al., 2011). Lack of fish passage at road crossings continues to be a significant concern in British Columbia

(Northcote and Hartman, 2004). As a result, culvert restoration was identified as a provincial management priority by the BC MOE.

Culverts on FSRs installed by crown corporations (e.g., BC Timber Sales) or installed prior to enactment of the Forest Practices Code Regulations in 1995 (i.e., pre-code) are the responsibility of the Province of British Columbia. Therefore, BC has the legal responsibility to remove or replace any problem culvert on crown-owned or pre-code roads to be compliant with the federal *Fisheries Act*. In contrast, culverts on private roads or on roads constructed and maintained by industry (e.g., active logging roads) are the responsibility of those owners or users.

The Proponent is proposing the replacement of select, "pre-code", fish barrier culverts with open-bottom structures (i.e., clear-span bridges or open-bottom arch culverts) in the Vanderhoof Forest District as part of its offsetting plan for the Project.

7.5.4.2 Culvert Identification and Prioritization

Avison conducted a desktop study to identify and prioritize potential problem culverts in the Vanderhoof Forest District that could be replaced with open-bottom structures by the Proponent (Avison, 2013a; **Annex J**). This study identified 78 potential candidate culverts: 59 crossings identified by Ecofor Consultants Ltd. in 2012 (Ecofor, 2012), 11 high priority culverts identified by the BC Ministry of Forests, Lands, and Natural Resource Operations (BC MFLNRO) in Vanderhoof, and 18 culverts identified by Avison during field work conducted for the Project.

Twenty-nine of these 78 culverts were ranked as having a high priority for field assessment to determine whether they were actually barriers to fish. High priority crossings were those that had ≥10 accumulated points for:

- Known barriers upstream or downstream;
- Known fish distribution upstream and downstream;
- Year of construction before or after *Forest Practice Code Guidelines* in 1995;
- Stream order at the crossing;
- Linear length of upstream stream habitat; and
- Known fisheries upstream or downstream of the crossing.

Results of field assessments conducted at these 29 high priority crossings by Avison in November 2013 (Avison, 2013b; **Annex K**) showed that 24 crossings were actual barriers to upstream fish passage (i.e., their "Fish Passage Culvert Inspection" scores were ≥20). Two other crossings (Sites 8 and 13) were determined to be "potential" barriers to upstream fish passage, one crossing (Site 14) on the Kluskus FSR had already been replaced with an open-bottom structure by the BC MOF, and two other sites (Sites 26 and 27 on Corkscrew Creek) were actually the same as Site 25 (i.e., one site with three culverts).

Of the 24 barrier culverts, 11 were installed on roads prior to 1995, and, therefore, are the responsibility of the Province of BC. The age of another eight of these barrier culverts was

unknown. Five others were installed on roads built after 1995 and are not eligible for inclusion in the Project offsetting plan. In total, approximately 171 km of upstream habitat is currently inaccessible to fish as a result these 11 culverts.

The 11 culverts known to be pre-code plus the eight barrier culverts of unknown date were then prioritized to identify the culverts best suited for inclusion in the Project offsetting plan. This prioritization was based on their total score which was a sum of each culverts priority score from the initial screening step and their Fish Passage Culvert Inspection score from the field assessments of these high priority culverts. Together, total scores took into consideration:

- The quantity and likely quality (based on the relative abundance of higher order streams) of fish habitat upstream of the culvert;
- The distribution and species composition of fish currently upstream and downstream of the road crossing;
- The potential benefit to fish species known to contribute to recreational, commercial, and/or Aboriginal fisheries;
- The type, size, and cost of replacement structures required;
- Construction logistics as they pertain to machine access, timing of work, maintenance of downstream flows, etc.; and
- Potential ancillary impacts to sensitive or rare vegetation or wildlife.

Table 7-7 shows the priority ranking of these 11 pre-code culverts (shaded in the table) and eight unknown aged culverts in the Vanderhoof Forest District from top to bottom. **Figure 7-11** shows their locations. Based on their total scores, and giving priority to known pre-code culverts, three culverts were selected for replacement with open-bottom structures as part of this offsetting plan. Pending assessment of their technical feasibility for replacement during detailed design, these culverts include:

- Site 17 on Suscha Creek. Removal of this culvert will provide access to approximately 45 km of upstream habitat for Chinook salmon, mountain whitefish, and blue-listed bull trout. Approximately 4.5 km of this habitat is in 4th order streams, streams typically large enough for Chinook salmon spawning. Removal would also eliminate isolation of the rainbow trout population upstream;
- Site 49 on Cutoff Creek. Removal of this culvert will provide access to approximately 59 km of upstream habitat for Chinook salmon, sockeye salmon, mountain whitefish. Approximately 18.5 km of this habitat is in 4th order streams or larger, streams typically large enough for Chinook salmon and sockeye salmon spawning. Removal would also eliminate isolation of the blue-listed bull trout and (non-listed) rainbow trout populations upstream and potentially provide access to habitat for endangered Nechako River white sturgeon; and
- Site 16 on Big Bend Creek. Removal of this culvert will provide access to approximately 22 km of upstream habitat upstream for kokanee and rainbow trout. Approximately 5.5 km of this habitat is in 5th order streams, streams large enough to provide the diversity of spawning and rearing habitat for both species.

The quantity and quality of habitat that will be made accessible to fish in each stream upstream of the road crossings will be verified prior to construction. This will be done by conducting habitat assessments and verifying the permanency of flow, the presence and location of other upstream barriers, natural or man-made, and the presence of fish. Additionally, the area of upstream habitat, using average stream widths, and locations of known upstream barriers will be calculated.

Table 7-7: Summary of Fish Passage Assessments at High Priority Stream Crossings Identified within the Vanderhoof Forest District

Rank	Crossing ID	Stream Name	Road Name	Priority Score[1]	Culvert Score[2]	Total Score[3]	Upstream Channel Length (km)[4]	Road Ownership or Responsibility	Year Culvert Installed/Road Constructed	Known Fish Species Downstream of Culvert	Known Fish Species Upstream of Culvert
1	**17**	Suscha Creek	Kluskus FSR	13	**36**	49	45.15	FSR	1980s	CH, BT, MW	RB
2	49	Cutoff Creek	Kenny Dam Road	16	**21**	37	58.72	BC MOT	1960s	WSG, CH, SK, MW	RB, BT
3	**16**	Big Bend Creek	Kluskus FSR	14	**24**	38	21.84	FSR	1980s	KO	RB
4	30	Finger Creek	Lavoie-Gold Road FSR	14	**34**	48	1.57	FSR	1980s	CH, KO, MW	RB
5	44	Cluculz Creek	Telegraph Trail	18	**34**	52	52.31	BC MOT	Unknown	KO, MW	KO, RB, MW
6	70	Nine Mile Creek	Settlement road	19	**31**	50	8.78	FSR	Unknown	WSG, CH, CO, SK	RB
7	36	Angly Creek	Sutherland FSR	11	**34**	45	0.41	FSR	1970s	MW	RB
8	69	Unnamed	Holy Cross – Binta FSR	10	**34**	44	5.56	FSR	1980		RB
9	83	Stoney Creek	Kluskus FSR	14	**29**	43	9.10	Canfor	Unknown	KO, MW	RB
10	29	Trib. to Finger Ck	Lavoie-Gold Road FSR	18	**24**	42	111.42	FSR	Unknown	CH, KO, MW	RB
11	89	Unnamed	Kluskus FSR	13	**29**	42	46.56	Canfor	Unknown	CH, KO, MW	RB
12	63	Trib. to Chedakuz Ck	Kluskus FSR	11	**29**	40	1.61	FSR	1980s	KO, MW	RB
13	60	Cabin Creek	Kluskus FSR	14	**24**	38	24.90	Canfor	Unknown	CH, KO, MW	RB
14	27	Corkscrew Creek	Corkscrew FSR	13	**24**	37	0.65	FSR	Unknown	KO, MW	RB
	26	Corkscrew Creek	Corkscrew FSR	13	**24**	37		FSR	Unknown[5]	KO, MW	RB
	25	Corkscrew Creek	Corkscrew FSR	13	**24**	37		FSR	Unknown[5]	KO, MW	RB
15	39	Duncan Creek	Sutherland-Shovel FSR	13	**24**	37	4.41	FSR	1980s	MW	MW, RB
16	2	Norman Creek	Bobtail Lake FSR	12	**24**	36	70.07	FSR	Unknown	KO, MW	RB
17	67	Trib. to Nulki Lake	Kluskus FSR	12	**24**	36	5.18	FSR	1970s	KO, MW	RB
18	66	Trib. to corkscrew	Corkscrew FSR	14	**21**	35	26.16	FSR	1970s	KO, MW	RB
19	51	Unnamed	Bobtail-Tatuk FSR	11	**21**	32	0.54	FSR	1980s	CH, MW	RB

Note: WSG = white sturgeon, SK = sockeye salmon, CH = chinook salmon, CO = coho salmon, KO = kokanee, RB = rainbow trout, BT = bull trout, MW = mountain whitefish; MOT = Ministry of Transport; FSR = Forest Service Road

[1] Priority scores >= 10 points were considered high priority; 6-9 points were considered medium priority; ≤5 points were considered low priority. Only the 19 potential culverts are shown in this table. Scoring for all 78 culverts assessed by Avison during the desktop review are provided in Avison (2013a) which is in **Annex F** of this report.

[2] Culvert scores >= 20 are considered barriers (indicated in bold in table), 15 to 19 are potential barriers, and <=14 are passable based on the provincial Fish Passage Culvert Inspection scoring system

[3] Total scores = priority score + culvert score. Total score was only used to rank the 29 high priority culverts assessed in the field by Avison (2013b)

[4] Upstream channel length based on GIS delineation of stream length upstream of noted barrier and any identified upstream barriers (e.g., existing roadway or natural obstruction within GIS layers) completed by AMEC

[5] Upstream stream length accounted for by habitat upstream at Site 27. Culverts at sites 25, 26, and 27 are actually one site with three culverts

Crossing ID	Stream Name
69	Tributary to Nithi River
36	Angly Creek
16	Big Bend Creek
60*	Cabin creek
44*	Cluculz Creek
13*	Cluculz Creek
25*	Corkscrew Creek
26*	Corkscrew Creek
27*	Corkscrew Creek
49	Cutoff Creek
39	Duncan Creek
30	Finger Creek
70	Nine Mile Creek
2	Norman Creek
83	Stoney Creek
17*	Suscha Creek
8	Targe Creek
61	Tributary to Cabin Creek
63	Tributary to Chedakuz Creek
66*	Tributary to Corkscrew Creek
29*	Tributary to Finger Creekk
12*	Tributary to Nulki Lake
20	Tributary to Nulki Lake
67	Tributary to Nulki Lake
3	Tributary to Chilako River
14	Tributary to Finger Creek
89	Tributary to Finger Creek
19*	Tributary to Stony Creek
51*	Tributary to Chilako River

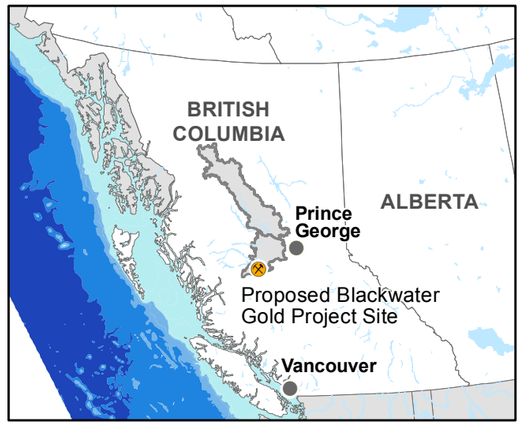
Legend

- Proposed Blackwater Gold Project Site
- Populated Place

Culverts

- Potential Barriers
- Barriers

- Highway
- Kluskus FSR
- Kluskus-Ootsa FSR
- Kluskus-Blue FSR
- Other FSRs
- Existing Roads
- Railway
- Existing Transmission Line
- Stream
- Waterbody
- Parks and Protected Areas
- Forest Districts



Scale: 1:675,000

0 5 10 20

Kilometres

Reference

BC Government GeoBC Data Distribution
NRCAN Geobase
Ministry of Forests, Lands and Natural Resource Operations

CLIENT: newgold

PROJECT: Blackwater Gold Project

Locations of Potential Culvert Restoration Sites Within the Vanderhoof Forest District

DATE:	ANALYST:	
April, 2014	WR	**Figure** 7-11
JOB No: VE52277	QA/QC: MY	PDF FILE: 10-100-198_VFD_culverts_v2.pdf
GIS FILE: 10-100-198_VFD_culverts_v2.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\Baseline\10-100-198_VFD_culverts_v2.mxd

7.5.4.3 Design Criteria and Engineering Requirements

Selection of clear-span bridges or open-bottom arch culverts as replacement structures will depend on the width and gradient of the stream, the height of the road above the stream; and the speed rating for vehicular travel on the road as required by the BC MOF or the BC MOT.

New channels and banks will be created under each open-bottom structure where the old culvert was located. Channels will be designed to allow upstream fish passage at all flows. These channel designs will include, but not be limited to:

- Low (<3%) to moderate (<6%) stream gradients;
- Inclusion of rock baffles and/or weirs to lower stream energy and velocities; and
- Strategic placement of boulders and logs to assist fish during their upstream migration.

Channel widths and shape will be designed to carry design-flows required by the bridge engineer (e.g., 1:200 year flow) but also to concentrate low flows so that fish can pass in summer. Stream banks will be sloped, armoured, and vegetated to minimize erosion. Bridge abutments will be protected with appropriately-sized rip-rap as required by the bridge engineer. Otherwise, the use of rip-rap will be minimized to encourage riparian vegetation growth and to keep the new stream channel as natural as possible.

Each site will require detailed surveys to document site conditions prior to design and construction. Data from these streams will be used to design the crossing structure by the road engineer and to design the new channel underneath the new crossing structure by a water resource engineer. Detailed design drawings will be completed for each new crossing and will be submitted to DFO and BC MOT/MOF for regulatory review and approval prior to construction.

7.5.4.4 Constructability and Mitigation Measures

BMPs and industry standards will be incorporated into an EMP prepared prior to construction. BMPs will be followed during construction to reduce or eliminate potential effects to fish, fish habitat, riparian vegetation, and wildlife. This EMP will be provided to provincial and federal regulators for review and approval prior to construction. BMPs and standards will include mitigation measures included in DFO's "*Measures to Avoid Causing Harm to Fish and Fish Habitat*" guidance document (DFO, 2013c), DFO's previous "*Clear-span Bridge," Operational Statement,*" and BC's "*Standards and Best Practices for Instream Works*".

7.5.4.5 Summary of Habitat gains

A total of 125,706 m of upstream habitat would be made accessible to fish by replacement of these three culverts with open-bottom structures (**Table 7-8**). The majority (53%) of this total length would be provided by non-fish-bearing, 1st order streams (67,091 m). Fish-bearing streams would provide the remaining 47%: 16% (20,187 m) for 2nd order streams; 8% (10,000 m) for 3rd order streams; 7% (9,312 m) for 4th order streams; 7% (9,426 m) for 5th order streams, and 8% (9,792 m) for 6th order streams.

Assuming the average widths of streams upstream of these culverts is the same as the average widths of streams of similar stream order in the Davidson Creek watershed, a total of 473,915 m^2 of stream habitat would be made accessible. Conservatively assuming that 1st order streams are not useable by fish, a total of 406,824 m^2 of fish-bearing habitat would be accessible to fish upstream of these three culverts.

Because of the quality of the habitat upstream of these culverts has not been assessed and because the future use of this habitat by the different life stages of the different fish species present downstream of these culverts cannot be known with certainty, habitat units were not calculated for any of these culvert replacement projects. Instead, it was conservatively assumed that 10% of this newly accessible fish-bearing habitat, or 40,682 m^2, would contribute towards offsetting the "serious harm to fish" caused by the Project. Similar assumptions were made at the recently approved Mount Milligan Project north of Fort St. James, BC.

In reality however, the likely benefit of these culvert removals to fish production of species valued by recreational and Aboriginal fisheries is likely higher than assumed. This is based on three lines of reasoning. First, numerous fish species important to recreational and Aboriginal fisheries would benefit from these culvert removals. These species include Chinook salmon, sockeye salmon, mountain whitefish, bull trout, rainbow trout, and potentially white sturgeon. Second, the length of large, higher order stream above these culverts is large and is, therefore, likely to provide the diversity of suitable spawning, rearing, and overwintering habitats required by these fish species. This would include spawning habitat for Chinook salmon, which require larger streams for spawning. Finally, other than providing fish passage, culvert removals do not require any further habitat enhancement to be effective. This fact greatly reduces the uncertainty surrounding their effectiveness.

Table 7-8: Total Estimated Length and Habitat Area Upstream of High Priority, Pre-Code Culverts in the Vanderhoof Forest District Selected for Inclusion in the Blackwater Offsetting Plan

Culvert ID	Total Estimated Upstream Length (m)	Total Length by Stream Order (m)						Total Estimated Upstream Area (m^2)
		1st Order	2nd Order	3rd Order	4th Order	5th Order	6th Order	
Site 49	58,716	31,982	6,108	2,156	4,874	3,804	9,792	308,196
Site 17	45,153	21,842	11,029	7,844	4,438	0	0	89,622
Site 16	21,837	13,267	2,950	0	0	5,621	0	75,377
Estimated Total	**125,706**	**67,091**	**20,087**	**10,000**	**9,312**	**9,426**	**9,792**	**473,915**

Note: Channel widths for 1st, 2nd, 3rd, 4th, 5th, and 6th order streams above these culverts were assumed to be 1 m, 2 m, 3 m, 5 m, 10 m, and 20 m, respectively, based on the average channel width for similar order streams in the Davidson Creek and Chedakuz Creek watersheds.

7.6 Contingency Plan

The options below are contingencies that could be implemented should any of the projects included in the Blackwater offsetting plan above prove to be unfeasible during detailed design or be found to not meet their success criteria during post-construction monitoring. Prioritization, selection, and need for projects that could be used as contingencies for the Blackwater offsetting plan would be conducted in consultation with federal and provincial regulators, First Nations, and relevant non-governmental organizations. The options below are not considered exhaustive but only the best available options known to the Proponent at present. A complete list of contingency options would be evaluated following consultation.

7.6.1 Murray Creek Rehabilitation Project

Murray Creek is a tributary of the Nechako River northwest of Vanderhoof, BC (**Figure 7-12**). Runs of anadromous salmon including Chinook, sockeye, and coho salmon spawn and rear in its lower reaches while rainbow trout reside in the upper reaches. Endangered white sturgeon also use the lower reaches of Murray Creek for foraging and the Nechako River near the confluence with the Murray Creek for spawning. Tributaries, such as Murray Creek, are therefore critical to the early life stages of the area's salmon (Hickey and Lister, 1981; Lister et al., 1981) and are also likely to be important to many other fish species found in the Nechako River.

Similar to Mathews Creek, habitat in Murray Creek has been impacted by past and current agricultural practices, particularly cattle ranching. Cattle grazing and access to the stream for drinking water has caused loss of riparian vegetation, collapsed and trampled the banks, increased sediment inputs, and decreased water quality from manure inputs. These effects have altered the channel morphology and geometry creating wider, shallower, and frequently undefined channels with dewatered sections, sediment bars, reduced cover and shading, and reduced water quality for trout and salmon. Other land use activities in the Murray Creek Watershed may also be contributing to this reduction in fish habitat quality including road crossings, woodlots, and a small forest licensee harvest operation.

The Murray Creek Rehabilitation Project (MCRP) was established to improving land and agriculture management practices and to restoring riparian and fish habitat in the Murray Creek watershed. The over-arching goals are to improve production of rainbow trout, Chinook, sockeye, and coho salmon in Murray Creek and to promote watershed stewardship values to landowners and land-users that protect fish habitat and improve water quality for the benefit of Murray Creek and Nechako River fisheries.

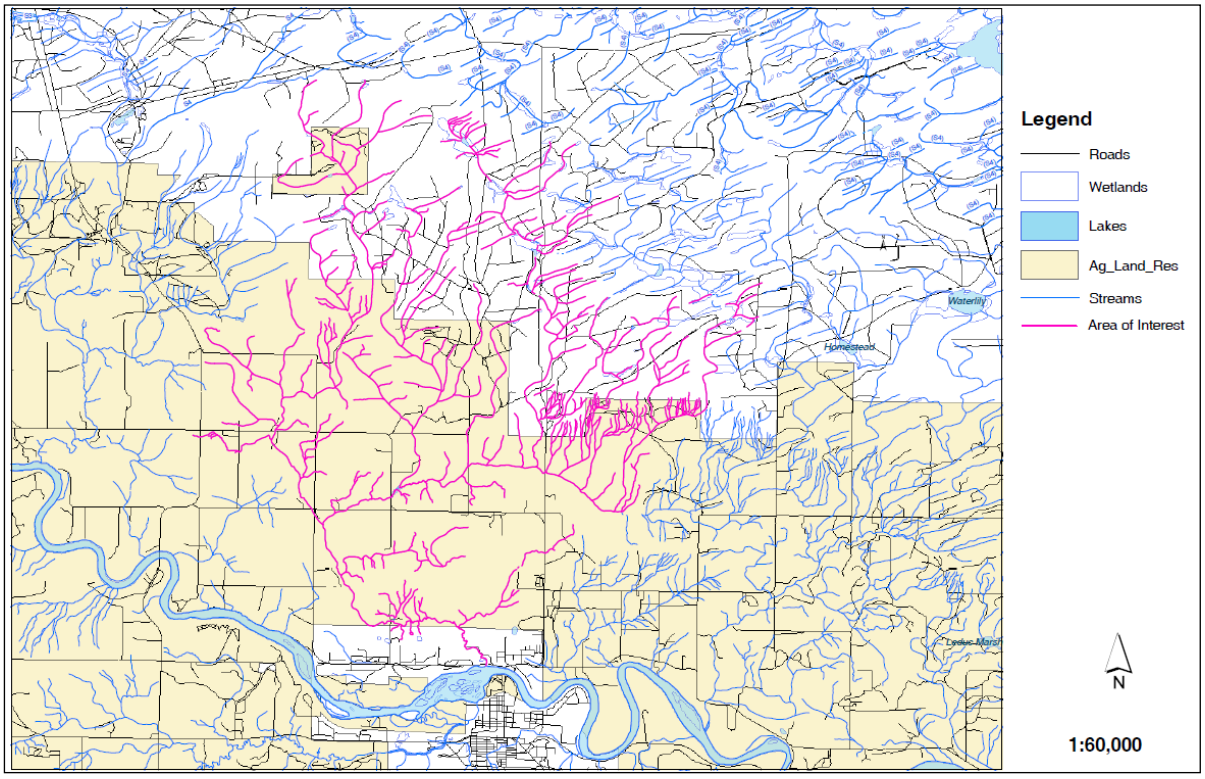


Figure 7-12: Murray Creek Watershed North of Vanderhoof, BC

Stakeholders and partners in the MCRP include various Murray Creek landowners, the BC Cattlemen's Association, the Vanderhoof Fish and Game Club, the Farmland-Riparian Interface Stewardship Program (FRISP), the Regional Cattlemen's Association, the Regional Districts of Bulkley, Nechako, and Vanderhoof, Rio Tinto Alcan, the Habitat Conservation Trust Foundation, DFO, the Fraser River Salmon and Watershed Program, the University of Northern British Columbia (UNBC), the Environmental Stewardship Division of BC MOE, Avison, M4 Contracting, School District #91, and the Northern Regional Drinking Water Team which includes Fraser Basin Council, Northern Health and UNBC.

Since its formation in 2008, habitat restoration work conducted in the Murray Creek watershed by the MCRP has included:

- Set-back fencing to exclude cattle from riparian areas and streams;
- Provision of off-channel watering facilities for cattle;
- Implementation of land-based erosion control measures;
- Stream bank stabilization projects, including riparian planting; and
- Road crossing improvements.

Other initiatives by the MCRP include public education and scientific research support.

Several habitat restoration opportunities were identified in Murray Creek during discussions and site visits with representatives of MCRP. These included:

- Habitat complexing with boulder clusters and large woody debris installations;
- Riparian planting and bank stabilization prescriptions;
- Cattle exclusion fencing;
- Replacement of impassable culverts at road crossings; and
- Projects to increase and maintain adequate water supply, rebuild degraded streambeds and establish wetlands in lower sections.

Assuming at least 10 different stream and riparian restoration projects could be built in the Murray Creek watershed, a conservative estimate of approximately 2,250 m^2 of instream habitat and approximately 105,200 m^2 of riparian habitat in the Murray Creek watershed could be created or enhanced.

Due to the high degree of degradation in the Murray Creek watershed (79% of the watershed is developed, mostly for agriculture) and the relatively high percentage of stream length within the ALR (45%), the likelihood of find additional sites in Murray Creek suitable for restoration and inclusion in the FMOP is high. The Proponent could partner with MCRP to move any of these projects forward should it be necessary and if approved by DFO and agreed by the BC Ministry of Forests, Lands, and Natural Resource Operations, and local First Nations that it would benefit fish production for important recreational or Aboriginal fisheries.

7.6.2 Nechako Environment Water Stewardship Society

7.6.2.1 Project Overview

The success and profile of the projects conducted to date in the Murray Creek watershed by the MCRP has generated much interested from landowners, conservative groups, and local and provincial governments to look at other impacted streams in the agricultural belt within the Nechako River valley (W. Solewski, personal communication). To address this expanded interest, the NEWSS was created in 2013.

NEWSS was formed to protect and restore streams in the Nechako Plateau that are experiencing environmental degradation due to land use practices (**Figure 7-13**). It is a registered conservation society in BC that acts in an advisory capacity to landowners and government agencies and serves as a vehicle for the delivery of incentives and investments for land and water stewardship in the Nechako Agricultural Belt (NEWSS, 2011). Specific objectives of the society include:

- Facilitate the rehabilitation of streams that flow through the Nechako Agricultural Belt;

- Identify opportunities to recognize agricultural producers that have farm stewardship plans in place and apply best management practices on the land with stewardship as an objective;
- Assist government with its stated vision for a cleaner and healthier environment;
- Facilitate and participate in environmental stewardship education including stream rehabilitation, water quality, Nechako white sturgeon and salmon; and
- Facilitate the mapping of the aquifer under the Nechako Agricultural Belt to compliment rehabilitation of those streams and to prepare for changes likely to come.

The society is currently pursuing stakeholder consultations to develop future funding initiatives, timelines, partnership opportunities, and potential priorities and/or candidate sites for fish habitat enhancements/restoration projects. Established project partners include: School District 91, UNBC, the BC Cattlemen's Association, FRISP, the Nechako Valley Regional Cattlemen's Association, the Fraser Basin Council, DFO, Avison, the Fraser River Action Plan, the BC MOE, the Nechako White Sturgeon Recovery Initiative – Community Working Group, Northern Health Authority, the Northern Water Drinking Team, and the Nechako Fisheries Conservation Program (NFCP).

One of the main initiatives of NEWSS is to take the successes achieved at the MCRP and apply the same principles and practices to 30 other small to medium-sized watersheds on the Nechako Plateau. The majority of these creeks have at least some of their watersheds within the Agricultural Land Reserve (ALR) (**Table 7-9**). All have experienced at least some impact due to past agricultural activities.

There is a total of 8,530 km of stream within these 30 watersheds (**Table 7-9**). Of this, approximately 2,054 km (~24%) is within the ALR. These streams range from small, second-order streams such as Puttah Creek to large, seventh-order streams such as Greer Creek.

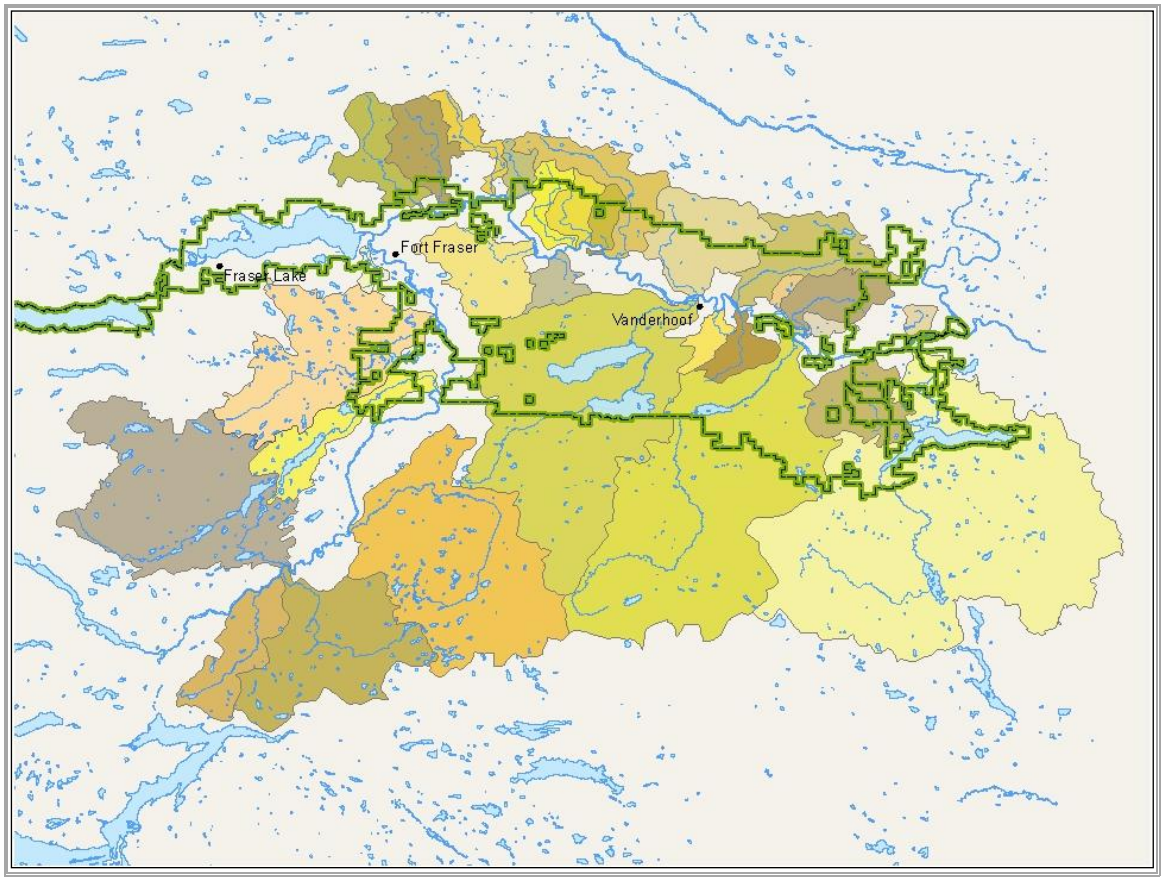


Figure 7-13: NEWSS Priority Watersheds in the Vanderhoof BC Region

The length of stream within the ALR and percentage of watershed development in each watershed varies considerably from stream to stream (Table 7-12). Stoney Creek has the longest length of stream within the ALR (535 km) while Clarke, Cutoff, and Targe creeks have no stream length within the ALR. 95% of the Halsey, Knight, and Trankle creek watersheds have been developed while <10% of the Trankle Creek Watershed has been developed. The top five creeks with the greatest combined percentage stream length within the ALR and percentage of developed watershed area are:

- Philip Creek (100% and 84%);
- Croft Creek (100% and 82%);
- Moss Creek (100% and 78%);
- Neuco Creek (100% and 75%); and
- Redmond Creek (100% and 74%).

By comparison, Murray Creek has a combined score of 125% (i.e., 45.6% stream length in ALR and 79% of the watershed developed). Eleven of the 30 streams in **Table 7-9** have summed scores greater than Murray Creek. This rough metric suggests that there are numerous opportunities for stream restoration and land-use best practice implementation in the NEWSS area of interest.

Table 7-9: Summary of Streams within the NEWSS Operating Area

Watershed Name	Stream Order at Confluence with Nechako River	Total Length of Stream (km)	Length of Stream in ALR (km)	Length of Stream Outside of ALR (km)	Percent Stream Length in ALR	Percent Stream Length Outside of ALR	Percent of Watershed Developed[(1)]
Chilco Creek	5	144.4	110.8	33.6	76.7	23.3	60
Clarke Creek	3	21.5	0.0	21.5	0.0	100.0	15
Clear Creek	4	149.6	37.7	112.0	25.2	74.8	71
Cluculz Creek	6	1,749.2	95.5	1,653.7	5.5	94.5	36
Croft Creek	4	49.0	49.0	0.0	100.0	0.0	82
Cutoff Creek	4	135.9	0.0	135.9	0.0	100.0	7
Engen Creek	5	204.3	191.0	13.2	93.5	6.5	67
Greer Creek	7	914.1	2.3	911.8	0.2	99.8	16
Halsey Creek	3	42.1	10.0	32.1	23.8	76.2	95
Hullat Creek	4	144.8	112.6	32.2	77.8	22.2	38
Kluk Creek	4	68.0	5.1	62.9	7.5	92.5	27
Knight Creek	4	221.4	139.4	82.0	63.0	37.0	95
LeDuc Creek	3	23.0	23.0	0.0	100.0	0.0	54
Leona Creek	4	28.3	11.8	16.5	41.6	58.4	78
Martens Creek	3	41.6	30.3	11.4	72.7	27.3	26
Moss Creek	3	27.8	26.0	1.9	93.3	6.7	85
Murray Creek	4	217.8	99.2	118.6	45.6	54.4	79
Neuco Creek	4	61.7	59.7	2.1	96.6	3.4	78
Nine Mile Creek	7	154.0	19.5	134.5	12.7	87.3	45
Phillips Creek	2	2.4	2.4	0.0	100.0	0.0	84
Puttah Creek	2	12.8	2.3	10.5	18.1	81.9	50
Redmond Creek	4	59.3	48.7	10.6	82.2	17.8	92
Sinkut River	6	1,157.1	234.3	922.9	20.2	79.8	64
Smith Creek	5	473.5	89.1	384.4	18.8	81.2	67
Stoney Creek	5	1,043.8	535.1	508.7	51.3	48.7	83
Swanson Creek	6	434.5	0.0	434.5	0.0	100.0	58
Tahultzu Creek	5	167.8	46.1	121.6	27.5	72.5	69
Targe Creek	4	574.9	0.0	574.9	0.0	100.0	90
Tatsutnai Creek	4	145.0	27.6	117.3	19.1	80.9	72
Trankle Creek	3	60.1	45.6	14.4	76.0	24.0	96
Grand Total		**8,529.8**	**2,054.1**	**6,475.6**	**24.1**	**75.9**	

Note: [(1)]Source: Wilson Sinclair (2012).

The Proponent has explored opportunities for partnering with NEWSS on habitat restoration activities in streams in the Nechako River watershed. This has included: discussions with

representatives from NEWSS; desktop reviews by Avison and Ecofor to identify "off-site" fish habitat offsetting opportunities for the Project (one of which was Murray Creek); site visits to select stream restoration sites by Avison and a steering community member of the MCRP in October 2012; and initial consultations with various landowners to discuss interest in participation.

Although existing information on the condition of streams in the NEWSS operating area is limited, similar types of restoration works as those prescribed in Murray Creek would also be appropriate for many of the streams in the NEWSS area. However, given that there are at least 11 watersheds in the NEWSS area with at least as much degraded stream and riparian habitat in the ALR as Murray Creek, the additional opportunities available to the Proponent to partner with NEWSS to rehabilitate these streams and use towards offsetting the Project is large.

Restoration of riparian habitats would likely form most (>90%) of the habitat enhancement and creation credits that the Proponent would apply from the Murray Creek and NEWSS projects towards offsetting "serious harm to fish" caused by the Project should these contingency options be required. Although not directly inhabitable by fish, riparian habitats provide valuable services to fish habitat and fish by stabilizing banks, reducing erosion and sedimentation, regulating stream temperatures, providing cover and nutrients (insects and leaf litter), and by minimizing land run-off peaks.

7.6.2.2 Potential Limitations for Inclusion as Contingency Option

Potential limitations for conducting stream restoration projects in Murray Creek or any of NEWSS projects as part of the Blackwater FMOP include:

- Acceptance of land and water stewardship best practices by landowners within the ALR;
- Access to private lands; and
- Agreement between stakeholders, including local First Nations, about which are priority watersheds and which are priority restorations projects within these watersheds.

There are likely fewer regulatory or technical challenges associated with projects in Murray Creek than with projects associated with NEWSS. This is because MCRP has already developed site-specific prescriptions and techniques suitable for the size, habitat, and fish species in Murray Creek. The MCRP has created momentum with many private landowners and, because of this, has already solved many access issues and is actively highlighting its successes with other land-owners in the ALR portion of the watershed. In addition, partnerships that have been developed over the past four years by MCRP allow for a smooth acquisition of permits from government and quick procurement of equipment, materials, and labour.

Consultations with various stakeholders in watersheds where stream and restoration opportunities were identified in the NEWSS area will need to be undertaken first to help prioritize projects. More site-specific data (e.g., culvert assessments, fish habitat and fish inventories) will then need to be gathered by qualified professionals to finalize this prioritization and to help

identify appropriate locations and techniques for identified restoration works. Once site-specific information is gathered, more detailed prescriptions will be developed.

7.6.3 Swanson Creek Restoration

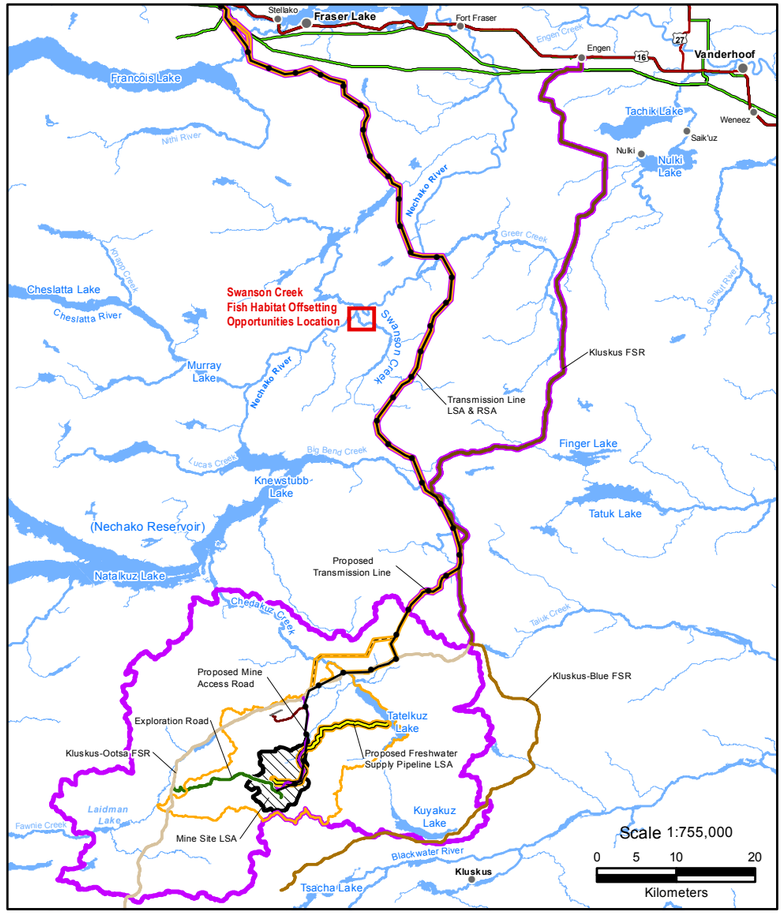
Representatives from the Proponent, Palmer Environmental Consulting Group, and the Saik'uz First Nation (SFN) conducted a two-day survey of four of the six Nechako River tributaries identified by the SFN as high priorities for restoration to improve production of fish species important to SFN fisheries. These included Swanson Creek, Greer Creek, Cutoff Creek, and Corkscrew Creek. Based on the outcome of this survey, SFN priorities, land tenure/access issues, and potential benefits to fish per dollar spent, it was determined that habitat restoration in Swanson Creek provides the best opportunity for increasing fisheries production as a contingency option for the Project offset plan. Details of Swanson Creek and the offsetting opportunities that exist are provided in detail in **Annex L**.

Swanson Creek (**Figure 7-14**) has experienced natural and anthropogenic disturbances that now limit its capacity to produce fish important to recreational, commercial, and traditional fisheries. These include fisheries for Chinook salmon, rainbow trout, and mountain whitefish, species known to spawn or rear in Swanson Creek (ARC and Triton, 1999, Upper Fraser Fisheries Conservation Alliance, 2009). Chinook salmon in particular are most valued by the SFN.

Past impacts to habitat in Swanson Creek include the effects of frequent flooding and beaver dam breaching during large storm events over the past 25 years and poor ranching practices, including cattle grazing in the riparian areas (ARC and Triton, 1999,; PECG, 2013). Natural flooding and beaver dam breaching has caused the most significant effects to fish habitat in Swanson Creek. These effects include (PECG, 2013):

- Erosion of high, unstable banks in the middle reaches and subsequent deposition in lower reaches;
- Washing out of the culvert road crossing at the Kenney Dam Road and subsequent bank erosion and downstream sedimentation; and
- Aggradation of the mainstem channel with release and subsequent deposition of large volumes of coarse bed material and large woody debris in middle and lower reaches of Swanson Creek.

Riparian grazing and access to Swanson Creek by cattle in the lowest reach of Swanson Creek, downstream of the Kenney Dam Road, has reduce the benefits of riparian vegetation to the creek (i.e., shade, bank stability, nutrient additions) and has increased sedimentation due to bank and channel erosion.



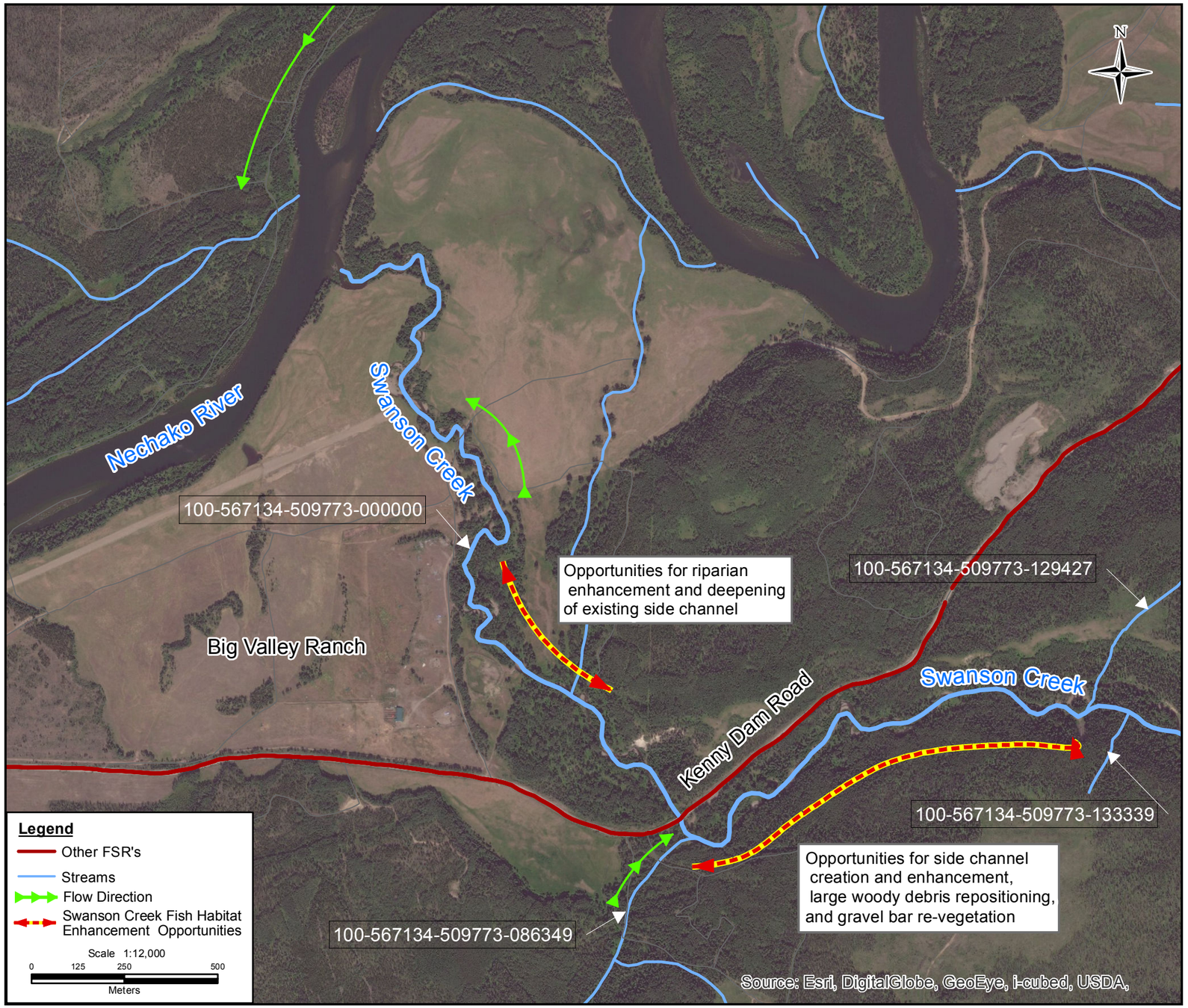
Legend (Key Map)

- Highway
- Kluskus FSR
- Kluskus-Blue FSR
- Kluskus-Ootsa FSR
- Existing Transmission Line
- Proposed Transmission Line
- Proposed Transmission Line Reroute
- Proposed Fresh Water Pipeline
- Proposed Airstrip
- Proposed Mine Site

Fisheries and Aquatic Resources

- Local Study Area
- Regional Study Area





Legend

- Other FSR's
- Streams
- Flow Direction
- Swanson Creek Fish Habitat Enhancement Opportunities

Scale 1:12,000
0 125 250 500
Meters

REFERENCE:
BC Government GeoBC Data Distribution

CLIENT
newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
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amec

ANALYST:	KA
QA:	BH
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	

PROJECT
Blackwater Gold Project

TITLE
Fish Habitat Offsetting Opportunities in the Swanson Creek Watershed

REV. NO:	A
DATE:	April, 2014
PROJECT NO:	VE52277
FIGURE NO:	7-14

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Swanson Creek was first identified as a candidate for habitat restoration during surveys conducted in the 1990s as part of the British Columbia Watershed Restoration Program (ARC and Triton, 1999). Identified restoration opportunities were focused on reaches immediately upstream and downstream of the Kenney Dam Road crossing and included:

- Forming step-pools in the mainstem using rock weirs and log structures;
- Installing large woody debris in the mainstem to promote channel stabilization;
- Removing debris jams that have accumulated since the last major flood event;
- Connecting a side-channel immediately upstream of the Kenney Dam Road crossing to the mainstem and modifying habitat in the side-channel specifically to improve spawning and rearing habitats for trout;
- Connecting a side-channel approximately 500 m downstream of the Kenney Dam Road crossing to the mainstem;
- Erecting fencing along the mainstem channel to keep cattle out of the creek and riparian areas and building alternative watering areas; and
- Re-establishing riparian zone vegetation in cattle-impacted reaches of the mainstem channel downstream of the Kenney Dam Road crossing.

The two side-channel connection projects as well as the installation of large woody debris structures in an 800 m section of the Swanson Creek mainstem upstream of the Kenney Dam Road crossing were implemented between 1998 and 2000 (Underhill, 2000). The completion of these projects and their effectiveness to improve habitat conditions in Swanson Creek was confirmed by representatives of PECG, the Proponent, and the SFN during a site visit to the creek in October 2013 (PECG, 2013;).

Four opportunities for further restoration of Swanson Creek were identified by PECG, the Proponent and SFN during the October 2013 site visit. Similar to the projects listed above, the overall objective of these opportunities is to improve spawning and rearing conditions for Chinook salmon, rainbow trout, and mountain whitefish (PECG, 2013).

All four projects are located in the lowest reach of Swanson Creek immediately upstream and downstream of the Kenney Dam Road crossing (**Figure 7-14**). This is because natural channel instability is highest here due to its position at the transition from a steeper gradient to a gentler gradient (PECG, 2013). It is in these lower reaches where bed materials eroded in the upper watershed, particularly at several unstable cut-banks along the outside of meander bends or stored behind the numerous upstream beaver dams, becomes deposited. A description of each contingency project is provided below based on the PECG (2013) report, which is included in **Annex L**. Each project is described below.

7.6.3.1 Enhancement of Groundwater-Fed Side-Channels

Opportunities exist to enhance an existing groundwater-fed side-channel upstream of the Kenney Dam Road crossing and to enhance habitat and restore connection of one of the

previously enhanced groundwater-fed side channels downstream of the Kenney Dam Road crossing. Enhancement and restoration of these side channels will involve deepening their head ponds, pools, and connection to Swanson Creek. This will improve interception of groundwater, to accommodate fish passage into and out of the channels during summer and fall low flows, and to improve the overwintering conditions (PECG, 2013). Where practical and necessary, small setback berms could be constructed to protect the side channels from avulsions or lateral migration of the mainstem channel. The upstream ends of these berms could incorporate a permeable barrier composed of large cobbles and boulders to allow surface water from the mainstem to periodically enter the side channel and help flush out any organic material that accumulates. However, prior to selection of these options, consideration must be given to groundwater levels relative to the creek bed (i.e., topographic surveys, test pits, and peizometer testing) to determine if these lower reaches of Swanson Creek are groundwater accruing or groundwater losing (as suggested by PECG, 2013).

A new groundwater-fed side channel could also be constructed upstream of Kenney Dam Road opposite of where the main creek follows one side of the valley (PECG, 2013). Here, groundwater currently discharges to the surface at the base of a high, gravelly terrace. This side channel will be constructed to have the same physical features as one of the existing side channels (i.e., using them as a natural template) and could also incorporate the same “leaky” bank entrance at the upstream end.

7.6.3.2 Maintenance and Repositioning of Existing LWD Structures

This project will involve restoring the integrity of various LWD structures previously installed in the Swanson Creek mainstem as part of the Watershed Restoration Program initiatives in the 1990s. Although most are intact and provide moderate cover for fish, some LWD structures have settled or otherwise shifted due to morphological changes to the channel. Effort will be required to reposition some of these structures at their existing location so that the trees and boulder anchors provide greater cover for fish and greater protection to the banks now that the channel location and shape has changed. Others structures will be moved to new locations at outside bends where scour pools are most likely to form. These will provide some protection from lateral erosion at these locations.

Finally, opportunity exists to completely or partially remove some or all of the large woody debris jams that currently exist in the Swanson Creek mainstem upstream and downstream of the Kenney Dan Road crossing. These large jams are currently accumulating large quantities of sediment, altering upstream and downstream channel morphology, creating shallow, braided channels downstream, and potentially impeding fish passage during high and low flows (PECG, 2013). Their removal will alleviate some or all of these negative effects.

7.6.3.3 Stabilization of Large Lateral Bars

Large, poorly vegetated gravel bars, likely formed during the 1993 flood, still flank portions of lower Swanson Creek upstream and downstream of Kenney Dam Road. These bars separate the channel from mature riparian vegetation, which could otherwise provide important cover habitat and LWD recruitment.

Bioengineering techniques such as planting live willow stakes in rows across the bars (i.e., perpendicular to the water flow) could be used to stabilize and vegetate these bars. Once established, the willow root systems will trap sediments and other organic debris, promote additional vegetative growth, and ultimately, allow the bar to increase in height and permanence over time. The channel will then become narrower, deeper, and more stable within this section of the river and will increase its capacity to form riffles and pools, habitats beneficial to salmon and trout.

7.6.3.4 Restoration of Banks and Riparian Vegetation in Ranch Land

This project will involve pursuing partnerships with landowners along lower Swanson Creek where agricultural impacts caused by cattle grazing have removed riparian vegetation and destabilized channel banks downstream of Kenney Dam Road. Once agreements were in place, this project will require implementation of measures to preclude cattle from accessing the creek and riparian areas (e.g., setback fencing, boulder pavements) and to provide alternative off-channel watering holes.

7.6.3.5 Summary of Habitat Gains

Based on the October survey, approximately 4,000 m^2 of instream and riparian habitat in the lower Swanson Creek watershed could be enhanced or created by these four projects. This would include:

- Approximately 900 m^2 (300 m x 3 m wide) from enhancing the existing groundwater fed side channel upstream of Kenney Dam Road;
- Approximately 300 m^2 (100 m long x 3 m wide) from enlarging and deepening an existing groundwater fed side channel downstream of Kenney Dam Road;
- Approximately 600 m^2 (200 m x 3 m wide) from build a new groundwater fed side channel upstream of Kenney Dam Road;
- Approximately 2,000 m^2 (500 m long x 4 m wide) from the combined efforts to remove, reposition or add LWD and from live willow staking of the gravel bars; and
- Approximately 200 m^2 (100 m long x 2 m wide) from cattle exclusion, riparian restoration, and alterative watering hole construction in ranches adjacent to Swanson Creek (pending access to privately held land).

7.6.4 Additional Culvert Restorations in the Vanderhoof Forest District

As a final contingency option for the Project offset plan, additional pre-code, problem culverts in the Vanderhoof Forest District could be replaced with open-bottomed structures. As stated in **Section 7.5.4** and identified in **Annex K**, there are at least another eight “high priority,” pre-code culverts that could be replaced. These include culverts on Finger Creek, Angly Creek, an unnamed creek crossed by the Holy Cross FSR, a tributary to Chedakuz Creek, Duncan Creek, a tributary to Corkscrew Creek, an unnamed creek crossed by the Bobtail-Tatuk FSR, and a

tributary to Nulki Lake. Together, these eight culverts currently block access to approximately 45 km of upstream habitat for species including Chinook salmon, rainbow trout, mountain whitefish, and kokanee, important species for recreational and Aboriginal fisheries.

7.7 Summary of Offsets and Loss-to-Gain Ratios

A summary of the serious, permanent harm to fish as well as the offsetting measures are presented below; summarized in both areal extent and HU values) and split between requirements for the Fisheries Act 35(2) Authorisation and the MMER Schedule 2 amendment. Spatial comparisons of potential fish habitat losses and gains are presented by the habitat types and classes used for this assessment. A summary of total habitat units is also provided by the different life stages of rainbow trout affected by the Project. This demonstrates the differences when habitat quantity and quality are factored into the assessment. Offsetting ratios are provided for both comparisons.

With the offsetting measures implemented as described within this plan, the serious, permanent harm to fish predicted by the Project are not anticipated to have a negative residual effect on the recreational or Aboriginal fisheries in the upper Chedakuz Watershed, because:

- Most of the high quality fish habitat in Davidson Creek contributing to these fisheries is in lower Davidson Creek. Potential effects to fish habitat for kokanee, mountain whitefish, and rainbow trout from stream flow changes below the TSF in lower Davidson Creek will be mitigated by flow maintenance using the freshwater supply pipeline;
- Spawning and fry summer rearing habitats for rainbow trout in the upper Davidson Creek Watershed that contribute to these fisheries, and are affected by the Project, are limited in distribution and quality in comparison to the lower watershed;
- Most of the upper headwater tributaries in the Davidson Creek Watershed predominantly provide juvenile rearing habitat opportunities. Baseline field programs documented low habitat use by all life stages of rainbow trout in the upper headwater tributaries in 2012, suggesting these habitats make limited contribution to downstream fisheries;
- Food and nutrient losses in the Davidson Creek Watershed will be mitigated by flow maintenance during operations, and the post-closure drainage scheme at the end of mine life;
- Construction of the off-channel ponds in the upper Chedakuz Creek target habitats understood to limit rainbow trout production; and
- Rehabilitation of degraded habitat located off-site will contribute to increased productivity and fishery potential in numerous watersheds throughout the Vanderhoof region.

Many offsetting measures exist in the upper Chedakuz and Fawnie Creek watersheds to offset potential serious, permanent harm to fish from the Project. The preferred options presented in this report are technically feasible, will provide habitat benefits for the fish species most directly affected by the project, and consist of well-recognized approaches that have been used in the province of BC and across Canada. Other technically feasible offsetting measures exist in the

Vanderhoof region that will also benefit rainbow trout and other fish species. If any of the preferred measures fail or do not meet their fisheries objectives, there are contingency offsetting measure opportunities that have been identified and can be implemented.

A number of factors are considered by DFO when assessing whether offsetting objectives can be achieved and whether an authorization for a Project should be issued. The Proponent recognizes that policy and criteria for evaluating projects has recently changed and have been working with regulators to ensure compliance with these changes. Ultimately, DFO is responsible to determine if the serious, permanent harm to fish and the offsetting measures are acceptable. The Proponent is committed to working with regulators, First Nations, and other stakeholders to ensure the final FMOPs for the Project meet or exceed DFO's requirements and guiding principles.

7.7.1 Section 35(2) *Fisheries Act* Authorization

Serious, permanent harm requiring offsets under Section 35(2) of the *Fisheries Act* total 101,073 m^2 (**Table 7-10**). The spatial area lost is stream habitat in the upper of Davidson Creek and Creek 661 watersheds that is located under the facility footprint, is isolated upstream of the footprint, or is affected by reduced flows downstream of the Project (Creek 661 tributaries only). The offsets required will be accomplished by creating lake and stream habitat associated with the Lake 01682LNRS enlargement and diversion project, and creation of off-channel ponds in Davidson Creek and Creek 661. Offsetting gains from these projects total approximately 153,700 m^2. A total of 52,600 m^2 more fish habitat will be created by the offsetting measures when compared to serious, permanent harm due to construction of surface facilities. This amounts to a spatial offset ratio of approximately 1.5:1.

Serious, permanent harm total approximately 133,000 HUs. Most of the HU losses will be associated with food production (36%), juvenile rearing (23%), and fry rearing (20%). Offsetting gains will total approximately 386,800 HUs with the creation of lake and stream spawning and rearing habitat at Lake 01682LNRS and in off-channel ponds. Construction of preferred offsetting measures will result in a net gain of 254,500 HUs (**Table 7-11**). This amounts to an offset ratio of approximately 2.9:1.

Table 7-10: Comparison of Total Estimated Area of Serious, Permanent Harm to Fish, and Offset Gains from the Project Associated with Section 35(2) Fisheries Act Authorization

Impact Type		Residual Serious, Permanent Harm				Habitat Area Gained			Net Change (m^2)	Offset Gain Ratio
Habitat Type	Class	Upstream Habitat Isolation (m^2)	Mine Site Facilities Footprint (m^2)	Downstream Flow Changes (m^2)	Total Residual Habitat Lost (m^2)	Lake 01628 Enlargement (m^2)[(1)]	Off-Channel Ponds (m^2)	Total Habitat Area Gained (m^2)		
Cascade	1		1,509		1,509				-1,509	
Riffle	1		38	588	626	40		40	-586	
	2	1,495	13,850	1,914	17,259	10		10	-17,249	
	3	336	2,081		2,417	-33		-33	-2,450	
Glide	1		200	2,168	2,368	40		40	-2,328	
	2	1,754	9,148	1,230	12,132	10		10	-12,122	
	3	951	725		1,676	859	48	907	-768	
Pool	1		2,059	529	2,588	351	12	363	-2,225	
	2		1,319		1,319	308		308	-1,011	
	3	1,104	28		1,132				-1,132	
Other	1						17,200	17,200	+17,200	
	2		14,131		14,131	5,075	4,300	9,375	-4,756	
Tributary	1	988	6,944	2,218	10,149				-10,149	
	2	16,671	10,636	3,676	30,983				-30,983	
	3	866	1,006		1,873				-1,873	
	4	911			911				-911	
Lake	1					62,690		62,690	+62,690	
	2					35,534		35,534	+35,534	
	3					27,255		27,255	+27,255	
Total		**25,076**	**63,676**	**12,322**	**101,073**	**132,139**	**21,560**	**153,699**	**+52,625**	**1.5 : 1**

Note: [(1)]Includes loss of Creek 705 Reach 8 due to diversion to Pond A (**Table 7-3**).

Table 7-11: Comparison of Total Estimated Habitat Units of Serious, Permanent Harm to Fish and Offset Gains from the Project Associated with Section 35(2) Fisheries Act Authorization

Impact Type	Residual Habitat Units Lost			Total Residual Habitat Units Lost	Habitat Units Gained			Net Change	Gain to Loss Ratio
	Upstream Habitat Isolation	Downstream Flow Changes	Mine Site Facilities Footprint		Lake 01628LNRS Enlargement	Off-Channel Ponds	Total Habitat Units Gained		
Life Stage	HUs	HUs	HUs	HUs	HUs	HUs	HUs	HUs	-
Spawning / Egg Incubation	1,251	3,555	8,256	13,062	67	0	67	-12,995	
Fry Summer Rearing	2,680	3,018	20,637	26,335	1,674	5,390	7,064	-19,271	
Juvenile Summer Rearing	6,592	3,343	20,567	30,502	89,556	18,311	107,867	77,365	
Adult Summer Foraging	0	0	0	0	78,437	0	78,437	78,437	
Overwintering	1,134	1,182	11,858	14,174	111,627	18,296	129,923	115,749	
Food & Nutrient Production	8,994	5,967	33,251	48,221	58,013	5,414	63,427	15,216	
Total	**20,651**	**17,065**	**94,569**	**132,285**	**339,374**	**47,411**	**386,785**	**254,500**	**2.9:1**

Note: HUs = habitat units

7.7.2 Section 27.1 Metal Mine Effluent Regulations

A total of 60,150 m^2 of stream habitat, or 92,360 rainbow trout habitat units, will be affected by the deposit of deleterious mine tailings and waste rock in the Davidson Creek and Creek 661 watersheds (**Table 7-12**). The projects required to offset this habitat include habitat rehabilitation in the Mathews Creek watershed and replacement of three pre-code, fish-barrier culverts in the Vanderhoof Forest District. The total habitat gains provided by these projects are estimated to be 105,600 m^2, for a net gain of approximately 45,500 m^2. This amounts to a spatial offset ratio of approximately 1.8:1.

Table 7-12: Comparison of Total Estimated Area of Serious, Permanent Harm to Fish and Offset Gains from the Project Associated with MMER Amendment

Impact Type		Residual Serious, Permanent Harm TIA Footprints (m^2)	Habitat Area Gained			Net Change[(1)] (m^2)	Offset Gain Ratio
Habitat Type	Class		Mathews Creek (m^2)	Culverts [(1)] (m^2)	Total Habitat Area Gained[(1)] (m^2)		
Cascade	1	1,714			0	-1,714	
Riffle	1	2,186			0	-2,186	
	2	9,035			0	-9,035	
	3	4,741			0	-4,741	
Glide	1	11,429			0	-11,429	
	2	4,199			0	-4,199	
	3	760	6,878		6,878	+6,117	
Pool	1	2,996	9,382		9,382	+6,386	
	2	2,622			0	-2,622	
	3	205			0	-205	
Other	1	0			0	0	
	2	0	48,000		48,000	+48,000	
Tributary	1	6,007			0	-6,007	
	2	11,150			0	-11,150	
	3	3,100	700		700	-2,400	
	4	0			0	0	
Lake	1	0			0	0	
	2	0			0	0	
	3	0			0	0	
Total		**60,145**	**64,960**	**40,682**	**105,642**	**+45,497**	**1.8 : 1**

Note: MMER = Metal Mining Effluent Regulation, TIA = tailing impoundment area
[(1)] Composition of habitat types above placement culverts will be determined by field surveys prior to finalization/rehabilitation. Therefore, spatial areas for different habitat types upstream of culverts are not known and, therefore, only the total area upstream of the three culverts is shown or used in calculating total habitat gain and net change.

The net gain in habitat units cannot be completed in its entirety due to the unknown quantity or quality of habitat types upstream of the three problem culverts (**Table 7-13**). Despite this limitation, the high spatial offset ratio, combined with the fact that the habitat upstream of these culverts includes relatively high percentages of large, higher order streams that are likely to

provide the diversity of habitats required by Chinook salmon, sockeye salmon, kokanee, rainbow trout, bull trout, mountain whitefish, and potentially endangered Nechako River white sturgeon (all species important to recreational and Aboriginal fisheries) for all or part of their life histories. As a result, the Proponent is confident that whatever habitat unit based offset ratio could be calculated, it would be significantly higher than 2:1 when all life stages of all these species are taken into account. Uncertainty associated with this unknown habitat unit-based offset ratio can be mitigated through early construction of offsetting projects, something that can be done as both of these projects area located "off-site" and can be started prior to any habitat disturbances at the Blackwater mine site.

Table 7-13: Comparison of Total Estimated Habitat Units of Serious, Permanent Harm to Fish and Offset Gains from the Project Associated with MMER Amendment

Impact Type	Residual Habitat Units Lost TIA Footprints	Habitat Units Gained			Net Change	Gain to Loss Ratio[2]
		Mathews Creek	Culverts [1]	Total Habitat Units Gained		
Life Stage	HUs	HUs	HUs	HUs	HUs	-
Spawning / Egg Incubation	16,881	0	0	0	-16,881	
Fry Summer Rearing	16,842	12,000	0	12,000	-4,842	
Juvenile Summer Rearing	18,824	6,806	0	6,806	-12,018	
Adult Summer Foraging	0	6,509	0	6,509	+6,509	
Overwintering	7,586	220	0	220	-7,366	
Food & Nutrient Production	32,227	16,526	0	16,526	-15,701	
Total	**92,360**	**42,060**	**not calculated**	**42,060**	**-50,300**	**not calculated**

Note: MMER = Metal Mining Effluent Regulation, TIA = tailing impoundment area, HUs = habitat units
[1] Composition of habitat types will be determined by field surveys prior to finalization/rehabilitation.
[2] Offset ratio not calculated because habitat types for gains related to culvert rehabilitations as are not sufficiently defined to calculate at this time.

8.0 MONITORING PLAN

The final monitoring plan will be developed in consultation with DFO, BC MOE, BC MFLNRO, and EC during the permitting phases of the Project. The plan will be designed to demonstrate that the approved FMOP was successfully implemented, mitigation and offsetting measures were effective, and that the objectives of the Plan were achieved.

In accordance with DFO's monitoring guidelines (DFO, 2012), monitoring of the offsetting works will include compliance, functional, and/or effectiveness components. Because mitigation measures described in **Section 5** of this plan and those identified in the Fish and Fish Habitat EAs will be directly incorporated into the project design, their effectiveness will be monitored as part of the larger aquatics environmental effects monitoring plan.

All potential physical, chemical, and biological limitations will be factored into establishing success criteria and monitoring metrics. Metrics used to measure the effectiveness may include physical metrics as surrogates for measuring the productive capacity but could also take into account fish population and productivity metrics as well.

8.1 Compliance Monitoring

In order to satisfy the requirements for a Section 35(2) *Fisheries Act* Authorization, compliance monitoring must be implemented to demonstrate all offsetting works are constructed according to the approved designs, schedule, environmental regulations, and permit conditions. This will be accomplished by comparing the "issued for construction" drawings associated with the FMOP with the "as-built" drawings, comparing before, during, and after construction photos, and providing daily construction monitoring reports. A comparison of the size, number, and type of discrete habitats built will be provided as part of the compliance monitoring component. A description of the quality of the construction will also be provided.

8.2 Effectiveness Monitoring

Effectiveness monitoring demonstrates, by field measurement, that the offsetting projects achieved the ecological milestones as set out in the Authorization (DFO, 2012). Metrics typically used to determine if ecological milestones have been achieved include, but are not assumed to be or limited to, fish abundance, species richness, community composition, or population biomass. If required, this will be done using a before-after-control-impact (BACI) study design that compares the agreed upon metrics from reference site(s) in the pre-disturbance watersheds or non-impacted sites near the Project area to sites in reaches where offsetting activities will occur.

Functional monitoring is the same as effectiveness monitoring but relies on physical habitat metrics as surrogates for productive capacity (DFO, 2012). If required, this will be done by assessing the physical stability, quantity, and quality of the habitat created or enhanced by the offsetting activities. Habitat-based metrics may include, but are not assumed to be or limited to, area or volume of habitat enhanced or created, relative change in habitat suitability, relative change in hydraulic conditions, and/or relative change in habitat accessibility.

A professional experienced in fish habitat restoration will conduct all monitoring. This party will prepare reports at the frequency stated in the Section 35(2) *Fisheries Authorization* and for the duration of the monitoring program. These reports will be submitted to DFO for review in a timely manner consistent with permit reporting requirements.

8.3 Schedule of Monitoring and Reporting

The duration and frequency of monitoring and the scheduling of reporting requirements will be determined in consultation with DFO prior to construction of the Project. Decision criteria for the duration of monitoring may include the duration of target species life-spans, the duration between successive generations entering the fisheries, and the duration necessary for habitats to stabilize and for streams to reach their new dynamic equilibriums. Decision criteria for the frequency of monitoring should include the sensitivity and/or resiliency of the fish species to changes in habitat and the complexity of the habitat enhancement or creation project. The duration and frequency of monitoring may be different for different offsetting projects depending on their complexity and the fish species and life-stages they are intended to benefit. Regardless, the initial years of monitoring will provide the information necessary to make any adjustments needed to increase the stability and effectiveness of the enhanced or created habitats.

Results of each year's monitoring activities will be analyzed, presented, and discussed, including photos, in reports prepared by a professional consultant. These reports will be submitted to DFO on a schedule consistent with permit reporting requirements. In addition to the reporting of annual results, the annual reports will make comparisons to previous year's results, as available, and make recommendations to address any deficiencies in the offsetting habitats that could be limiting their compliance, functionality and/or effectiveness in achieving their stated objectives. Any deficiencies in the monitoring program will also be reported.

A final report will be prepared in the final year that provides the final year's monitoring results and summarizes the findings of the entire monitoring program. This report will identify any trends in the data throughout the program's duration. The final report will provide a functional assessment of the performance of the offsetting habitats and will include photographs of the constructed habitat showing their maturation over the duration of the monitoring period.

8.4 Contingencies

The different metrics for success, their thresholds, and the frequency and duration of monitoring will be determined in consultation with DFO. If the monitoring program indicates that the effectiveness and functional monitoring criteria, success, and thresholds are not being achieved, then the Proponent will correct any deficiencies. This may involve adding to the existing habitat, enhancing the existing habitat, or re-engineering the existing habitat. If these steps do not correct the deficiency, then the Proponent will commit to implementing some or all of the contingency offsetting projects identified in **Section 7**.

REFERENCES

Alabaster, J.S., D.W.M. Herbert, and J. Hemens. 1957. The survival of rainbow trout and perch at various concentrations of dissolved oxygen and carbon dioxide. Annals of Applied Biology 45: 177-188.

Anderson, J. 2002. Overwintering use by stream-dwelling salmonids of small to mid-sized systems in the Peace Region: a literature review. A report prepared for Fisheries Renewal BC, Peace-Liard Watershed Council by J. Anderson, BC Conservation Foundation, Prince George, BC.

ARC Environmental Ltd. and Triton Environmental Consultants Ltd. 1999. Swanson Creek Report on Restoration Activities, 1999. Draft Report. Prepared for: Ministry of Environment, Lands and Parks. Fisheries Branch, B.C. Ministry of Environment, Prince George, B.C.

Avison Management Services Ltd.(Avison). 2010a. Baseline sediment and biota contaminant study for Chu Molybdenum Mining Project. Prepared for TTM Resources Inc. by Avison Management Services, Vanderhoof, BC. January 2010.

Avison. 2010b. 2008/2009 fish distribution inventory for Chu Molybdenum Mining Project. Prepared for TTM Resources Inc. by Avison Management Services, Vanderhoof, BC. April 2010.

Avison. 2010c. 2009 reconnaissance lake inventory of Lake 113 for Chu Molybdenum Mining Project. Prepared for TTM Resources Inc. by Avison Management Services, Vanderhoof, BC. April 2010.

Avison. 2010d. 2009 reconnaissance lake inventory of Mills Lake for Chu Molybdenum Mining Project. Prepared for TTM Resources Inc. by Avison Management Services, Vanderhoof, BC. April 2010.

Avison. 2012. Offsite fish habitat compensation opportunities for the Blackwater Gold Project (Draft). Prepared for AMEC Environment & Infrastructure by Avison Management Services, Vanderhoof, BC.

Avison. 2013a. Culverts and fish passage prioritization: desktop review of Vanderhoof Forest District. Prepared for AMEC Environment & Infrastructure by Avison Management Services, Vanderhoof, BC.

Avison, 2013b. Assessment for Fish Passage Status of Selected Priority Culverts in the Vanderhoof Forest District. A report prepared for New Gold Inc by Avison Management Services, Vanderhoof, BC.

Azimuth. 2012. Site C Clean Energy Project. Volume 2, Appendix J, Mercury Technical Reports, Part 1 Mercury Technical Synthesis Report. Prepared by Azimuth Consulting Group Partnership, Vancouver, for BC Hydro Power and Authority.

Beatty, J.M., L.E. McDonald, F.M. Westcott, and C.J. Perrin. 2006. Guidelines for sampling benthic invertebrates in British Columbia streams. Prepared for BC Ministry of Environment. Available at http:// www.env.gov.bc.ca/epd/regions/.../wq.../bi-sampling-06update.pdf (accessed 2012).

Beauchamp, D.A., D.L. Parrish, and R.A. Whaley. 2009. Sampling coldwater fish in large standing waters. Pages 97-118 in Standard Sampling Methods for North American Freshwater Fishes. S.A. Bonar, W.A. Hubert, and D. Willis (eds.). American Fisheries Society, Bethesda, Maryland.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Chapter 4 in Influences of Forest and Rangeland Management of Salmonid Fishes and their Habitat. W. Meehan ed. American Fisheries Society Special Publication 19.

Brandt, S. B. 1996. Acoustic assessment of fish abundance and distribution. Pages 385-432 in Fisheries Techniques, 2nd edition. L.A. Nielsen and D.L. Johnson (eds.). American Fisheries Society, Bethesda, Maryland.

British Columbia Conservation Data Centre (BC CDC). 2013. BC Species and Ecosystems Explorer. Available at http://a100.gov.bc.ca/pub/eswp/. Accessed 2012.

British Columbia Fisheries Inventory Summary System (BC FISS). 2011. Fisheries Society of BC. Available at http://www.env.gov.bc.ca/fish/fiss/index.htmlBC FishWizard. Accessed 2012.

BC Forest Practices Board. 2009. Fish passage at stream crossings. Special Investigation. FPB/SIR25. January 2009. Available at http://www.fpb.gov.bc.ca/SIR25_Fish_Passage_at_Stream_Crossings.pdf. Accessed 2013.

BC Hydro, BC Transmission Corporation, Fisheries and Oceans Canada, and the Ministry of Water, Land and Air Protection. 2003. Approved work practices for managing riparian vegetation. Vancouver, BC. Available at http://www.bchydro.com/content/dam/hydro/medialib/internet/documents/bctc_documents/work_practices_riparian.pdf. Accessed 27 November 2013.

British Columbia Integrated Land Management Bureau (BC ILMB). 1997. Vanderhoof Land and Resource Management Plan. January 1997. Available at http://archive.ilmb.gov.bc.ca/slrp/lrmp/princegeorge/vanderhf/plan/vanderhoof_lrmp/index.html (accessed 2012).

BC ILMB. 2010. Vanderhoof Sustainable Forest Management Plan. Vanderhoof Forest District Public Advisory group. Available at http://www.for.gov.bc.ca/hfd/library/FIA/2010/LBIP_8033003.pdf. Accessed 2012.

British Columbia Ministry of Water. Land and Air Protection (BC MWLAP). 2004. Region 7 Omineca – Reduced risk timing windows for fish and wildlife: standards and best practices for instream works. Ministry of Water, Lands and Air Protection, Omineca Region Ecosystem, Environment Stewardship Division. WLAP BMP Series. April 2004. 10 pp.

British Columbia Ministry of Forests, Lands, and Natural Resource Operations (BC MWLAP). 2011. Freshwater Atlas. Accessed at: http://www.ilmb.gov.bc.ca/geobc/FWA.

British Columbia Ministry of Environment (BC MOE). 2001. Ambient water quality guidelines for temperature: overview. Available at http://www.env.gov.bc.ca/wat/wq/BC guidelines/temptech/temperature.html

BC MOE. 2001. Field assessment for determining fish passage status of closed bottom structures. Available at http://www.for.gov.bc.ca/ftp/hcp/external/!publish/web/fia/Field-Assessment-for-Determining-Fish-Passage-Status-of-CBS.pdf. Accessed 2012.

BC MOE. 2009. The strategic approach: Protocol for planning and prioritizing culverted sites for fish passage assessment and remediation, 3rd edition, Victoria, B.C. Available at http://www.for.gov.bc.ca/hfp/fish/strategic%20approach%202009.pdf. Accessed 2012.

BC MOE. 2007. Freshwater fisheries management plan. Available at: http://www.env.gov.bc.ca/esd/documents/ff_program_plan.pdf. Accessed 2012.

BC MOE. 2011. Field assessment for determining fish passage status of closed bottom structures. Fourth edition. August 2011. Available at: https://www.for.gov.bc.ca/ftp/hcp/external/!publish/web/fia/Field-Assessment-for-Determining-Fish-Passage-Status-of-CBS.pdf. Accessed 2012.

BC MOE. 2012a. Water and air baseline monitoring guidance document for mine proponents and operators. BC Ministry of Environment, Victoria, BC. 9 October 2012.

BC MOE. 2013. Habitat Wizard. BC Ministry of Environment, Victoria, BC. Available at http://www.env.gov.bc.ca/habwiz/. Accessed 2012.

British Columbia Ministry of Forests (BC MOF). 1995. Riparian management area guidebook. Forest Practice Code of British Columbia. Province of British Columbia. Victoria, BC. 68 pp.

BC MOF. 1998. Fish stream identification guidebook. Forest Practice Code of British Columbia. Province of British Columbia. Victoria, BC.

BC MOF. 2002. Forest practices code of British Columbia: Fish-stream crossing guidebook. Victoria, BC 68 pp.

BC MOF. 2012. Fish-stream crossing guidebook. Forest Practices Code of British Columbia guidebook. Province of British Columbia. Victoria, BC.

Bourne, C., D. Kehler, et al.,2011. Barriers to fish passage and barriers to fish passage assessments: the impact of assessment methods and assumptions on barrier identification and quantification of watershed connectivity. Aquatic Ecology 45: 389-403.

Buchanan, D.V., and M.G. Wade. 1983. Restoration of the native winter steelhead run on the South Santiam River above Foster Dam. Oregon Department of Fish and Wildlife, Fisheries Research Project DACW57-79-C-O059-P0001, Annual Progress Report, Portland, Oregon, USA.

Burns, J.F. 1977. A reconnaissance survey of Kuyakuz Lake 01689LNRS. Report ID: 28864. BC Ministry of Environment, Lands and Parks. Available at http://a100.gov.bc.ca/pub/acat/public/welcome.do (accessed 2012).

Bustard, D.R. and D.W. Narver. 1975a. Aspects of the winter ecology of juvenile coho salmon (*Oncorhynchus kisutch*) and steelhead trout (*Salmo gairdneri*). Journal of the Fisheries Research Board of Canada. 32: 667-680.

CABIN (Canadian Aquatic Biomonitoring Network). 2011. CABIN Resources. Available at http://www.ec.gc.ca/rcba-cabin/default.asp?lang=En&n=74876ADD-1. Accessed 2012.

CABIN. 2012. CABIN Database. Available at http://cabin.cciw.ca/Application/birc_login.asp?Lang=en-ca. Accessed 2012.

Clark, M.J.R. (ed.). 2003. British Columbia field sampling manual. BC Ministry of Water, Land and Air Protection, Water, Air and Climate Change Branch. Victoria, BC.

Coombes, D.M.V. 1985a. A reconnaissance survey of Laidman Lake 01815UEUT. Report ID: 28859. Fisheries Branch, BC Ministry of Environment. Available at http://a100.gov.bc.ca/pub/acat/public/welcome.do. Accessed 2012.

Coombes, D.M.V. 1985b. A reconnaissance survey of Top Lake 01045UEUT. Report ID: 28866. Fisheries Branch, BC Ministry of Environment. Available at http://a100.gov.bc.ca/pub/acat/public/welcome.do. Accessed 2012.

COSEWIC (Committee on the Status of Endangered Wildlife in Canada). 2013. Wildlife species assessments. November 2012. Available at http://www.cosepac.gc.ca/eng/sct0/index_e.cfm (accessed 2012).

Cunjak, R.A., 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Sciences 53(Suppl. 1): 267-282.

Cunjak, R.A., and G. Power. 1986. Winter habitat utilization by stream resident brook trout and brown trout. Canadian Journal of Fisheries and Aquatic Sciences 43: 1970-1981.

Cunjak, R.A., J.-M. Roussel, M. A. Gray, J. P. Dietrich, D. F. Cartwright, K. R. Munkittrick and T. D. Jardine. 2005. Using stable isotope analysis with telemetry or mark-recapture data to identify fish movement and foraging. Oecologia 144: 636-646.

Davis, J.C. 1975. Minimum dissolved oxygen requirements of aquatic life with emphasis on Canadian species. Journal of the Fisheries Research Board of Canada 32: 2295-2332.

DFO (Fisheries and Oceans Canada). 1986. National Policy for the management of fish habitat. Communications Directorate. Department of Fisheries and Oceans Canada. Ottawa, Ontario.

DFO. 1995. Freshwater intake end-of-pipe fish screen guideline. Fisheries and Oceans Canada, Ottawa, ON. Available at http://www.dfo-mpo.gc.ca/library/223669.pdf. Accessed 2013.

DFO. 1998a. Habitat conservation and protection guidelines. Second Edition. Communications Directorate. Department of Fisheries and Oceans Canada. Ottawa, Ontario.

DFO. 1998b. Decision framework for the determination and Authorization of harmful alteration, disruption or destruction of fish habitat. Communications Directorate, DFO.

DFO. 2007. Practitioners Guide to Habitat Compensation for DFO Habitat Management Staff. Version 1.1.

DFO. 2010a. Pathways of Effects – Fish passage issues. Fisheries and Oceans Canada, Ottawa, O.N. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed January 2014.

DFO. 2010b. Pathways of Effects – Placement of materials or structures in water. Ottawa, ON. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed 2013.

DFO. 2010c. Pathways of Effects – Change in timing, duration and frequency of flows. Ottawa, O.N. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/frequency-frequence-eng.html. Accessed 2013.

DFO. 2010d. Pathways of Effects – Use of explosives. Ottawa, O.N. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/frequency-frequence-eng.html. Accessed 2013.

DFO. 2010e. Pathways of Effects – Vegetation Clearing. Ottawa, ON. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed 2013.

DFO. 2010f. Pathways of Effects – Grading. Ottawa, O.N. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed 2013.

DFO. 2010g. Pathways of Effects- Excavation. Ottawa, ON. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed January 2014.

DFO. 2010h. Pathways of Effects – Use of industrial equipment. Ottawa, ON. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed 2013.

DFO. 2010i. Pathways of Effects – Cleaning or maintenance of bridges or other structures. Ottawa, O.N. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/pathways-sequences/index-eng.html. Accessed 2013.

DFO. 2012. Assessing the Effectiveness of Fish Habitat Compensation Activities in Canada: Monitoring Design and Metrics. National Capital Region

DFO. 2013a. Fisheries Protection Policy Statement. October, 2013.

DFO. 2013b. Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting. November 6, 2013.

DFO. 2013c. Measures to avoid causing harm to fish and fish habitat. Available at http://www.dfo-mpo.gc.ca/pnw-ppe/measures-mesures/index-eng.html Accessed 19 December 2013.

DFO. 2013d. An Applicant's Guide to Submitting an Application for Authorization under Paragraph 35(2)(b) of the *Fisheries Act*. November 6, 2013.

DWB Forestry Services Ltd. (DWB). 2001. 2001 Stream inventory: A18157 – Top Lake. Final Report, FDIS Files, Non-Fish-Bearing Status Reports, Arcview Mapping Data, and Photo Documentation. Prepared for Slocan Forest Products Ltd. Plateau Division. Vanderhoof, BC.

DWB. 2002. 2002 Stream inventory. Vanderhoof Operating Area 14. Final Report, FDIS Files, Non-Fish-Bearing Status Reports, Arcview Mapping Data, and Photo Documentation. Prepared for Slocan Forest Products Ltd. Plateau Division. Vanderhoof, BC.

DWB. 2008. Stream crossing restoration of an unnamed tributary to Tatelkuz Lake (Site 60), Nechako Watershed, Northern Interior Forest Region. NOTSA242668,2668051, 2007/2008. Available at http://www.for.gov.bc.ca/hfd/library/fia/2007/LBIP_2668051.pdf (accessed 2012).

Ecofor Consulting Ltd. (Ecofor). 2004. 2004 Stream classification project for Areas 29, 30, 33, 34, 35, 37, 38, 45. Final Report, FDIS Files, Non-Fish-Bearing Status Reports, Arcview Mapping Data, and Photo Documentation. Prepared for Canadian Forest Products Plateau Division. Vanderhoof, BC.

Ecofor. 2012. Blackwater Gold Project offsite compensation options in the Vanderhoof Forest District (Draft). Prepared for New Gold Inc. Project Number: 2012-2071-21. Version 1.0. Vancouver, BC. 18 June 2012.

Environment Canada (EC). 2010. Canadian Aquatic Biomonitoring Network (CABIN) field manual wadeable streams. Environment Canada, Dartmouth, Nova Scotia. March 2010.

EC. 2011a. Guidelines for the assessment of alternatives for mine waste disposal. Environment Canada, Mining and Processing Division. Ottawa, Canada.

EC. 2011b. 2011 Metal Mining Environmental Effects Monitoring (EEM) Technical Guidance Document. National Environmental Effects Monitoring Office. Ottawa, ON.

Fish Passage Technical Working Group. 2014. British Columbia Ministry of Forests, lands and Natural Resource Operations. Accessed at: http://www.for.gov.bc.ca/hfp/fish/FishPassage.html.

Golder Associates Ltd. (Golder). 1998. Reconnaissance level (1:20,000) fish and fish habitat inventory of Slocan Group Plateau (Vanderhoof) Division Operating Area – 1997 Nechako River Watershed 180-00000; Stuart River Watershed 182-00000; West Road (Blackwater) River Watershed; 170-00000.

Government of Canada. 2002. Metal Mining Effluent Regulations. SOR/2002-222.

Government of Canada. 2013. *Fisheries Act.* Amendments to *Fisheries Act* RSC 1985, c. F-14 enacted on June 29, 2012.

Grant. C.G.J., and E.M. Lee. 2004. Life history characteristics of freshwater fishes occurring in Newfoundland and Labrador, with major emphasis on riverine habitat requirements. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2672.

Gregory, J.S., and J.S. Griffith. 1996. Winter concealment by sub-yearling rainbow trout: space size selection and reduced concealment under surface ice and in turbid water conditions. Canadian Journal Of Zoology 74: 451-455.

Harper D.J., and J.T. Quigley. 2000. No net loss of fish habitat: An audit of forest road crossings of fish-bearing streams in British Columbia, 1996-1999. Canadian Technical Report of Fisheries and Aquatic Sciences 2319.

Hickey, D.G., and D.B. Lister. 1981. Salmonid enhancement baseline investigations at Stuart River, British Columbia in 1980. Part II – Adult chinook salmon study. Prepared by D.B. Lister and Associates Ltd.

Interviews with Lhoosk'uz Dene Elders. 2013. Interview with LDN elders. Prince George, BC, Canada. July 2013.

Januchowski-Hartley, S.R., P.B. McIntyre, M. Diebel, P.J. Doran, D.M. Infante, C. Joseph and J.D. Allan. 2013. Restoring aquatic ecosystem connectivity requires expanding inventories of both dams and road crossings. Frontiers in Ecology and the Environment 11: 211-217.

Johnston, J.M. 1981. Development and evaluation of hydroacoustic techniques for instantaneous fish population estimates in shallow lakes. Washington Department of Game Fishery Research Report No. 81-18, Olympia.

Johnston, N.T., and P.A. Slaney. 1996. Fish habitat assessment procedures. Prepared for the BC Ministry of Environment, Lands and Parks and the BC Ministry of Forests, Vancouver, BC.

Jones, C., K.M. Somers, B. Craig, and T.B. Reynoldson. 2004 Ontario benthos biomonitoring network protocol manual. Version 1.0. Ontario Ministry of Environment, Dorset, ON. May 2004.

Koning, C.W., and E.R. Keeley. 1997. Salmonid Biostandards for estimating production benefits of fish habitat rehabilitation techniques. Chapter 3 in Fish Habitat Rehabilitation Procedures (P.A. Slaney and D. Zaldokas eds). Watershed Restoration Technical Circular. No. 9. BC Watershed Restoration Program.

Lister, D.B., I. Wallace and D.G. Hickey. 1981. Salmonid enhancement baseline investigations at Stuart River, British Columbia. Part I - 1980 Juvenile chinook salmon study (Volume I). Prepared by D.B. Lister and Associates Ltd. for the Department of Fisheries and Oceans, Vancouver, B.C. 65p + appendices.

Lister, D.B., R.J. Beniston, R. Kellerhals, and M. Miles. 1995. Rock size affects juvenile salmonid use of stream bank rip-rap. In C.E. Thorne et al. (eds. River, coastal and shoreline protection, erosion control using rip rap and armourstone. John Wiley & Sons Ltd., Chichester, England. 166 p.

Lloyd, D.S., J.P. Koenings, and J.D. LaPerriere. 1987. Effects of turbidity in fresh waters of Alaska. North American Journal of Fisheries Management 7: 18-33.

McDermott, H., T. Paull, and S. Strachan. 2010. Canadian Aquatic Biomonitoring network: laboratory methods – processing, taxonomy, and quality control of benthic macroinvertebrates. Prepared for Environment Canada.

McPhail,, J.D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press. Edmonton, AB.

Mount, C., S. Norris, R. Thompson, and D. Tesch. 2011. GIS modeling of fish habitat and road crossings for the prioritization of culvert assessment and remediation. Streamline Watershed Management Bulletin 14: 7-13.

New Gold. 2012. Blackwater Gold Project: Project Description. Prepared for New Gold Inc. by AMEC Environment and Infrastructure. October 2012.

Newbury, R.W., and M.N. Gaboury. 1994. Stream analysis and fish habitat design: a field manual. Second edition. Newbury Hydraulics, Gibsons, B.C. 262p.

Newcombe, C.P. 1994. Suspended sediments in aquatic ecosystems: Ill effects as a function of concentration and duration of exposure. British Columbia Ministry of Environment, Lands, and Parks, Habitat Protection Branch, Victoria, BC.

Northcote, T.G., and G.F. Hartman (editors). 2004. Fishes and Forestry Worldwide: Watershed Interactions and Management. Blackwell Science, Oxford, UK.

Nowosad, D.M., and E.B. Taylor. 2013. Habitat variation and invasive species as factors influencing the distribution of native fishes in the lower Fraser River Valley, British Columbia, with an emphasis on brassy minnow (*Hybognathus hankinsoni*). Canadian Journal of Zoology 91: 71-81.

Osborne, L.L. and Kovacic, D.A. 1993. Riparian vegetated buffer strips in water quality restoration and stream management. Freshwater Biology 29: 243-258.

Park D., M. Sullivan, E. Bayne, and G. Scrimgeour. 2008. Landscape-level stream fragmentation caused by hanging culverts along roads in Alberta's boreal forest. Canadian Journal of Forest Research 38: 566–575.

Perkin, J.S., and K.B. Gido. 2012. Fragmentation alters stream fish community structure in dendritic ecological networks. Ecological Applications 22: 2176-2187.

PECG. 2013. Blackwater Project: Fish and Fish Habitat Baseline Assessment and Compensation Program, Mathews Creek Watershed Rehabilitation Project. Prepared for AMEC Environment & Infrastructure, Burnaby, by Palmer Environmental Consulting Group Inc., Vancouver, BC. 8 November 2013.

Raleigh, R.F., T. Hickman, R.C. Solomon and P.C. Nelson. 1984. Habitat suitability information: rainbow trout. U.S. Fish and Wildlife Service FWS/OBS-82/10.60. 64 pp.

Resource Inventory Standards Committee (RISC). 1997. British Columbia fish collection methods and standards. Version 4.0. January 1997.

RISC. 1999a. Fish and fish habitat inventory: lake survey form field guide. Errata in March 2000. Province of British Columbia, Victoria, BC.

RISC. 1999b. Reconnaissance (1:20,000) fish and fish habitat inventory: site card field guide. Errata in March 2000. Province of British Columbia, Victoria, BC.

RISC. 2000. Reconnaissance (1:20,000) fish and fish habitat inventory: reach information guide. Version 1.0. Province of British Columbia, Victoria, BC. March 2000.

RISC. 2001. Fish and fish habitat inventory: standards and procedures. Version 2.0. Province of British Columbia, Victoria, BC. April 2001.

RISC. 2008. Fish and fish habitat inventory: lake survey form field guide. Version 2.0. April 2008. Province of British Columbia, Victoria, BC. April 2001.

RISC. 2009a. Bathymetric standards for lake inventories. Version 3.0. Province of British Columbia.

RISC. 2009b. The Canadian Aquatic Biomonitoring Network: field manual. Version 1.0. Prepared by BC Ministry of Environment, Science & Information Branch, Watershed and Aquifer Science Section for the Resources Information Standards Committee. Province of British Columbia, Victoria, BC.

Roberge, M., J.M.B. Hume, C.K. Minns, and T. Slaney. 2002. Life history characteristics of freshwater fishes occurring in British Columbia and the Yukon, with major emphasis on stream habitat characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2611.

Riehle, M.D., and J.S. Griffith. 1993. Changes in habitat use and feeding chronology of juvenile rainbow trout in fall and the onset of winter in Silver Creek, Idaho. Canadian Journal of Fisheries and Aquatic Sciences 50: 2119-2128.

Schick, R.S., and S.T. Lindley. 2007. Directed connectivity among fish populations in a riverine network. Journal of Applied Ecology 44: 1116–1126.

Simmonds, E.J., and D.N. MacLennan. 2005. Fisheries acoustics. Chapman and Hall, London.

Simpkins, D.G., W.A. Hubert, and T.A. Weshce. 2000. Effects of fall-to-winter changes in habitat and frazil ice on the movements and habitat use of juvenile rainbow trout in a Wyoming tailwater. Transactions of the American Fisheries Society 129: 101-118.

Singleton, H.J., 1985. Water quality criteria for particulate matter: Technical appendix. British Columbia Ministry of Environment, Lands, and Parks, Victoria, BC.

Tappel, P. D., and T. C. Bjornn. 1983. A new method of relating size of spawning gravel to salmonid embryo survival. North American Journal of Fisheries Management 3:123–135.

Thompson, K. 1972. Determining stream flows for fish life, p.31-46. *In* Pacific Northwest River Basins Commission (ed.), Proc. Instream Flow Requirement Workshop. March 15-16, 1972. Portland, Oregon.

Thorne, R.E. 1983. Hydroacoustics. Pages 239-260 in Fisheries Techniques. L. Nielsen, and D. Johnson (eds.). American Fisheries Society, Bethesda, Maryland.

Triton Environmental Consultants Ltd. (Triton). 2006. Stream classification within CanFor's (Plateau Division) Planning Cell #s 70, 72, 73, 75, 76, 77, 78, 79, 80, and 81. Draft

Report, FDIS Files, Non Fish Bearing Status Reports, Arcview Mapping Data, and Photo Documentation. Prepared for Canfor Forest Products Plateau Division. Vanderhoof, BC.

Underhill, D. 2000. Annual compendium of aquatic rehabilitation projects for the Watershed Restoration Program, 1999-2000. Watershed Restoration Program Report No. 18.

US FWS (United States Fish and Wildlife Service). 1981. Habitat Evaluation Procedures (HEP). ESM 102. U.S. Department of the Interior, Fish and Wildlife Service, Division of Ecological Services.

Vadas, R.L. Jr. 1998. Human impacts on aquatic and riparian ecosystems in two streams of the Thompson River drainage, British Columbia. Pages 13-30 *in* M.K. Brewin and D.M.A. Monita, Tech. Coords. Forest-fish conference: land management practices affecting aquatic ecosystems. Proc. Forest-Fish Conf., May 1-4, 1996, Calgary, Alberta. Natural Resources Canada, Canadian Forest Service, Northern Forest Centre, Edmonton, Alberta, Information Report NOR-X-356.

Walsh, H.G., and Hale. 1977. A reconnaissance survey of Tatelkuz Lake 01419LNRS. Report ID: 10595. Ministry of Environment, Lands, and Parks. Available at http://a100.gov.bc.ca/pub/acat/public/welcome.do. Accessed 2012.

Wightman, J.C., and G.D. Taylor. 1976. Salmonid swimming performance in relation to passage through culverts. B.C. Ministry of Recreation and Conservation, Fish and Wildlife Branch, Victoria, B.C.

Wilson, K., and C. Sinclair, 2012. Blackwater Gold Project: Off-site Compensation Options in the Vanderhoof Forest District. Draft Report V 1.0. Prepared for New Gold Inc. by Ecofor Consulting BC Ltd. 18 June 2012.

Wright D.G., and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Canadian Technical Report of Fisheries and Aquatic Sciences 2107.

Yule, D.L. 2000. Comparison of horizontal acoustic and purse-seine estimates of salmonid densities and sizes in eleven Wyoming waters. North American Journal of Fisheries Management 20: 759-775.

ANNEXES

Annex A

Photos of Stream and Lake Habitat in the Blackwater Project Area



Photo 1: Glide habitat with gravel silt substrate in Reach 1 of Davidson Creek, August 4, 2012



Photo 2: Large woody debris in pool habitat and silt gravel substrate in Reach 1 of Davidson Creek, August 4, 2012



Photo 3: Glide habitat with cobble gravel substrate in Reach 2 of Davidson Creek, August 4, 2012



Photo 4: Riffle habitat with large woody and cobble substrate in Reach 2 of Davidson Creek, August 4, 2012



Photo 5: Glide habitat with small woody debris and gravel substrate in Reach 3 of Davidson Creek, August 6, 2012



Photo 6: Aerial view of Reach 3 of Davidson Creek, June, 2013



Photo 7: Logjam in Reach 4 of Davidson Creek, August 8, 2011



Photo 8: Riffle/glide habitat with cobble substrate in Reach 4 of Davidson Creek, August 8, 2011



Photo 9: Large pool section with overhanging vegetation and spawning gravels in Reach 5 of Davidson Creek, August 7, 2011



Photo 10: Glide/pool habitat with overhanging vegetation, large woody debris, and cobble/gravel/fine substrates in Reach 5 of Davidson Creek, August 7, 2011



Photo 11: Close-up of cobble/boulder substrate in Reach 6 of Davidson Creek, August 17, 2011



Photo 12: Riffle habitat with cobble substrates in Reach 6 of Davidson Creek, August 17, 2011



Photo 13: Riffle habitat with cobble substrates and overhanging vegetation in Reach 7 of Davidson Creek, August 17, 2011



Photo 14: Plunge pool habitat with bedrock and large woody debris in Reach 7 of Davidson Creek, August 17, 2011



Photo 15: Riffle habitat with boulder/cobble substrates in Reach 7.1 of Davidson Creek, August 19, 2011



Photo 16: Reach 7.1 of Davidson Creek, August 19, 2011



Photo 17: Logjam in glide habitat with cobble substrates in Reach 8 of Davidson Creek, August 7, 2011



Photo 18: Riffle habitat with cobble substrates and overhanging vegetation in Reach 8 of Davidson Creek, August 7, 2011



Photo 19: Pool habitat in Reach 9 of Davidson Creek, August 7, 2011



Photo 20: Glide habitat with large woody debris in Reach 9 of Davidson Creek, August 7, 2011



Photo 21: Glide/pool habitat with undercut banks in Reach 10 of Davidson Creek, August 7, 2011



Photo 22: Cobble/boulder substrate and large woody debris in Reach 10 of Davidson Creek, August 7, 2011

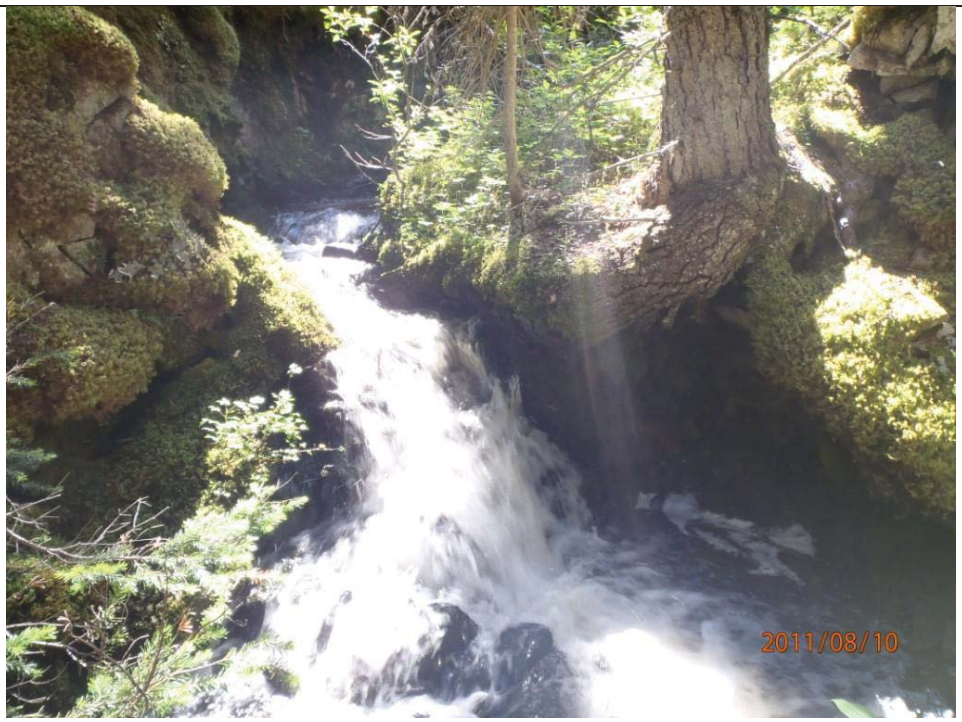


Photo 23: Bedrock cascade section in Reach 11 of Davidson Creek, August 10, 2011



Photo 24: Heavily vegetated glide habitat in Reach 11 of Davidson Creek, August 10, 2011



Photo 25: Pool/glide habitat with undercut banks and overhanging vegetation in Reach 12 of Davidson Creek, August 10, 2011



Photo 26: Pond/wetland habitat in Reach 12 of Davidson Creek, August 10, 2011



Photo 27: Habitat in Reach 1 of Creek 636713, June 25, 2012



Photo 28: Habitat in Reach 1 of Creek 636713, June 25, 2012



Photo 29: Habitat in Reach 3 of Creek 636713, August 7, 2012



Photo 30: Habitat in Reach 3 of Creek 636713, August 7, 2012



Photo 31: Habitat in Reach 4 of Creek 636713, August 1, 2012



Photo 32: Habitat in Reach 4 of Creek 636713, August 1, 2012



Photo 33: Riffle habitat with gravel/cobble substrate in Reach 1 of Creek 688328, August 7, 2012



Photo 34: Reach 1 of Creek 688328, August 7, 2012



Photo 35: Glide habitat with gravel/cobble substrate in Reach 2 of Creek 688328, August 8, 2012



Photo 36: Glide/riffle habitat with gravel/cobble substrate in Reach 2 of Creek 688328, July 20, 2012



Photo 37: Reach 3 of Creek 688328, August 8, 2012



Photo 38: Riffle habitat with cobble/gravel substrate in Reach 3 of Creek 688328, August 8, 2012



Photo 39: Riffle habitat with cobble/gravel substrate in Reach 1 of Creek 704454, August 9, 2012



Photo 40: Reach 1 of Creek 704454, August 9, 2012



Photo 41: Glide habitat with cobble/gravel substrate and large woody debris in Reach 2 of Creek 704454, August 7, 2012



Photo 42: Reach 2 of Creek 704454, August 7, 2012



Photo 43: Riffle habitat with cobble/gravel substrate and large woody debris in Reach 3 of Creek 704454, August 9, 2012



Photo 44: Reach 3 of Creek 704454, August 9, 2012



Photo 45: Cascade-riffle habitat with overhanging vegetation and boulder/cobble substrate in Reach 4 of Creek 70445, August 5, 2012



Photo 46: Woody debris in Reach 4 of Creek 70445, August 5, 2012



Photo 47: Riffle habitat with overhanging vegetation, large woody debris, and mixed substrates in Reach 5 of Creek 704454, August 20, 2011



Photo 48: Riffle habitat with cobble/boulder habitat in Reach 5 of Creek 704454, August 5, 2012



Photo 49: Riffle habitat with overhanging vegetation and gravel/cobble substrate in Reach 6 of Creek 704454, August 6, 2012



Photo 50: Reach 6 of Creek 704454, August 6, 2012



Photo 51: Riffle habitat with overhanging vegetation and gravel/cobble substrate in Reach 1 of Creek 661, August 3, 2012



Photo 52: Pool habitat with cobble/gravel substrate in Reach 1 of Creek 661, August 3, 2012



Photo 53: Riffle habitat with gravel/cobble substrate in Reach 2 of Creek 661, August 2, 2012



Photo 54: Glide habitat with gravel substrate in Reach 2 of Creek 661, August 2, 2012



Photo 55: Pool habitat with large woody debris and overhanging vegetation in Reach 3 of Creek 661, August 11, 2011



Photo 56: Glide habitat with cobble/gravel substrate in Reach 3 of Creek 661, August 11, 2011



Photo 57: Mid-channel gravel bar in riffle habitat in Reach 4 of Creek 661, August 12,2011



Photo 58: Undercut banks, large woody debris, overhanging vegetation, and cobble/fine substrates in Reach 4 of Creek 661, August 12, 2011



Photo 59: Pool habitat with cobble/fine substrates and undercut banks in Reach 5 of Creek 661, August 12, 2011



Photo 60: Narrow riffle habitat with undercut banks and overhanging vegetation in Reach 5 of Creek 661, August 12, 2011



Photo 61: Glide Habitat in Reach 1 of Creek 505659, August 15, 2013



Photo 62: Glide habitat with gravel/boulder substrate in Reach 1 of Creek 505659, August 15, 2013



Photo 63: Looking Upstream Towards Beaver Dam, Reach 2 of Creek 505659, August 15, 2013



Photo 64: Riffle in Reach in Reach 2 of Creek 505659, August 15, 2013



Photo 65: Reach 3 of Creek 505659, August 15, 2013



Photo 66: Reach 3 of Creek 505659, August 15, 2013



Photo 67: Beaver occupied habitat in Reach 4 of Creek 505659, August 02, 2012



Photo 68: Beaver occupied habitat in Reach 4 of Creek 505659, August 02, 2012



Photo 69: Riffle habitat in Reach 6 of Creek 505659, June 26, 2012



Photo 70: Reach 6 of Creek 505659, June 26, 2012



Photo 71: Pool habitat with cobble/fine substrates and undercut banks in Reach 7 of Creek 505659, August 02, 2012



Photo 72: Reach 7 of Creek 505659, August 02, 2012



Photo 73: Habitat in Reach 1 of Creek 146920, August 3, 2012



Photo 74: Habitat in Reach 1 of Creek 146920, June 26, 2012



Photo 75: Plunge pool over log habitat in Reach 2 of Creek 146920, June 26, 2012



Photo 76: Habitat in Reach 2 of Creek 146920, June 26, 2012



Photo 77: Glide habitat in Reach 3 of Creek 146920, August 20, 2011



Photo 78: Large woody debris in Reach 3 of Creek 146920, August 20, 2011



Photo 79: Habitat in Reach 1 of Creek 543585, August 3, 2012



Photo 80: Habitat in Reach 1 of Creek 543585, August 3, 2012



Photo 81: Habitat in Reach 2 of Creek 543585, August 3, 2012



Photo 82: Habitat in Reach 2 of Creek 543585, August 3, 2012



Photo 83: Panoramic view of Lake 01682LNRS shoreline



Photo 84: Aerial Photo of Lake 01682LNRS in the top right hand corner



Photo 85: Emergent Weed Bed in Northwestern End of Tatelkuz Lake, July 2013



Photo 86: Middle Chedakuz Creek Entering Tatelkuz Lake, 14 July 2013



Photo 87: Tatelkuz Lake Facing Northwest, 14 July 2013



Photo 88: Glide/pool habitat with overhanging vegetation and undercut banks in Reach 1 of Turtle Creek, August 16, 2011



Photo 89: Section of Turtle Creek Reach 1 inundated by beaver activity, August 16, 2011



Photo 90: Large woody debris providing cover in glide habitat in Reach 2 of Turtle Creek, August 9, 2011



Photo 91: Riffle habitat with cobble substrates in Reach 2 of Turtle Creek, August 9, 2011



Photo 92: Pool habitat in Reach 3 of Turtle Creek, August 16, 2011



Photo 93: Pool habitat with fine substrates and minimal gravels/cobbles in Reach 3 of Turtle Creek, August 16, 2011



Photo 94: Pool/glide habitat in with fine/gravel substrate and functional large woody debris in Reach 4 of Turtle Creek, August 15, 2011



Photo 95: Glide habitat with gravel/fine substrate in Reach 4 of Turtle Creek, August 15, 2011



Photo 96: Glide habitat in Reach 5 of Turtle Creek, August 9, 2011



Photo 97: Beaver activity in pool habitat in Reach 5 of Turtle Creek, August 9, 2011

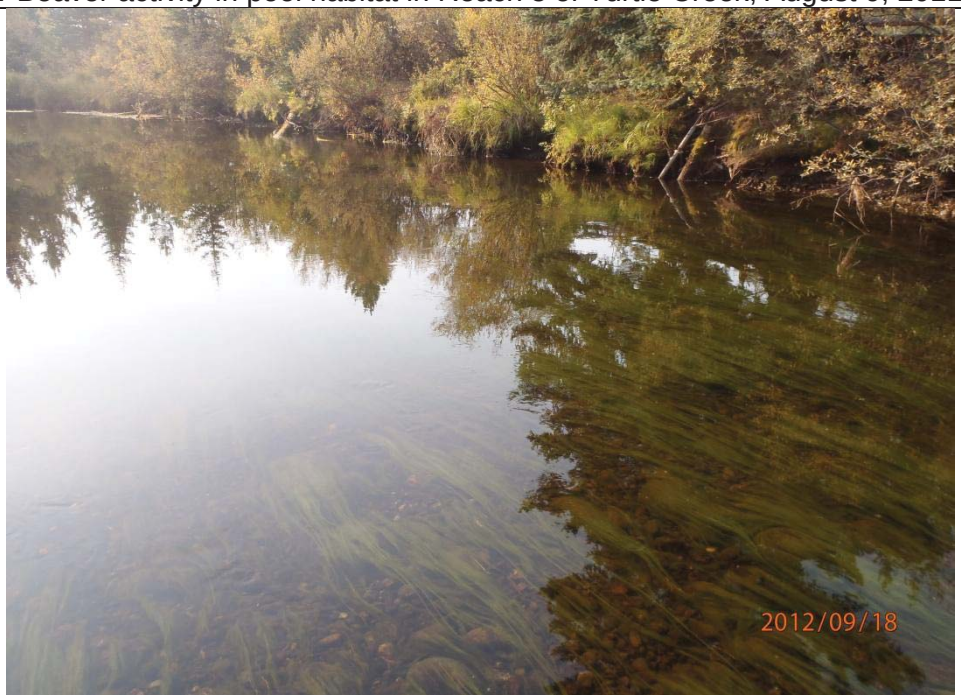


Photo 98: Glide habitat with gravel/cobble substrate and algae in Reach 15 of Chedakuz Creek, September 18, 2012



Photo 99: Riffle habitat with gravel/fines substrate in Reach 15 of Chedakuz Creek, September 18, 2012



Photo 100: Submergent Weeds near Chedakuz Creek in Northwestern End of Tatelkuz Lake, July 2013



Photo 101: Glide Habitat, Reach 4 of Creek 705, 21 August 2013



Photo 102: Reach 4 of Creek 705, August 21, 2013



Photo 103: Riffle in Reach 5 of Creek 705, 23 August 2013



Photo 104: Reach 5 of Creek 705, 23 August 2013



Photo 105: Narrow Braided Riffle, Reach 6 of Creek 705, 23 August 2013



Photo 106: Reach 6 of Creek 705, August 23, 2013



Photo 107: PL-1 , August 17, 2013



Photo 108: PL-1, at road crossing, August 17, 2013



Photo 109: PL-2, at road crossing, August 17, 2013



Photo 110: PL-2, at road crossing, August 17, 2013



Photo 111: PL-3, at road crossing, August 17, 2013



Photo 112: PL-3, at road crossing, August 17, 2013



Photo 113: PL-4, at road crossing, August 18, 2013



Photo 114: PL-4, at road crossing, August 18, 2013



Photo 115: PL-6, at road crossing, August 18, 2013



Photo 116: PL-6, at road crossing, August 18, 2013



Photo 117: PL-8, at road crossing, August 18, 2013



Photo 118: PL-8, at road crossing, August 18, 2013

Annex B

Lake 16 Spawning Habitat and Diversion Routing Assessment

Memo

To	Nigel Fisher, New Gold Inc.	**File No.**	VE52277.7100.02
From	Vincent Harper, Brett McLeod AMEC Environment & Infrastructure	**cc**	Michael McGurk Brad Horne Alvaro Paredes Ryan Todd
Tel	604-294-3811		
Fax			
Date	April 4, 2014		

Subject Rainbow trout spawning habitat requirements and Diversion Channel Alternative Assessment for the Lake 01682LNRS Diversion and Enlargement' concept

1.0 INTRODUCTION

1.1 Background

Rainbow trout (*Oncorhynchus mykiss*) are present throughout the Davidson Creek watershed including the headwater lake (Lake 01682LNRS). Previous baseline studies have documented two separate rainbow trout populations in the Davidson Creek watershed. One population is a lake-resident population that originates from Tatelkuz Lake and uses the lower to mid reaches of Davidson Creek for spawning and juvenile rearing. In the upper watershed, there is a separate lake-resident headwater population in Lake 01682LNRS. A steep cascade feature in Reach 11 of Davidson Creek obstructs upstream fish migration and effectively maintains these two separate populations in the watershed. Juvenile rainbow trout are found in the upper reaches of Davidson Creek and this habitat is important to sustaining this population.

The construction of a saddle dam in Reach 11 of Davidson Creek, approximately 1,000 m downstream of the lake, is required for development of the Site C Tailings Storage Facility (TSF). Construction of the TSF would isolate the headwater lake and result in the loss of stream habitat in the upper reaches of Davidson Creek that helps support this headwater rainbow trout population. Without mitigation, there is considerable risk that the Project could result in the permanent loss of or population declines in the headwater rainbow trout population following the construction of the TSF.

In order to mitigate the loss of potential spawning habitat in Reach 11 of Davidson Creek and the isolation of Lake 16 upstream of the TSF, the Project has proposed diversion of the lake into the Creek 705 Watershed. Further, the Project proposes to enlarge Lake 01682LNRS to provide rainbow trout habitat to offset unavoidable losses that occur at other locations in the Davidson Creek and Creek 661 drainages. In addition, a small pond located to the west of Lake 01682LNRS, which currently flows into the Creek 705 Watershed, will be redirected to flow into Lake 01682LNRS before flowing back into Creek 705 (**Figure 1**). Details of the diversion and enlargement concept are provided in the Fisheries Mitigation and Offsetting Plan (FMOP).

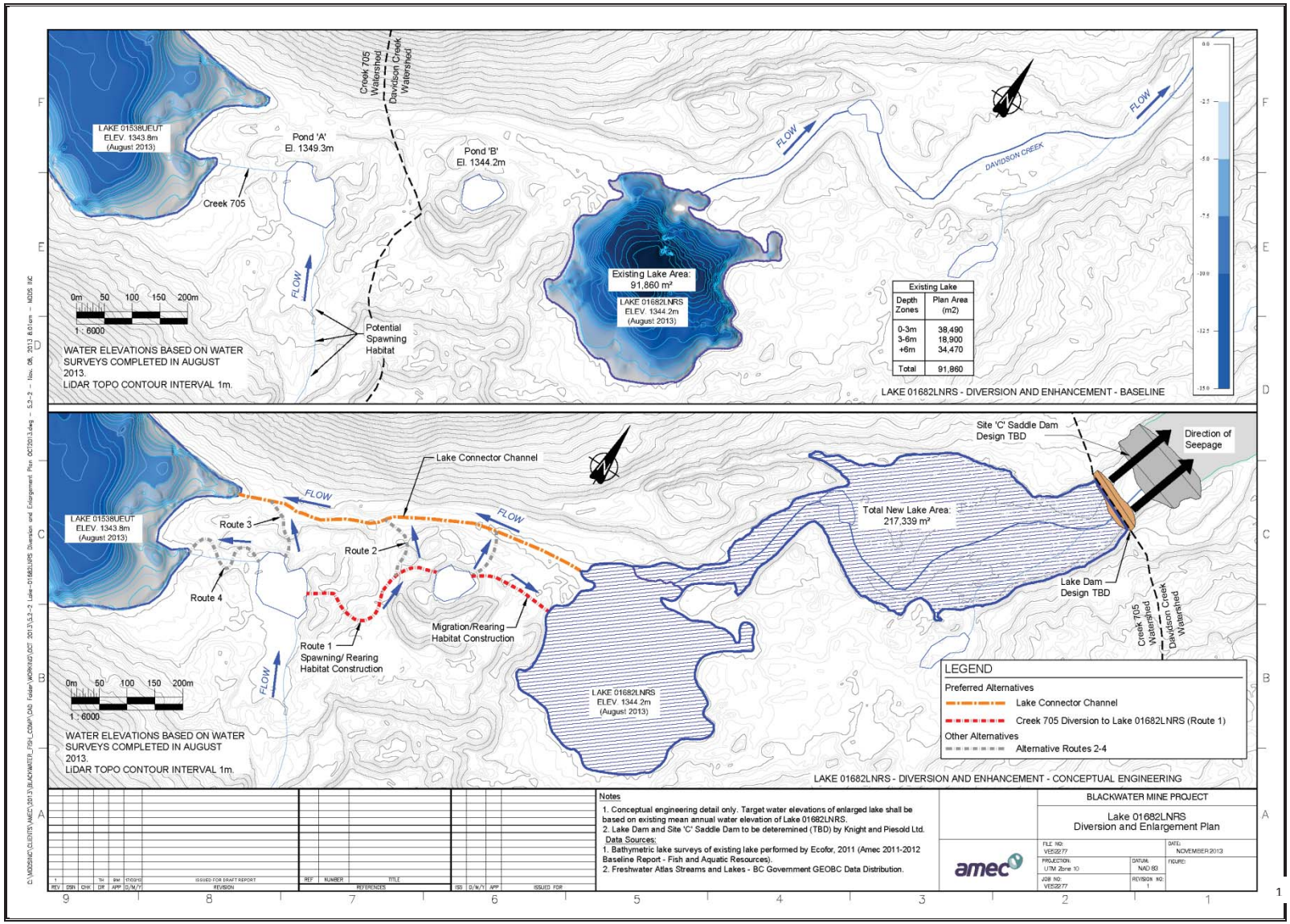


Figure 1: Lake 0162LNRS Diversion and Enlargement Concept

Numerous potential benefits of this lake diversion and enlargement concept exist. First, the lake enlargement component of this concept supports long-term mine water management objectives by avoiding potential effects to the lake from TSF seepage and reducing seepage management infrastructure and costs. Creation of a lake upstream of the TSF will establish a hydraulic gradient to prevent seepage of TSF supernant into Lake 16 (**Section 2.2** of the Application). Second, enlarging the lake would create additional lake habitat to offset unavoidable losses elsewhere on the Project. Third, when designed and built, the new inlet channel would provide new spawning and rearing habitat for fish in Lake 01682LNRS to replace spawning and rearing habitat lost in the natural lake outlet due to flooding, and to support the larger rainbow trout population in the enlarged lake. Finally, the new inlet channel would provide improved access to existing spawning habitat, an area currently being utilized by longnose sucker (*Catostomus catostomus*) accessing the area from Creek 705. It is well documented that rainbow trout and longnose sucker utilize similar types of habitat for spawning purposes. These benefits support the principle objectives of the proposed lake diversion and enlargement concept: to maintain the existing population in the lake, and to create new habitat to offset unavoidable losses elsewhere on the Project.

1.2 Field Study Overview and Objectives

In September 2013, AMEC conducted an assessment of potential rainbow trout spawning habitat in the vicinity of Lake 01682LNRS and Lake 01538UEUT in the headwaters of Davidson Creek and Creek 705, respectively. The main objectives of this assessment were to:

- Identify the location, quantify the spatial extent and collect qualitative physical habitat data on available rainbow trout spawning habitat in the upper Davidson Creek and Creek 705 watersheds;
- Evaluate the distribution, quality and quantity of existing spawning habitat in the upper Davidson Creek watershed that supports the existing headwater population in Lake 01682LNRS;
- Evaluate the distribution, quality and quantity of spawning habitat in Creek 705 above Lake 01538UEUT;
- Determine the quantity of spawning habitat that needs to be created within the Lake 01682LNRS Diversion and Enlargement concept to mitigate potential losses in upper Davidson Creek and to support rainbow trout recruitment in the enlarged headwater lake area.

Information obtained from this survey was used to evaluate how much spawning habitat can and needs to be built into the diversion to offset the habitat lost and to support an increased rainbow trout population in the larger lake. This included an analysis of the various alignment options, which could be used to divert the upper Creek 705 watershed from its existing inlet location at Lake 01538UEUT, and the ability of each alignment option to provide spawning and rearing habitat for Lake 01682LNRS fish.

2.0 STUDY METHODS

Rainbow trout spawning surveys were completed by two fisheries biologists from AMEC Environment & Infrastructure from 15 to 17 September 2013. The surveys were conducted by walking Davidson Creek from Lake 01682LNRS down to the impassable cascade at the bottom of Reach 11, and reaches of Creek 705 immediately upstream and downstream of Lake 01538UEUT. Study sections were selected based on baseline information and current knowledge of stream habitat used by fish populations associated with these two headwater lakes. Surveyed reaches included:

- Upper Davidson Creek (Reaches 11 and 12) from the the steep cascade obstruction in Reach 11 upstream to Lake 01682LNRS;
- An unmapped groundwater fed inlet stream and several small seepages on the south side of Lake 01682LNRS (first identified in September 2013);
- Creek 705 from the outlet of Lake 01538UEUT to the confluence of Creek 606013 (Reaches 4, 5 and 6); and,
- Creek 705 upstream of Lake 01538UEUT to the upstream limit of fish distribution (Reaches 8 to 11).

A rapid assessment approach was used to focus field data collection in those areas where potential spawning habitat was present. No investigations were conducted in study sections that contain no potential spawning habitat, such as open water wetlands or ponds with fine bed materials, or stream sections dominated by cobble/boulder substrates.

During the stream walks, potential rainbow trout spawning habitat was identified based on measurements and/or visual observations of the following characteristics:

- Substrate sizes (rainbow trout prefer gravels between 10 -100 mm diameter) and absence of fine substrates (prefer < 5%);
- Gravel permeability;
- Water depths estimated to be between 0.15 m and 2.5 m during the spring spawning period;
- Water velocities estimated to be between 0.5 m/s and 0.9 m/s during the spawning period; and
- Evidence of hyporheic flows (i.e., groundwater upwelling or localized down welling through stream gravels caused by localized channel hydraulics).

Where potential spawning habitat was identified, it was assigned a unique Numerical Identifier Number (NID), a GPS coordinate was taken and spawning area dimensions (length and width) were recorded on a field data sheet. If several small patches of spawning habitat were observed in clusters, a single GPS coordinate and a total area estimate were recorded. Photos were taken to document the range in size and quality of potential spawning habitat within each reach.

Habitat characteristics were recorded for each potential spawning area identified. This included habitat unit type (riffle, glide or pool), bed size classification (% fines, small gravel, large gravel, small cobble, other), water depth (actual and predicted during spawning period), water velocity, gravel permeability (loose, slightly compacted or compacted) and other general observations of characteristics potentially affecting spawning habitat quality (e.g., presence of upwelling or down welling, intra-gravel flows, proximity to structure that creates suitable conditions, and pool tail outs).

An overall spawning habitat quality ranking (high, moderate or low) was then assigned based on the combination of all physical attributes observed during the assessment judgement. For the purposes of this assessment, spawning habitat quality rankings were defined as:

- High – meets all rainbow trout spawning habitat requirements; high potential for spawning habitat use.
- Moderate – gravel present and meets most rainbow trout spawning habitat requirements but missing one or two key attributes; moderate potential for spawning habitat use.
- Low – some gravel present but either in low density, too much silt or cobbles present, or wrong depths and velocities; low potential for spawning habitat use.

3.0 RESULTS

3.1 Distribution of Potential Spawning Habitat

Potential rainbow trout spawning habitat was identified in Reach 11 of Davidson Creek and in one small unmapped inlet stream located on the south side of Lake 01682LNRS (Figure A1 in Attachment A). No spawning habitat was identified in Reach 12 of Davidson Creek due to the lack of suitable spawning gravels. Substrates in this reach were dominated by cobbles and boulders.

Potential rainbow trout spawning habitat was identified in all the surveyed reaches within the upper Creek 705 watershed. Figures A2 and A3 show the distribution of potential rainbow trout spawning habitat identified in Creek 705 below and above Lake 01538UEUT, respectively.

3.2 Quantity and Quality of Potential Spawning Habitat

A summary of potential rainbow trout spawning habitat in the upper Davidson Creek and Creek 705 watersheds is provided in Table 1. Photos showing the range of spawning habitat conditions found within the two watersheds are presented in Attachment B.

3.2.1 Upper Davidson Creek Watershed

A total of 27 m^2 of potential rainbow trout spawning habitat was documented in the upper Davidson Creek watershed (Table 1). Most of the potential spawning habitat (18 m^2 or 67%) was located in the small unmapped inlet stream located on the south side of Lake 01682LNRS. Suitable spawning gravels in this inlet stream were found primarily in the lowermost 80 metres,

immediately upstream of Lake 01682LNRS. At the time of survey, water depths were too low for spawning. However, adequate water depths and velocities to support rainbow trout spawning are expected during the spawning and incubation periods in spring. The remainder of the rainbow trout spawning habitat (9 m^2 or 33%) in the Upper Davidson Creek watershed was found in seven small isolated pockets throughout Reach 11 of Davidson Creek (Figure A1).

No rainbow trout spawning habitat was observed in Reach 12, the outlet channel immediately downstream of Lake 01682LNRS. This was because substrates in this reach are dominated by cobbles and boulders.

All potential rainbow trout spawning habitat identified above and below Lake 01682LNRS in the upper Davidson Creek watershed was ranked as low quality. The habitat in the inlet channel above Lake 01682LNRS was considered low quality primarily because this section is very shallow and is expected to have high velocities in the spring due to its high gradient. The habitat below the lake in Reach 11 was considered low quality because of the large amount of silt and excessive channel depth expected during the spawning period.

3.2.2 Upper Creek 705 Watershed

In total, there were 292 m^2 of rainbow trout spawning habitat identified in the upper Creek 705 watershed (Table 1). Of this, 55 m^2 (19%) was identified in the surveyed section below Lake 01538UEUT (Reaches 4 to 6) while 232 m^2 (81%) was observed upstream of Lake 01538UEUT in Reaches 10 and 11 (Figure A3).

Potential rainbow trout spawning habitat in Creek 705 below Lake 01538UEUT is predominantly located in Reach 4 (35 m^2) and Reach 5 (17 m^2). Reach 6 contains less potential spawning habitat (3 m^2) due to the fine sediments, lower gradient wetlands and beaver ponds that exist in this reach. All potential spawning habitats in Reaches 4 to 6 of Creek 705 below Lake 0158UEUT was considered low quality because of the amount silt, low gravel densities and the channel being too deep in many places.

Potential rainbow trout spawning habitat in Creek 705 above Lake 01538UEUT was mostly found in Reach 10 (197 m^2 or 67%) with the remainder in Reach 11 (39 m^2 or 13%). In Reach 10, 60 m^2 (30%) was low quality while over half was moderate quality (108 m^2 or 55%). Reach 10 had the only high quality spawning habitat observed during the survey (29 m^2 or 15% of the total in the reach). All spawning habitat in Reach 11 was either low (23 m^2 or 60%) or moderate quality (15m^2 or 40%). Most of the potential spawning habitat in these reaches was moderate to high quality due to appropriate gravel sizes, low amounts of silt and appropriate depths and velocities expected during the spawning period. These reaches drain into a small pond (Reach 9) prior to discharging through a small (<0.30 m wide) inlet channel (Reach 8) to Lake 01538UEUT. There was only 1 m^2 of low quality spawning habitat identified in Reach 8, due to the abundance of moss covered cobbles and the lack of suitable gravels.

Table 1: Summary of Potential Rainbow Trout Spawning Habitat Identified in the Upper Davidson Creek and Creek 705 Watersheds

Watershed	Stream / Waterbody	Reach Number	Reach Length (m)	Total Habitat Area[1] (m^2)	Potential Spawning Habitat (m^2)	Potential Spawning Habitat in Reach (%)	Total Potential Spawning Habitat Within Surveyed Reaches (%)	No. of Spawning Habitat Locations			Total Area (m^2)			Percent by Habitat Quality (%)		
								Low	Mod	High	Low	Mod	High	Low	Mod	High
Creek 705	Creek 705	4[2]	1114	2339	35	2%	12%	16	0	0	35	0	0	100%	0%	0%
	Creek 705	5	890	1246	17	1%	6%	12	0	0	17	0	0	100%	0%	0%
	Creek 705	6	380	1254	3	0%	1%	4	0	0	3	0	0	100%	0%	0%
	Creek 705	8	160	240	1	1%	0%	1	0	0	1	0	0	100%	0%	0%
	Creek 705 (Pond)	9	130	-	-	-	-	-	-	-	-	-	-	-	-	-
	Creek 705	10	380	760	197	26%	67%	13	11	4	60	108	29	30%	55%	15%
	Creek 705	11	1840	3128	39	1%	13%	6	3	0	23	15	0	60%	40%	0%
Total for Creek 705 Watershed			**4894**	**8967**	**292**	**-**	**100%**	**52**	**14**	**4**	**140**	**124**	**29**	**48%**	**42%**	**10%**
Davidson Creek	Davidson Creek	11	850	1456	9	1%	33%	7	0	0	9	0	0	100%	0%	0%
	Davidson Creek	12	980	4244	0	0%	-	-	-	-	-	-	-	-	-	-
	Inlet Stream to Lake 0168LNRS	-[3]	155	N/A	18	N/A	67%	7	0	0	18	0	0	100%	0%	0%
Total for Davidson Creek Watershed			**1985**	-	**27**	-	**100%**	**14**	**0**	**0**	**27**	**0**	**0**	**100%**	**0%**	**0%**

Notes:
[1] Total habitat area estimates calculated from reach length and mean bankfull width from Reconnaissance (1:20,000) Fish and Fish Habitat Inventories completed by AMEC.
[2] The survey included Reach 4 from the confluence with Creek 606613 to the Reach 5 boundary.
[3] Previously unmapped.
N/A = data not available

4.0 DISCUSSION

4.1 Spawning Habitat Offsetting Requirements

Previous fish sampling during baseline studies has shown that juvenile rainbow trout are found throughout Davidson Creek, including in Reaches 11 and 12 above the cascade barrier. Because juvenile fish would not be able to move upstream past the cascade, these fish must be the progeny of fish resident in Lake 01682LNRS and spawning upstream of the barrier. The presence of juvenile rainbow trout in Reaches 11 and 12 indicates that this section of Davidson Creek is being used for spawning, rearing, and migration.

Once the Site C TSF is constructed and Lake 01682LNRS is enlarged, spawning habitat above the barrier will be lost. While small in area, this 9 m^2 of spawning habitat in Reach 11 represents one third of the total potential spawning habitat (27 m^2) available to sustain the current lake-resident population.

To minimize potential effects to the spawning habitat in the inlet stream to Lake 01682LNRS, the lake enlargement design will maintain the baseline range of lake level elevations to the maximum practical extent. The control elevation of the new outlet connector channel will be similar to the natural outlet elevation. This will prevent disturbance to the existing lake shoreline, the function of littoral habitat, and to the 18 m^2 of spawning habitat in the lower sections of the inlet stream. As a result, 9 m^2 of spawning habitat in Reach 11 of Davidson Creek will be inundated and lost due to the enlargement of Lake 01682LNRS.

4.2 Enhancing Productive Capacity

The extent and quality of spawning habitat likely limits rainbow trout productivity in Lake 01682LNRS. The paucity of spawning habitat likely results in density-dependent egg mortality if spawning adults disturb previously established redds. This typically occurs in systems with severely limited spawning habitat. While not the only factor likely to limit fish production in the lake, any additional spawning habitat could alleviate this potential habitat bottleneck and provide offsetting for unavoidable habitat losses elsewhere on the Project.

The lake enlargement concept involves increasing the surface area of Lake 01682LNRS from approximately 9.2 hectares to 21.7 hectares. The new lake will be 2.4 times the size of the existing lake. Assuming that other factors governing annual recruitment, survival and growth (i.e., dissolved oxygen concentrations, predation rates, prey production) remain unchanged following lake enlargement, the larger lake will support and enlarged population of rainbow trout.

Additional spawning habitat will be required to support this enlarged population. It is assumed that an increase in suitable spawning habitat area equivalent to the change in lake area will be required. Therefore, it is estimated that a total of approximately 65 m^2 (i.e., 27 m^2 x 2.4) of spawning habitat will be required. Given that 18 m^2 of potential spawning habitat in the inlet stream to Lake 01682LNRS will remain unaffected, an additional 47 m^2 of new spawning

habitat would be required to maintain the current level of annual recruitment for rainbow trout in the enlarged lake.

To increase the productive capacity of the larger lake, the lake enlargement design will add habitat complexity to the newly flooded area to increase primary productivity, food production, and habitat requisites. The purpose of adding habitat complexity will be to increase rainbow trout productivity in the new lake area. Natural features common to Lake 01682LNRS in its current state and in other headwater lakes in the local study area will be replicated in the newly created portion of the enlarged lake. This will include the creation of littoral habitats by adding appropriate substrates and planting of emergent and submergent vegetation, the addition of physical habitat features such as large woody debris and boulder fields and planting of riparian shrubs and upland vegetation species (**Figure 2**).

4.3 Lake Connector Channel

A 645 m long lake connector channel will be constructed between Lakes 01682LNRS and 01538UEUT (**Figure 3**). The elevation difference between the two lakes is here is 0.4 m, meaning that the average channel gradient will be about 0.1 %. This gradient is insufficient to develop any spawning habitat between the two lakes.

The lake diversion and enlargement concept will also divert flows from Creek 705 upstream of Lake 01538UEUT into Lake 01682LNRS. The purpose of diverting upper Creek 705 into Lake 01682LNRS is to provide a new inlet stream for Lake 01682LNRS. New spawning habitat will be created in the diversion channel and access to existing spawning habitat in Reaches 10 and 11 of Creek 705 will be improved.

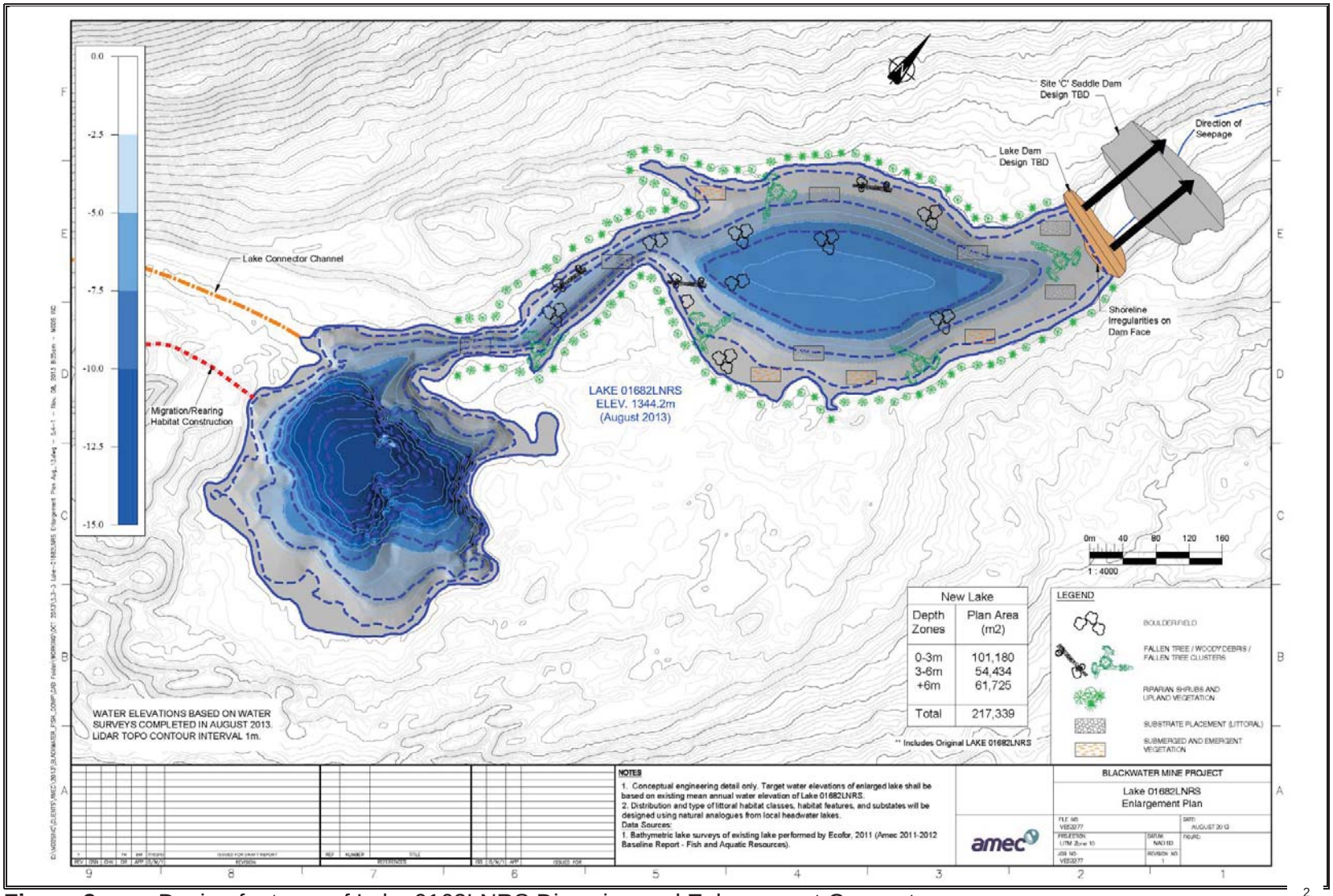


Figure 2: Design features of Lake 0162LNRS Diversion and Enlargement Concept

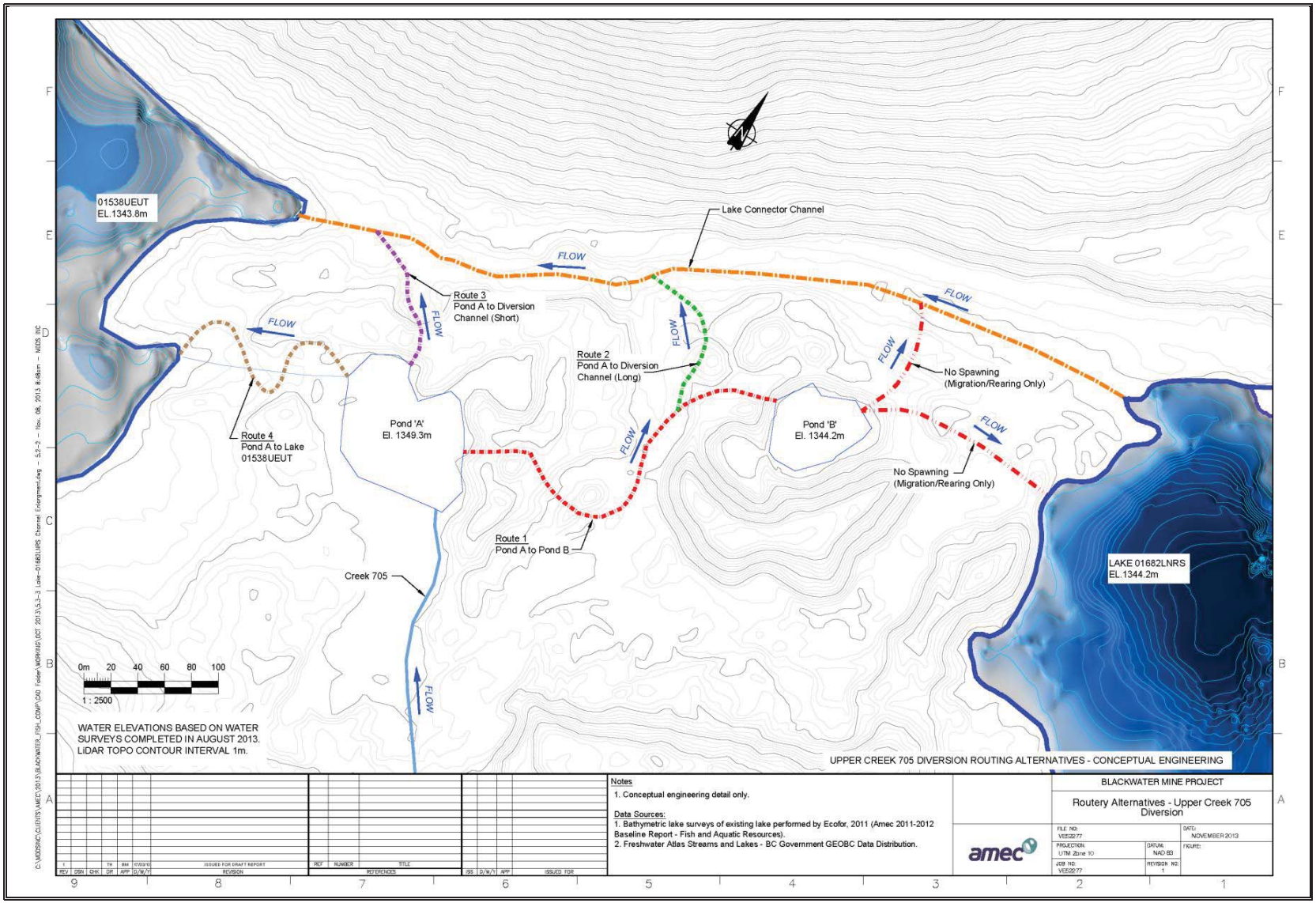


Figure 3: Diversion Channel Routing Alternatives

4.4 Spawning/Diversion Channel Routing Evaluation

Several alternatives for the diversion of Creek 705 headwater tributaries upstream of Lake 01538UEUT were evaluated to determine the best possible channel that could be built to provide additional spawning habitat for rainbow trout in the enlarged Lake 01692LNRS. This evaluation included assessment of the hydrologic and geo-technical aspects as well as evaluation of the quantity and quality of spawning and rearing habitat that each alternative could provide to rainbow trout in the enlarged lake. All alternatives were located downstream of Pond A (Reach 9) and involve the creation of new stream channel habitat. Four alternative diversions were evaluated (Figure 3):

1. A channel connecting Pond "A" in the Lake 01538UEUT watershed to Pond "B" in the Lake 01682LNRS watershed (Route 1);

2. A channel connecting Pond "A" in the Lake 01538UEUT watershed to the middle of the diversion channel connecting Lake 01682LNRS to Lake 01538UEUT (Route 2);

3. A channel connecting Pond "A" to the lower end of the diversion channel connecting Lake 01682LNRS to Lake 01538UEUT (Route 3); and

4. A modification of the existing outlet of Pond "A" to Lake 01538UEUT (Route 4).

Route 1 would connect Pond A (Reach 9) to Pond B by means of new ~1.3 m wide channel. This channel would be approximately 310 m in length, have an average gradient of 1.65% and have a total habitat area of 403 m2 (Table 2). Assuming a conservative estimate of 15% of the total area channel area could be designed for rainbow trout spawning, 60 m2 of spawning habitat could be created within this section of new channel. Assuming 25% of the total area could be spawning habitat, 101 m2 of spawning habitat could be created.

Route 1 would include the construction of a second channel to connect Pond B with Lake 01682LNRS. However, due to the low gradient (<1%), no additional spawning habitat could be constructed in this channel.

Route 2 would connect Pond A to the connector channel connecting Lake 01629LNRS to Lake 01538UEUT. Route 2 would require a 350 m long channel that has an average gradient of 1.51% and a total area of 455 m^2. If the conservative estimate of 15% of the total area could be used to construct spawning habitat, 68 m^2 of spawning habitat could be created in Route 2 (Table 2). If using 25% of the total area, 114 m^2 of spawning habitat could be created.

Although there is slightly less potential spawning habitat that could be created in Route 1 compared to Route 2, Route 1 is preferred channel over Route 2 because it connects directly with Lake 01682LNRS. This direct connection increases the likelihood of fish in both Lakes 01682LNRS and 01538UEUT finding and accessing this new channel. This is because it will require fish to continually move upstream into the new channel, something rainbow trout, like most fish, prefer to do during spawning migrations. If there is no direct connection to Lake

01682LNRS, then the rainbow trout in this lake would first have to move downstream of the lake to locate the new diversion channel and associated spawning and rearing habitat.

Similar to Route 2, Route 3 would connect Pond A to connector channel between the two lakes. This would result in a shorter diversion channel (110 m) than the Route 2 alternative (350 m). The gradient of this channel would be higher (~5%) than any of the other route alternatives (Table 2). If the conservative estimate of 15% of the total area could be used to construct spawning habitat, 21 m^2 of spawning habitat could be created in Route 3. If using 25% of the total area, 36 m^2 of spawning habitat could be created.

Route 4 would require creating a more meandering channel between Pond A and Lake 01538UEUT. This channel would likely be 220 m long and would have a gradient of ~2.5%. If the conservative estimate of 15% of the total area could be used to construct spawning habitat, 43 m^2 of spawning habitat could be created in Route 4. If using 25% of the total area, 72 m^2 of spawning habitat could be created.

Route 1 is preferred to Route 3 and Route 4. This is because the quantity of spawning habitat that can likely be created in Route 3 and Route is lower in comparison to Route 1. In addition, the gradients of Routes 3 and 4 are higher than what would be preferred by rainbow trout for spawning, making the likelihood of creating a channel with suitable depth and water velocities for rainbow trout spawning less likely than in Route 1 or Route 2. Similar to Route 2, these two alternatives would also make it more difficult for rainbow trout from Lake 01682LNRS to find and utilize the new channel; Route 3 would require fish in Lake 01682LNRS to move to the downstream end of the connector channel to find the outlet to the spawning channel while Route 4 would require fish in Lake 01682LNRS to move all the way downstream into Lake 01538UEUT.

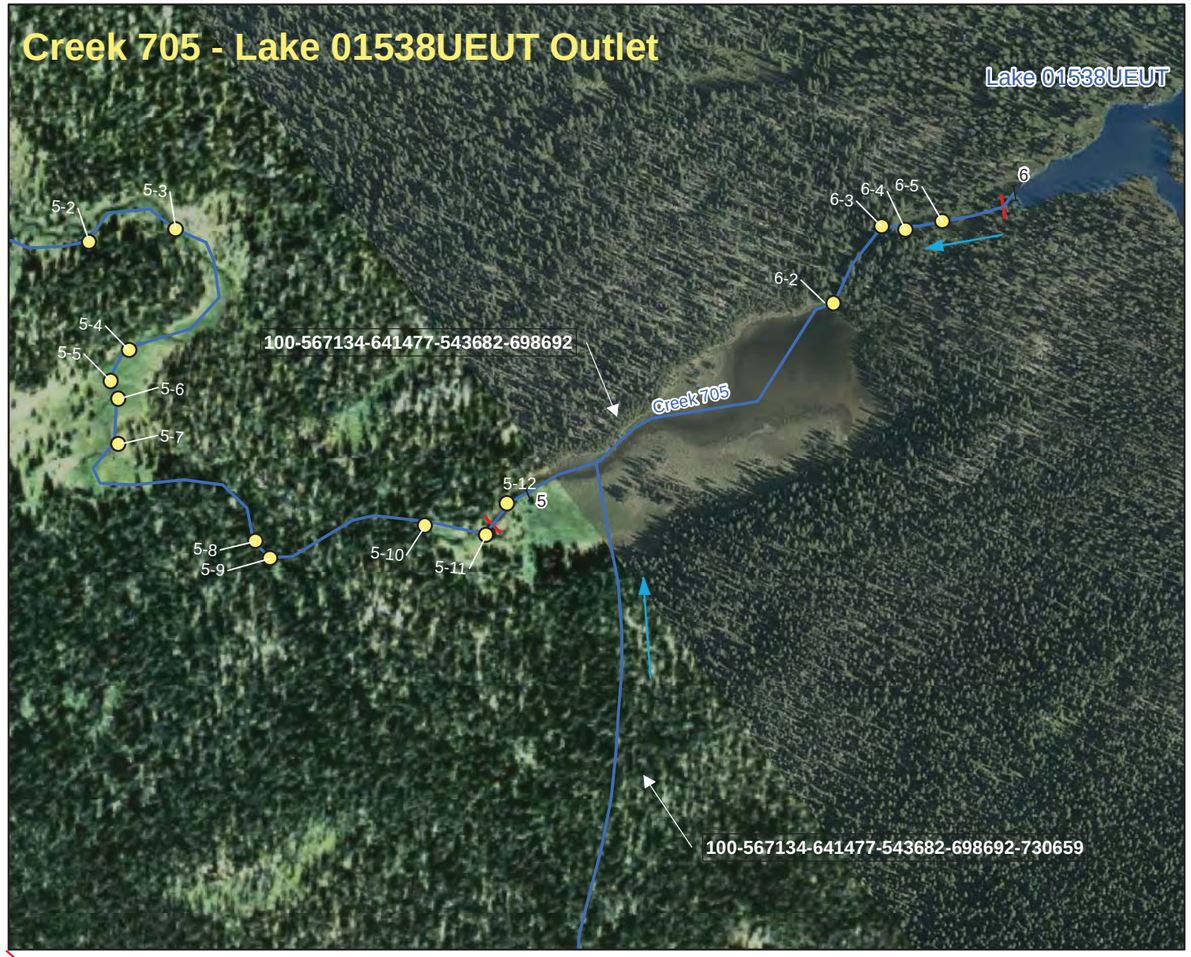
Table 2: Summary of Spawning Habitat Created by the Proposed Alternatives

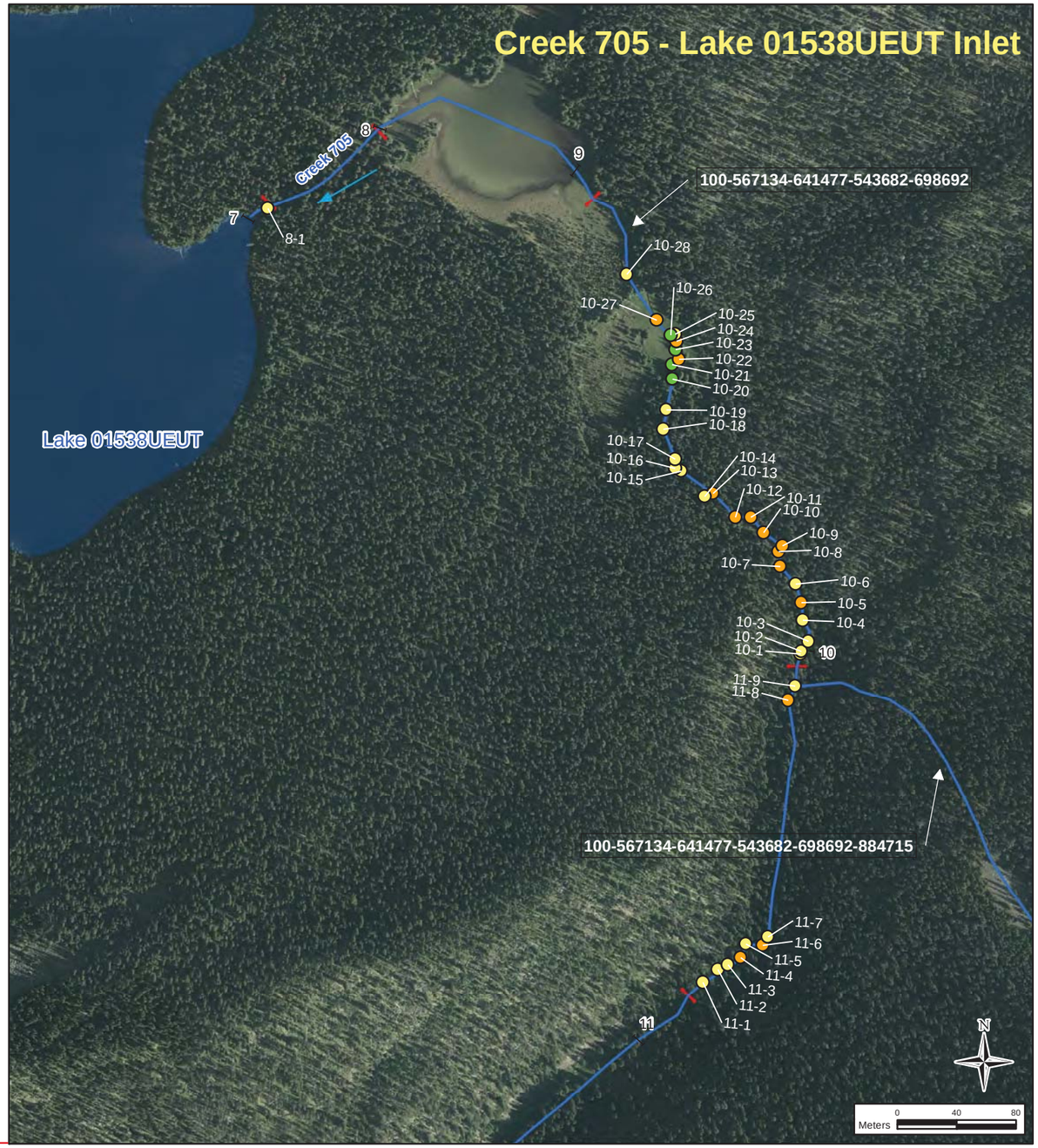
Route No.	Description	Assumed Channel Length (m)	Assumed Channel Width (m)	Average gradient in new channel (%)	Assumed Total Habitat Area (m^2)	Range of Potential Spawning Area (m^2)	
						15%	25%
1	Pond A to Pond B	310	1.3	1.65%	403	60	101
2	Pond A to Diversion Channel - Long	350	1.3	1.51%	455	68	114
3	Pond A to Diversion Channel - Short	110	1.3	4.96%	143	21	36
4	Pond A - Lake 15	220	1.3	2.48%	286	43	72

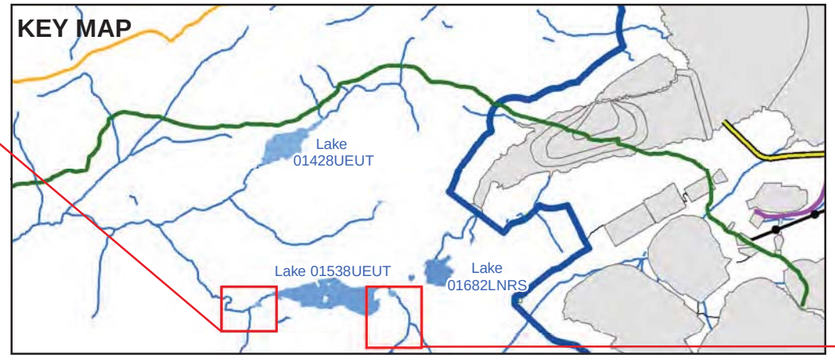
Where possible, the diversion channel along Route should be constructed as a low gradient, riffle-pool type channel. Riffles and runs should include appropriately size gravels for spawning. This is most similar to ideal habitat for rainbow trout spawning. Importantly, the channel along Route 1 should include other habitat features that will increase its suitability for rainbow trout spawning and juvenile rearing. These features include pools immediately downstream of riffles and runs, pools with cover from large woody debris, undercut banks, and boulders, and a meandering flow pattern. These features should be incorporated into the final design of the diversion channel.

Attachment A

Figures A1 to A3







REFERENCE:
Stream data edited from Freshwater Atlas (BC Government GeoBC Data Distribution) using survey data collected Sept. 13-16, 2013

Orthophoto Date: 2011

Legend

- Stream Direction
- Streams
- Reach Break
- Survey Start/End

Spawning Habitat Quality

- High
- Moderate
- Low

Freshwater Atlas Code

CLIENT: newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

ANALYST:	KA
QA:	MY
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:3,500

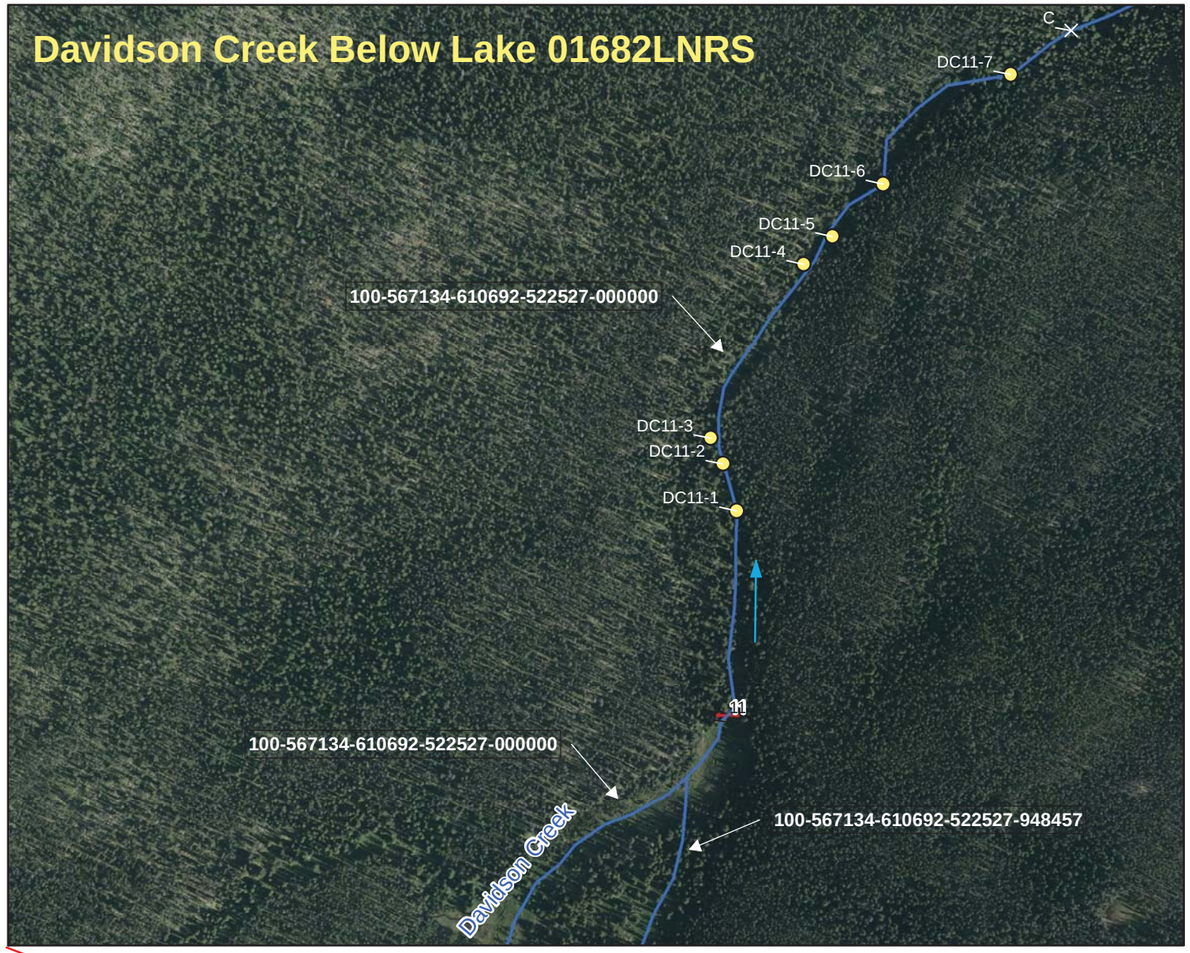
PROJECT: Blackwater Gold Project

TITLE: **Potential Rainbow Trout Spawning Habitat Creek 705 and Lake 01538UEUT Area**

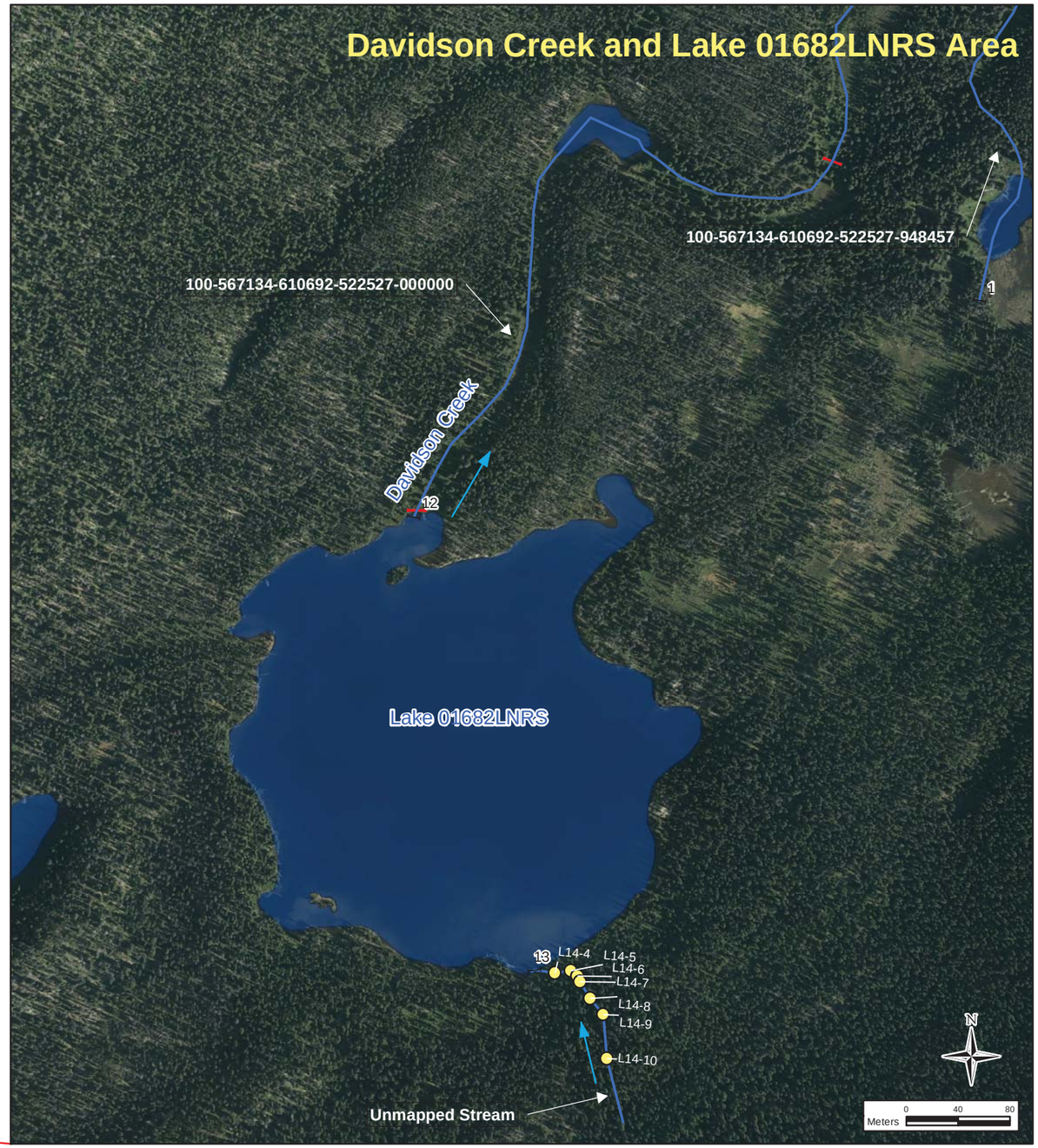
REV. NO:	A
DATE:	October, 2013
PROJECT NO:	VE52277
FIGURE NO:	A3

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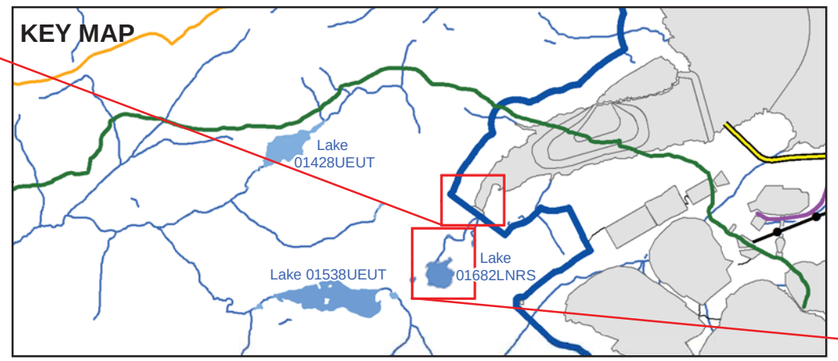
Davidson Creek Below Lake 01682LNRS



Davidson Creek and Lake 01682LNRS Area



KEY MAP



REFERENCE:
Stream data edited from Freshwater Atlas (BC Government GeoBC Data Distribution) using survey data collected Sept. 13-16, 2013

Orthophoto Date: 2011

Legend

- Stream Direction
- Streams
- Reach Break
- Survey Start/End
- C Obstruction (Cascade)

Spawning Habitat Quality

- High
- Moderate
- Low

Freshwater Atlas Code

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:	KA
QA:	MY
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:4,000

PROJECT: Blackwater Gold Project

TITLE: **Potential Rainbow Trout Spawning Habitat Davidson Creek and Lake 01682LNRS Area**

REV. NO:	A
DATE:	October, 2013
PROJECT NO:	VE52277
FIGURE NO:	A1

Y:\GIS\Projects\VE\VE52095_Richfield_Blackwater\Mapping\10_fisheries-aquatics\EIA\10-100-155_RBSpawning_L01682LNRS_v3.mxd

Creek 705 - Lake 01538UEUT

Meters 0 40 80

N

Creek 705

100-567134-641477-543682-698692-606013

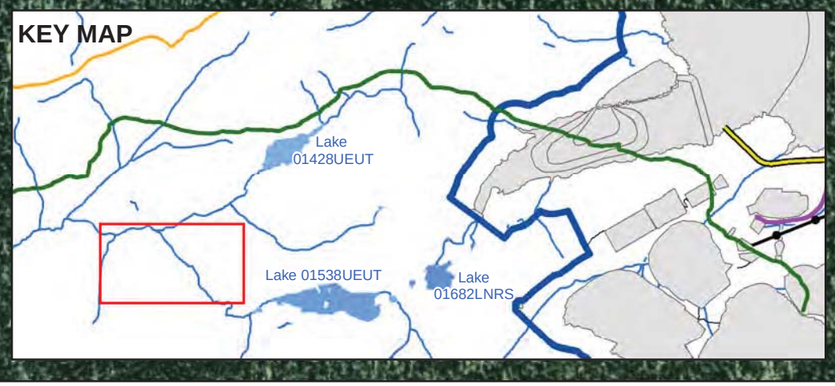
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4-24
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5-1

KEY MAP



REFERENCE:
Stream data edited from Freshwater Atlas (BC Government GeoBC Data Distribution) using survey data collected Sept. 13-16, 2013

Orthophoto Date: 2011

Legend

- Stream Direction
- Streams
- Reach Break
- Survey Start/End

Spawning Habitat Quality

- High
- Moderate
- Low

Freshwater Atlas Code

CLIENT: newgold

AMEC Environment and Infrastructure
4445 Lougheed Highway, Suite 600, Burnaby, B.C. V5C 0E4
Tel. 604-294-3811 Fax 604-294-4664

ANALYST:	KA
QA:	MY
DATUM:	NAD83
PROJECTION:	UTM Zone 10
SCALE:	1:4,500

PROJECT: Blackwater Gold Project

TITLE: **Potential Rainbow Trout Spawning Habitat Creek 705 Below Lake 01538UEUT**

REV. NO:	A
DATE:	October, 2013
PROJECT NO:	VE52277
FIGURE NO:	A2

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Attachment B

Photo Documentation



Photo 1: Typical section of Reach 12 of Davidson Creek showing dominant substrate types (boulders and fines); no rainbow trout spawning habitat observed in this reach (September, 2013).



Photo 2: Example of low quality spawning habitat in Reach 11 of Davidson Creek (NID DC11-005) showing patch of angular rocks and silt deposits (September, 2013).



Photo 3: **Example of low quality rainbow trout spawning habitat in inlet creek (Reach 14) to Lake 01682LNRS of Davidson Creek (NID L16-007); note shallow flows along right undercut bank (left side of photo) at time of survey (September, 2013).**



Photo 4: **Example of moderate quality rainbow trout spawning habitat in Reach 10 of Creek 705 (NID 10-010) upstream of Lake 01538UEUT (September, 2013).**



Photo 5: Example of high quality rainbow trout spawning habitat in Reach 10 of Creek 705 (NID 10-026) upstream of Lake 01538UEUT (September, 2013).

Annex C
Habitat Suitability Index

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ACRONYMS

Abbreviations and Units of Measure	Definition
CPUE	Catch per Unit Effort
FMOP	Fisheries Mitigation and Offsetting Plan
HEP	Habitat Evaluation Procedures
HSI	Habitat Suitability Index
HU	Habitat Unit
LWD	Large Woody Debris,
NCD	Non-classified Drainage
NFC	No Fish Captured
NVC	No Visible Channel

EXECUTIVE SUMMARY

The proposed Project will affect fish and fish habitat, and will require a mitigation and offsetting plan consistent with the requirements of the *Fisheries Act*. The two species most directly affected, and targeted by mitigation and offsetting projects, are rainbow trout (*Oncorhynchus mykiss*) and kokanee (*Oncorhynchus nerka*). Determination of the extent and magnitude of potential effects on these species, both potential adverse Project effects and mitigation and offsetting benefits, requires an approach to quantify habitat within the Project area.

Two metrics were used to quantify the residual serious harm to fish, and the anticipated benefit of mitigation and offsetting projects: the simple extent of habitat affected (m^2) and a metric which integrates both habitat quality and quantity. This metric, the habitat unit (HU), is based on the Habitat Evaluation Procedures (HEP) (US FWS, 1981a) and is the product of habitat area and a relative index of habitat quality. This habitat suitability index (HSI) is a relative index between zero and one, with zero representing habitat of no value, and one representing habitat of optimum value. Separate HSI models are required for each species and life stage considered.

This annex summarises the development of HSI models that reflect the relative quality of different habitat types for each life stage of rainbow trout and kokanee that use Project area streams. A separate HSI was developed to represent the food and nutrient contributions of stream and lake habitat to aquatic productivity. This food and nutrient production HSI integrates aquatic inputs from within the littoral zone or stream channel and terrestrial inputs from the surrounding riparian zones. In streams, these inputs support fish production at and downstream of the habitat receiving the food and nutrients. In lakes, these inputs contribute to fish production in the entire lake ecosystem.

HSIs for each rainbow trout and kokanee life stage were applied only to fish-bearing reaches in potentially affected streams. The HSI for food and nutrient production was applied to all stream reaches because all reaches contribute to downstream productivity.

Published literature and Project data from baseline field programs were used to summarise the life history requirements and habitat selection information that is required to develop HSI models. This information was used to define habitat categories appropriate to the Project site and to assign habitat suitability ratings to each habitat category for each rainbow trout and kokanee life stage (e.g., spawning, rearing). It was also used to rationalize the contribution of instream and riparian habitats to food and nutrient production for different habitat types.

The application of these models to quantify potential habitat effects and habitat benefits is described in the FMOP (**Appendix 5.1.2.6C** to the EA). The approach to HSI development, and to the quantification of potential habitat effects, is considered to be comprehensive and conservative. All habitats are quantified, and a relative habitat value assigned to each category for each life stage of rainbow trout and kokanee that may be present. The contribution of adjacent aquatic and terrestrial habitats, including the riparian zone, is considered, both in the inherent quality of each fish habitat and with respect to the food and nutrient contribution of every stream and lake section to the adjacent or downstream habitats.

1 INTRODUCTION

Construction and operation of the Blackwater Project (the Project) will result in effects to rainbow trout and kokanee habitat in Davidson Creek and Creek 661 due to direct habitat losses under mine infrastructure and to indirect losses or alterations of habitat upstream and downstream of mine infrastructure. The two species most directly affected by the Project are rainbow trout and kokanee, and these two species are therefore targeted by proposed mitigation and offsetting projects. Two metrics were used to quantify the potential residual serious harm to fish and the anticipated benefit of mitigation and offsetting projects: the simple areal extent of habitat affected (m^2) and Habitat Units (HUs). A HU is a dimensionless metric based on the Habitat Evaluation Procedures (HEP) (US FWS, 1981a) that integrates habitat quality and quantity. A HU is calculated as the product of habitat quantity (in m^2) and an index of habitat quality. The index of habitat quality is known as the habitat suitability index (HSI) and is expressed in relative terms as an index between zero and one, with zero representing habitat of no value, and one representing habitat of optimum value.

To support the analysis of areas affected by Project activities, including both potential adverse effects and offsetting benefits, HSI models were developed to reflect the quality of different habitat types for each life stage of rainbow trout and kokanee that may use these areas. A separate HSI was developed to represent the food and nutrient contributions of each stream reach and lake section to aquatic productivity. This HSI integrates inputs to from instream sources and from the surrounding riparian zone. Particularly in streams, these inputs support fish production within and downstream of the reaches that receive food and nutrients as water flows downstream. Therefore, although HSIs for each life stage of rainbow trout and kokanee were applied to fish bearing reaches only, the HSI for food and nutrient production was also applied to non-fish-bearing reaches as all contribute to downstream productivity.

This annex summarises the life history requirements and habitat selection for each life stage of rainbow trout and kokanee present in Project area streams. It also summarizes the contribution of instream and riparian habitats to food and nutrient production. The summary is based on the published literature and on Project-specific data from baseline field programs. Fish and fish habitat information obtained from these sources was used to:

- Define habitat categories appropriate to the Project site, as described in **Section 6** of the FMOP;
- Assign habitat suitability ratings to each habitat category for each life stage of rainbow trout and kokanee potentially affected by the Project; and
- Assign habitat suitability ratings to each habitat category for food and nutrient production, including inputs from riparian and instream habitats.

2 METHODS

The HSI models for rainbow trout and kokanee were developed in accordance with published standards and guidelines for developing HSI models (USFWS, 1981b; Terrell et. al., 1982). Model development incorporated information on life history requirements for rainbow trout and kokanee obtained from the published literature (Hynes, 1970; Crouse et al., 1981; Raleigh et al., 1984; Ford et al., 1995; Cunjak, 1996; Porter and Rosenfeld, 1999; Muhlfeld et al., 2001; Bradford and Higgins, 2001; Roberge et al., 2002; McPhail, 2007) and from fish and aquatic resource baseline field programs completed in the Project area in 2011 and 2012 (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**).

Information from baseline field programs was incorporated to consider site-specific habitat selection and potential deviations from habitat use reported in published literature for the different life stages of rainbow trout and kokanee. Fish and fish habitat information from baseline field programs in the Davidson Creek and Creek 661 watersheds considered in the development of these HSI models included:

- Distribution of rainbow trout and kokanee and their different life stages;
- Meso-habitat (i.e., riffle, pool, and glides) distribution and their site-specific physical characteristics;
- Fish habitat use, habitat quality and habitat distribution data for Project area streams.

Habitat variables contained within a rainbow trout HSI model developed by the US Fish and Wildlife Service (USFWS) (Raleigh et al., 1984) were considered and incorporated into model development, where appropriate. All life stages of rainbow trout present in streams and lakes in the Davidson Creek and Creek 661 watersheds were considered within the HSI model.

No HSI model has been published for kokanee or sockeye salmon. Therefore, model development was dependent on literature describing life history and habitat requirements for kokanee, and on site-specific data. Lower Davidson Creek and Creek 661 are used by kokanee for spawning and egg incubation only. Therefore, no other kokanee life stages were required for the stream HSI model.

A site-specific food and nutrient production HSI model was developed to address the combined contributions of water, nutrients, and benthic invertebrate drift from upstream reaches and organic litter, woody debris, and terrestrial invertebrates from surrounding riparian vegetation.

3 LIFE HISTORY REQUIREMENTS AND HABITAT SELECTION

Life history requirements and habitat selection by rainbow trout and kokanee reported in published literature was the primary source of information used to develop the HSI models. This section summarizes information compiled from the published literature for all rainbow trout and kokanee life stages potentially affected by the Project.

3.1 Rainbow Trout

Rainbow trout have several different life history strategies, with considerable variation depending on geographical location and habitat (Fort et al., 1995). Besides the anadromous steelhead form, the main freshwater life history strategies for rainbow trout include:

- Populations that live their entire life in small streams (i.e., stream-resident);
- Populations that spawn in small streams and migrate to larger rivers to rear and mature (i.e., adfluvial); and,
- Populations that spawn in small streams and move into lakes to rear and mature (i.e., potamodromous).

Riverine rainbow trout prefer clear, cold, silt free, well-oxygenated streams with stable flow and an approximately 1:1 pool-to-riffle ratio (Raleigh et al., 1984). Watersheds with large groundwater inputs (i.e., base flow >50% of average annual daily flow) generally provide higher quality rainbow trout habitat than watersheds with low groundwater inputs (Raleigh et al., 1984). Groundwater moderates water temperatures and provides the baseflow needed in summer and winter to maintain the hydraulic conditions, habitat, invertebrate drift, and dissolved oxygen concentrations needed by rainbow trout to maximize growth and survival.

Optimal habitat for lake-resident rainbow trout consists of oligotrophic lakes that contain inlet and outlet streams with suitable spawning gravels (Ford et al., 1995; Raleigh et al., 1984). However, rainbow trout populations have been documented in mesotrophic and eutrophic lakes. Key limiting factors in lake populations include low dissolved oxygen concentrations in winter, summer temperatures greater than 20 to 25ºC with inadequate dissolved oxygen concentrations, competition from other species, and lack of spawning and rearing streams.

3.1.1 Spawning / Egg Incubation

Rainbow trout spawn in streams during spring at water temperatures between 8ºC and 15ºC (McPhail, 2007) with migrations at or just before ice-out in late April to May. Pre-spawning movements are typically triggered by rising water temperatures (>5ºC) and rising water levels (McPhail, 2007). Preferred spawning sites are most often in areas with sub-gravel flow (i.e., tailouts of pools, immediately upstream of riffles, or sites with groundwater upwellings).

Information on rainbow trout spawning habitat indicates that water velocities between 0.30 m/s and 0.90 m/s and depths between 0.15 m and 2.5 m are suitable (McPhail, 2007). Optimal substrate sizes for spawning and egg incubation are between 4 to 100 mm with less than 5% fines (Ford et al., 1995). Optimal water velocities, depths and substrate sizes are dependent on

the size of spawning fish. For example, smaller resident rainbow trout prefer gravel substrates between 15 mm and 60 mm (Raleigh et. al., 1984) while larger lake-dwelling rainbow trout can use a broader range of gravel substrate sizes.

3.1.2 Fry Summer Rearing

Young-of-the-year (fry) rainbow trout emerge from the gravel in summer. Incubation time at optimal temperatures (11ºC) typically ranges between 29 and 49 days (Ford et. al., 1995). Following emergence, rainbow trout fry migrate to rearing areas of streams or lakes. Rearing habitat for rainbow trout fry includes stream margins and small pocket pools, usually in riffles, which they access immediately after swim-up (Ford et al., 1995; McPhail, 2007). Rainbow trout fry prefer shallower water and slower water velocities than juvenile and adult rainbow trout (Raleigh et al., 1984) and show territorial behaviour at swim-up, immediately after the egg sac has been absorbed (McPhail, 2007). Recently emerged fry in streams are typically found in water velocities <0.30 m/s and prefer velocities <0.08 m/s. However, use of habitat with depths <0.20 m and water velocities <0.01 m/s has been documented (Muhlfeld et al., 2001). Cover in the form of aquatic vegetation, debris piles, and interstices of rocks are critical for rainbow trout fry rearing. As they grow, fry move into deeper, faster water where cover is more abundant.

3.1.3 Juvenile Summer Rearing and Adult Summer Foraging

During the summer, stream-dwelling juvenile rainbow trout occupy riffles, runs, and pools but are typically found in shallower and slower water than are adults (McPhail, 2007). This is likely due more to their relegation to less desirable habitat by the aggressive behaviour of adults than to their preference for this shallower, slower habitat. As a result, the habitat they select in the wild is not typically the habitat they prefer. Juveniles have been shown to use run habitat with water depths <0.25 m, cobble/boulder substrates, and average water velocities between 0.20 m/s and 0.40 m/s (Porter and Rosenfeld 1999).

Cover is an important habitat variable for both adult and juvenile rainbow trout. Instream cover such as large woody debris, boulders, undercut banks, and deep pools provide rainbow trout with protection from predators but also refugia from high water velocities (Roberge et al., 2002). Overhanging vegetation provides protection from predators, a source of terrestrial invertebrates for food, and shade for regulation of water temperatures. Overhead vegetation is particularly important for rainbow trout in summer in streams without large groundwater inputs to regulate water temperatures.

Riffles are the primary areas for benthic macro-invertebrate production in streams. Therefore, the position of a pool below a riffle increases the volume of benthic macro-invertebrate drift available to rainbow trout as food. Rainbow trout will defend territories that maximize their ability to acquire benthic macro-invertebrate drift and minimize their energy requirements to maintain their position in the current. Larger adults are better able to defend the best territories than juveniles and when a stream has limited cover or pools, juveniles will often be found near the stream margins or in higher velocity habitats.

In small lakes, adult rainbow trout use all parts of the lake but are typically associated with logs and complex boulder habitats in the littoral zone (McPhail, 2007). The depth distribution of adult

lake rainbow trout is usually a function of dissolved oxygen concentration, temperature and food availability. Adult rainbow trout remain at depths below the 18ºC isotherm and at dissolved oxygen levels >3 mg/L (Raleigh et al., 1984). Optimum oxygen levels appear to be ≥7mg/L at temperatures ≤15ºC and ≥9 mg/L at temperatures >15ºC (Raleigh et. al., 1984).

In lakes, juveniles remain inshore during winter and early spring and, by day, are often associated with cover in the form of cobble/boulder substrates and woody debris. Rainbow trout tend to move offshore in the late spring and summer (McPhail, 2007). Juveniles will abandon cover at night when predation risk is lower and will forage over sand and gravel substrates.

Juvenile and adult diets in lakes consist mostly of large adult insect larvae. However, their diet is influenced by prey abundance and the presence of other competitive fish species. Some populations are primarily planktivorous, while others are mainly benthivores, and some individuals in larger lakes (especially if kokanee are present) become piscivorous (McPhail, 2007).

3.1.4 Overwintering

In small streams, rainbow trout move into primary pools (i.e., pools that span the entire channel width) to overwinter. These pools provide protection from injury caused by ice damage, and allow them to conserve energy (Raleigh et.al., 1984; Cunjak 1996; McPhail, 2007). Ideally, these pools include boulders or large woody debris which provides resting areas and cover for adults. Point sources of groundwater discharge provide microhabitats which serve as winter refugia from instream problems such as ice and variable stream flow (Cunjak, 1996). Deeper waters in beaver ponds and adjacent flooded backwaters can provide the requisite space in the winter to swim and aggregate, even beneath a complete ice cover (Cunjak, 1996).

Juvenile rainbow trout move into similar pools to overwinter but can also be found buried in the substrate (15 to 30 cm deep) (Cunjak, 1996; Bradford and Higgins, 2001) or between rocks under anchor ice (Raleigh et al., 1984). Other forms of winter cover include undercut banks, ice shelves, and macrophyte mats (Cunjak, 1996). Young rainbow trout occupy different habitats in winter than summer, with log jams and rubble important as winter cover.

Fry of stream dwelling populations move into pools in the fall and late winter (Ford et al., 1995) but also use rubble in shallow areas with low velocities along stream margins (Raleigh et al., 1984). Juvenile, adult and fry rainbow trout will also move downstream to larger tributaries or rivers if sufficiently deep pools to avoid anchor ice are unavailable.

Low dissolved oxygen concentrations can be detrimental to the survival of rainbow trout in winter. The lethal level of dissolved oxygen for adult and juvenile rainbow trout is approximately 3 mg/L or less, depending on temperature.

3.2 Kokanee

Kokanee are the ‘non-anadramous’ form of sockeye salmon. For most of the year, kokanee reside in the pelagic or littoral zones of freshwater lakes. Here, all of the juvenile and adult growth occurs while they feed on plankton and small fish. Once reaching maturity, kokanee begin fall spawning migrations to their natal streams or move to lake beaches to spawn in depths

that are less than 10 m (McPhail, 2007). Egg development occurs throughout fall and winter, with emergence and dispersal during the spring.

The only kokanee life stage potentially affected by the Project is spawning and egg incubation. Kokanee spawn in the late summer to fall, usually when water temperatures drop below 12ºC. However, the migration of adults to spawning sites can start as early as July (McPhail, 2007). Spawning occurs in shallow water (<1 m deep) in lake tributary streams dominated by gravels or on lake beaches over gravel and cobble substrates. Preferred spawning sites have subgravel flows in shallow riffles, outlets of lakes, or on beaches of lakes where there is upwelling (McPhail, 2007). Gravel diameters range from about 10 mm to 25 mm and gravel selection is dependent on water velocities and female size. Preferences for water velocities and depths are also variable and range from 0.15 m/s to 0.85 m/s and from 0.06 m to 0.37 m, respectively (McPhail, 2007).

Intragravel flows, substrate composition (size and relative amount of fines), water quality (temperature, pH, dissolved oxygen concentrations, and biological oxygen demand) are considered the primary factors determining successful development of kokanee eggs (Ford et al., 1996). Because of this, areas of upwelling are critical for egg development and are specifically chosen by females when building redds.

Egg incubation occurs over the fall and winter with fry emergence occurring in the early spring. Upon emergence, kokanee fry migrate to their nursery lake, usually at night prior to feeding. If multiple days are required for migrants to reach nursery habitats, shelter under rocks, aquatic vegetation and organic debris is used during the day (McPhail, 2007; Ford et al., 1996).

4 FOOD AND NUTRIENT PRODUCTION

Aquatic production in streams and lakes is driven by autochthonous (i.e., production driven by photosynthetic organisms within the aquatic environment) and allochthonous (i.e., production driven by terrestrial inputs) inputs. Production of photosynthetic organisms in streams (i.e., algae) and lakes (i.e., phytoplankton) is dependent on the dissolved concentrations of carbon, nitrogen, and phosphorus in addition to the intensity and duration of sunlight. In streams, these nutrients are derived from the breakdown of organic matter and the erosion of inorganic soil in the upstream watershed. In lakes, these nutrients are provided by inputs from upstream tributaries, precipitation, and from the decomposition of organic matter in the sediments and recycling of nutrients in the water column.

Allochtonous inputs include leaf litter and woody debris as well as invertebrates that fall into the water. All of these are inputs from the surrounding terrestrial habitats and, in particular, the riparian zones immediately adjacent to the stream or lake. These inputs are either rapidly eaten, as in the case of invertebrates, or gradually broken down into course and fine particulate matter, in the case of leaf litter, that contributes to the nutrients used by algae or is eaten directly by different taxa of benthic invertebrates. This process of decomposition occurs over time, particularly for fallen trees, and as it is transported downstream, particularly for leaf litter.

The food and nutrient HSI is intended to integrate contributions to aquatic productivity autochthonous inputs from within and upstream of a particular habitat and from allochthonous inputs from the riparian zone. Riparian zones are vegetated corridors along the borders of streams, lakes, and wetlands. Therefore, in addition to its contribution of leaf litter and terrestrial invertebrates, riparian vegetation also stabilizes stream banks, provides shade in summer and supplies small and large woody debris used by fish as cover. These functions have high value for fish and fish habitat. Because the HSI models developed for each species and life stage are a relative index, and are intended to integrate all of the factors that contribute to the relative value of each habitat type, HSI values were assigned by considering the direct utility of the habitat to fish and by their relative contribution of food and nutrients provided to fish by the instream and riparian habitat. A conservative approach was taken when applying food and nutrient values to individual habitat types in Project area streams and lakes:

- Food and nutrient values were reflected in the values assigned to the species- and life stage-specific HSIs;
- The food and nutrient production HSIs were applied to every stream and lake habitat type identified, including fish-bearing, assumed fish-bearing, and non-fish-bearing habitats. This was considered conservative because the contributions of upstream, instream and riparian habitat were already been included in the fish species and life stage HSIs. However, it did ensure that the food and nutrient contributions of small, non-fish-bearing tributaries and headwater streams, particularly in the steeper terrain on the slopes of Mount Davidson, which are ephemeral in summer and freeze to the bottom in winter, were accounted for; and
- The food and nutrient HSIs were applied to every reach of every potentially affected stream and lake, including those for which riparian inputs were partially addressed by the fish HSIs.

5 DEFINING POTENTIALLY AFFECTED HABITAT TYPES AND AREAS

A Project-specific habitat classification system was developed to support the application of the HEP approach. This classification system is described in full in **Section 6** of the FMOP. It was based on the meso-habitat types present in the Davidson and Creek 661 Watersheds and on the observed variation in habitat quality and fish habitat use within these types. This classification system was required to assign HSI suitability scores to the wide diversity of stream habitats present under, upstream and downstream of the Project.

Seven habitat types were defined (**Table 5-1**). Stream habitat types included the four commonly used meso-habitat types: cascades, riffles, glides, and pools, as well as a "Tributary" category to define small first-, second-, and third-order tributaries to mainstem creeks. Two additional habitat types were defined to ensure all habitat types present in the Project area where included in the classification system: "Other" and "Lake." The "Other" category included fish habitat provided by open water wetlands, beaver ponds, and off-channel areas not represented by the major stream meso-habitat types. The "Lake" habitat type represented lake environments.

Each of the seven habitat types was sub-divided into classes to represent the range of habitat quality within each type. By doing so, 19 habitat classes were included in the classification system to represent the variety of fluvial and lacustrine habitats within Project area streams and lakes. They also include all habitats that will be protected, created, enhanced, or restored as part of the mitigation and offsetting measures.

Habitat types defined in **Table 5-1** were assigned to each stream reach or area of lake potentially affected by the Project or by mitigation or offsetting proposals. The area of each habitat type and class was calculated in a geographic information system (GIS) using either geo-referenced habitat data collected during baseline surveys, or design attributes of offset habitats to be enhanced or created.

Table 5-1: Habitat Types and Class Definitions

Habitat Type	Class	Definition and Habitat Variables
Cascade	1	Steep, stepped riffles of bedrock or emergent cobbles/boulders, fast-flowing water, turbulent, shallow, gradients >4%
Riffle	1	Turbulent, fast-flowing water, shallow, moderate gradient, spawning gravels extensive, dominant substrate are gravels, low cover and habitat complexity
	2	Turbulent, fast-flowing water, shallow, moderate gradient, pockets of spawning gravels, dominant substrates are cobbles or boulders, moderate cover and habitat complexity
	3	Turbulent, fast-flowing water, shallow, moderate gradient, no spawning gravels, dominate substrates are cobbles or boulders, high cover and habitat complexity
Glide	1	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, spawning gravels extensive, dominant substrates are gravels, low cover and habitat complexity
	2	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, pockets of spawning gravels, dominant substrates are cobbles or boulders, moderate cover and habitat complexity
	3	Fast-flowing, non-turbulent water, pool tailouts, moderately-shallow, no spawning gravels, dominant substrates are cobbles or boulders, high cover and habitat complexity or areas of slow flowing, deep water with fine substrates
Pool	1	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, good pool depth (>0.50 m), abundant cover, high LWD and overhead cover
	2	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, moderate pool depth (0.3 to 0.5 m), moderate cover, moderate LWD and overhead cover
	3	Areas of slower, deeper water, concave bottom profile, deposition of fines, water gradient near 0%, low pool depth (<0.3 m), low cover, low LWD and overhead cover
Other	1	Off-channel habitat, >2 m deep, abundant cover, high LWD and overhead cover abundance, substrates widely variable
	2	Beaver dams, open water wetland complexes, shallow <2 m, low gradient, fine substrates, variable cover
Tributary Streams	1	Second or third-order headwater streams or tributaries with riffle-pool morphology, variable cover, juvenile rearing habitat only
	2	First-order headwater streams or tributaries with riffle-pool morphology, variable cover, juvenile rearing habitat only
	3	First- or second-order headwater streams or tributaries, or small third-order tributaries (lower valley) with large channel morphology, low gradient wetland habitats, intermittent channel features, fine substrates, juvenile rearing habitat only
	4	Ephemeral, headwater or tributary streams, NVC and NCD, non fish-bearing
Lake	1	Shallow littoral habitat, <3 m deep, greatest light penetration, high productivity (benthic and aquatic macrophyte communities), juvenile rearing and adult foraging habitat
	2	Deep littoral habitat, 3 m to 6 m deep, low light penetration, moderate to low productivity, juvenile rearing and adult foraging habitat
	3	Pelagic habitat, deep water habitat >6 m deep, low productivity, juvenile rearing and adult foraging habitat

Note: m = metres, LWD = large woody debris, NVC = no visible channel, NCD = non-classified drainage

6 DEFINING HABITAT SUITABILITY RATINGS

This section outlines habitat suitability ratings used for the assessment of potential residual adverse effects, and potential mitigation and offsetting benefits, and provides the rationale for these assigned ratings based on published literature and habitat selection information from baseline field programs.

Habitat suitability ratings for the different life stages of rainbow trout and kokanee were developed using life history requirements and habitat selection criteria from published literature summarized in Section 2.0. Using data collected during baseline field programs within these watersheds (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**), habitat suitability ratings were modified to reflect site-specific habitat selection in the Davidson Creek and Creek 661 watersheds. Habitat suitability ratings for each life stage of rainbow trout and kokanee present in the study area (**Table 6-1**) were assigned to all habitat categories (**Table 5-1**) developed for the Project.

The habitat suitability ratings assigned to each habitat type are relative, with ideal habitat represented by a score of one, and unsuitable habitat scored as zero. Intermediate habitats were assigned relative value as above average (0.75), average (0.50) or below average (0.25) in quality.

Table 6-1: Habitat Suitability Ratings for Different Life Stages of Rainbow Trout and Kokanee

Fish Species		Rainbow Trout					Kokanee	
Habitat Type	**Class**	**Spawning/ Egg Incubation**	**Fry Summer Rearing**	**Juvenile Summer Rearing**	**Adult Summer Foraging**	**Overwintering**	**Spawning/ Egg Incubation**	**Food & Nutrient Production**
Cascade	3	0.00	0.00	0.00	0.00	0.00	0.00	0.50
Riffle	1	0.50	0.50	0.00	0.00	0.00	0.75	0.75
	2	0.25	0.75	0.25	0.00	0.25	0.50	1.00
	3	0.00	0.50	0.75	0.00	0.25	0.00	1.00
Glide	1	1.00	0.25	0.00	0.00	0.00	1.00	0.50
	2	0.50	0.50	0.25	0.00	0.25	0.50	0.75
	3	0.00	0.25	0.50	0.00	0.25	0.00	0.75
Pool	1	0.00	0.25	1.00	0.00	0.75	0.00	0.25
	2	0.00	0.25	0.75	0.00	0.25	0.00	0.25
	3	0.00	0.25	0.25	0.00	0.00	0.00	0.25
Other	1	0.00	0.25	1.00	0.00	1.00	0.00	0.25
	2	0.00	0.25	0.25	0.00	0.25	0.00	0.25
Tributary Streams	1	0.00	0.00	0.50	0.00	0.00	0.00	0.25
	2	0.00	0.00	0.25	0.00	0.00	0.00	0.25
	3	0.00	0.00	0.25	0.00	0.00	0.00	0.25
	4	0.00	0.00	0.00	0.00	0.00	0.00	0.25
Lake	1	0.00	0.00	0.75	0.50	0.75	0.00	0.75
	2	0.00	0.00	0.75	0.75	1.00	0.00	0.25
	3	0.00	0.00	0.50	0.75	1.00	0.00	0.00

6.1 Stream Models

6.1.1 Spawning and Egg Incubation

Optimal spawning habitat for rainbow trout and kokanee was assigned to Class 1 glides. This is because Class 1 glides contain extensive spawning gravels and typically provide the preferred combination of substrates (gravels), gradient, water depth and water velocity for salmonid spawning and egg incubation; particularly pool-tail out areas. Dense groups of spawning kokanee and tight clusters of redds were observed in Class 1 glides in lower Davidson Creek and in Creek 661 during baseline stream counts (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**). Habitat suitability is lower in Class 2 glides due to differences in gradient, depths, water velocity and in the availability of spawning gravels. Suitable spawning gravels are recruited and maintained under localized hydraulic conditions and limited to isolated pockets only. Class 3 glides are typically steeper in gradient compared to Class 1 and Class 2 glides and unsuitable for spawning since cobbles and/or boulders are dominant substrate types.

Class 1 riffles contain similar substrate characteristics to Class 1 glides and provide above average quality spawning habitat for kokanee. Spawning habitat use by kokanee was observed in Class 1 riffles during baseline stream counts in Davidson Creek and Creek (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**), but fewer fish and fewer redds were observed than in Class 1 glides. Lower depths and velocities are the primary physical characteristics reducing the suitability of riffles compared to glides. The suitability of Class 1 riffles for rainbow trout spawning is lower than for kokanee, because water velocities are higher under spring conditions when rainbow trout spawn. Similar to glide habitats, Class 2 riffle habitats have lower suitability for rainbow trout and kokanee spawning, due to differenced in gradients, water velocities and depths, and availability of suitable spawning gravels. Class 3 riffle habitats are not suitable for rainbow trout or kokanee spawning due to the absence of spawning gravels (**Table 5-1**).

Pools and wetland complexes are generally unsuitable for spawning because water velocities are too low and because substrates typically have >5% fines. Cascades are unsuitable for salmonid spawning due to high water velocities and the lack of suitable substrates. Rainbow trout use of small headwaters or tributary streams is limited to juvenile rearing only; there was no evidence of spawning of fry use during baseline field programs (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**). Rainbow trout do not spawn in lakes. Although kokanee can spawn on appropriate lake beaches (**Section 3.2**), there is no kokanee spawning in the Project area lakes that the HSIs were applied to.

6.1.2 Fry Summer Rearing

Riffles that provide low energy environments along stream margins are the preferred habitat type for rainbow trout fry summer rearing. Above average quality habitats exist in Class 2 riffles which contain a better combination of substrate complexity, pocket pools, velocity breaks, and accessibility from local spawning gravels compared to other riffle classes. Slow moving margin habitat for rainbow trout fry must be accessible immediately after swim-up, and small pocket pools and interstices of rocks are critical (Ford et al., 1995; McPhail, 2007). Glides provide lower quality habitat for rainbow trout fry summer rearing than do riffles, providing average to below average habitat quality depending on margin habitat complexity (**Table 6-1**). As for riffles,

Class 2 glides provide better habitat for rainbow trout fry compared to other glide classes. Pools and 'Other' habitat categories provide lower quality habitat for rainbow trout fry, than do riffles and glides. Reduced suitability in part reflects competition with juvenile fish rather than habitat preference (**Section 3.1**). Cascade and lake habitats do not provide suitable habitat for rainbow trout fry summer rearing. Because there is no rainbow trout spawning in tributary habitat classes, these habitat types do not support rainbow trout fry summer rearing. Juvenile rainbow trout may move upstream into these habitats when they are available (**Section 6.1.3** following).

Meso-habitat use by rainbow trout fry was during baseline field programs in Davidson Creek and Creek 661. Positive habitat selection for riffles by rainbow trout fry was observed in the field, confirming the habitat suitability ratings assigned (**Figure 6-1**).

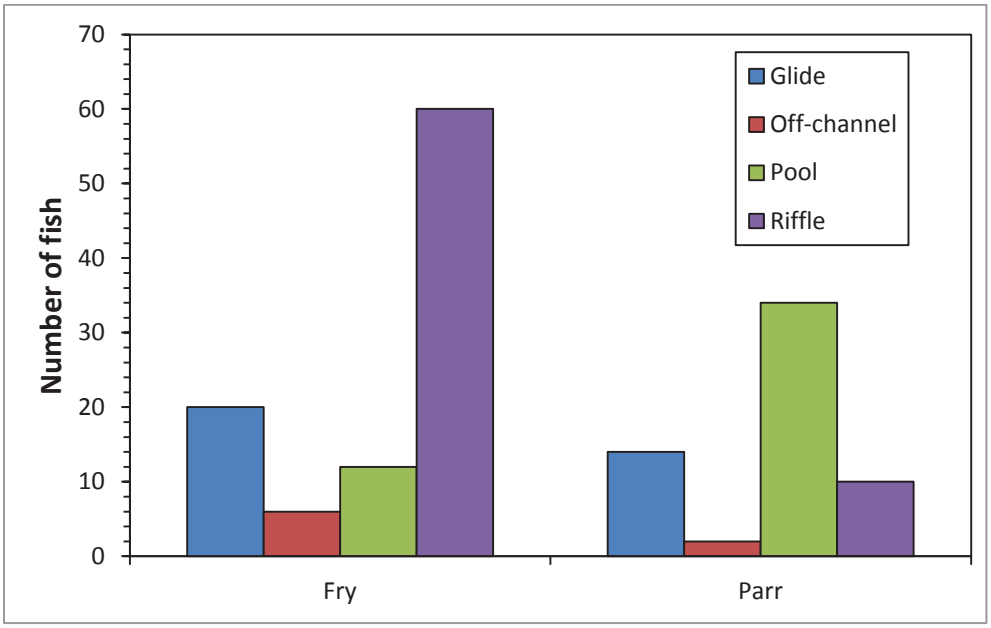


Figure 6-1: Meso-Habitat Selection by Rainbow Trout Fry and Juveniles in Davidson Creek and Creek 661, 2012

Kokanee fry migrate downstream to lake habitats and thus no HSI was developed for kokanee fry use of stream habitats.

6.1.3 Juvenile Summer Rearing

Pool habitats with high cover from deep water, large woody debris and overhanging vegetation provide optimal summer rearing habitat for juvenile rainbow trout. This reflects both the habitat structure inherent in pool habitats, as well as contributions from the riparian zone, in terms of provision of bank stability, woody debris inputs, and terrestrial insect drop. The value of pools for juvenile summer rearing also reflects food inputs from upstream habitats, chiefly in the form of benthic invertebrate drift. Pools provide a refuge from higher velocities in other habitats, and from predators and competitors, that permit juvenile rainbow trout to feed on the stream drift and terrestrial insect drop. Shallower pools (Class 2 and 3) provide lower quality habitat than deeper Class 1 pools (**Table 6-1**). Selection of pool habitats by summer rearing juvenile rainbow trout in

the Davidson Creek and Creek 661 watersheds was demonstrated during baseline field survey programs (**Figure 6-1**). This selection trend is consistent with published literature; particularly in systems where there is not competition with stream-resident adults.

The 'Other' Class 1 category representing deep water (>2 m) off-channel habitats with abundant cover (**Table 5-1**) also provides optimal summer juvenile rearing habitat for juvenile rainbow trout (**Table 6-1**). This habitat class will be created by proposed off-channel pond offsetting projects, where constructed habitat will be similar to deep pools with good cover. Natural habitats of this type were not observed in the field, which provides part of the justification for developing these projects as offsetting alternatives. Shallower habitats (Other Class 2) were present in the Project area, were used by limited numbers of fry and juveniles (**Figure 6-1**) and provide low quality habitat for juvenile summer rearing (**Table 6-1**).

The quality of juvenile rainbow trout summer rearing habitat is lower in riffle and glide habitats compared to pools, and this pattern of use was observed in the field (**Figure 6-1**). Habitat suitability ratings for these habitat categories vary based on substrate complexity (**Table 5-1**) because appropriate substrates provide resting and cover opportunities for fish. Cascade habitat is generally unsuitable for fry and juvenile rainbow trout in summer because water velocities are too high and depths are too shallow.

Juvenile rainbow trout densities in headwater and tributary streams in the Davidson Creek and Creek 661 watersheds was low relative to mainstem habitats. However, summer use by juvenile rearing rainbow trout was documented in these tributary streams (this was the only life stage documented in these streams). Rainbow trout electrofishing catch per unit effort (CPUE) and density both showed decreasing trends with upstream distance from the Davidson Creek and Creek 661 mainstems. For example, in eleven sites sampled in first and second order streams in the Davidson Creek and Creek 661 watersheds (**Table 6-2**), only one juvenile rainbow trout was captured in first order streams (0.09 fish/100 m^2, CPUE = 0.02 fish/100 seconds), and 51 juvenile rainbow trout were captured in second order streams (1.9 fish/100 m^2, CPUE = 0.6 fish/100 seconds). The density and CPUE in these first and second order headwater streams was much lower than in lower reaches of Davidson Creek and Creek 661 (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**). Habitat use in the upper headwater streams is likely limited by stream size, and reflects distance from natal and overwintering habitats.

Table 6-2: Rainbow Trout Captured from Headwater Streams in the Davidson Creek and Creek 661 Watersheds, Summer 2011-2012

Method/Parameter	First Order Streams		Second Order Streams	
Gear Type	Electrofishing	Minnow Traps	Electrofishing	Minnow Traps
Number of Sites	11	7	11	6
Total Sampling Effort[1]	5,527	899	9,298	354
Total Area Sampled (m^2)	1,175	-	2,755	-
Total Fish Captured	1	NFC	51	7
Fish Density (No./100 m^2)	0.09	-	1.9	-
CPUE[2]	0.02	0	0.6	1.9

Note: [1]Electrofishing effort is in seconds; minnow trapping effort is in trap-hours
[2] CPUE for electrofishing is number fish/100 EF seconds; and CPUE for minnow trapping is number fish/100 trap-hour
CPUE - Catch-Per-Unit-Effort; NFC - no fish captures, m^2 - metres squared; number/m^2 - number per metres squared

In addition, the low densities of rainbow trout juveniles (relative to other rainbow trout streams in BC), suggests limited competition in preferred mainstem habitats and therefore limited incentive to move upstream into smaller, lower quality streams.

Amongst headwater and tributary streams, habitat quality (and demonstrated habitat use) is highest for Class 1 'Tributary Streams' compared to other 'Tributary Stream' categories. This category represents small second and third order streams that contain riffle-pool morphologies with relatively good cover. These streams were assigned and average habitat suitability rating (**Table 6-1**). Class 2 and 3 'Tributary Streams' contain extremely limited habitat value, exhibit low use by juvenile fish, and were assigned a below average habitat suitability rating. Class 4 'Tributary Streams' are ephemeral and non fish-bearing reaches in the upper headwaters, provide no value for summer rearing rainbow trout, and were assigned a habitat suitability of zero.

Kokanee fry migrate downstream to lake habitats and thus no HSI was developed for juvenile kokanee use of stream habitats.

6.1.4 Adult Summer Foraging

Stream habitat in the Davidson Creek and Creek 661 watersheds is not used by adult rainbow trout or adult kokanee, except to spawn. No stream-resident rainbow trout population was identified during baseline field programs (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**). Therefore, no habitat suitability rating for adult summer foraging by rainbow trout or kokanee was assigned to stream habitat.

6.1.5 Overwintering

Optimal habitat for juvenile rainbow trout overwintering will be created in off-channel ponds constructed as a component of proposed offset works. These habitats will be designed to provide ideal habitat conditions for juvenile overwintering, including deep water (>2 m) and refugia such as cobble/boulder placements, woody debris and aquatic macrophytes. The relative lack of natural, high quality overwintering habitat for juvenile rainbow trout was identified as a potential habitat bottleneck in Project area streams; this is one of the rationale for proposing creation of such habitats as a component of the offset plan.

Amongst habitats present in Project area streams, deep pools (Class 1) provide above average winter habitat and refugia for juvenile rainbow trout (**Table 6-1**). Habitat quality is lower in shallower Class 2 and 3 pools because these provide limited refugia due to ice cover. Class 2 pools with moderate residual depths (0.30 m to 0.50 m) were rated below average and shallow Class 3 pools (<0.30 m) are unsuitable for overwintering. During most winters, these pools would freeze to bottom, particularly in the upper watershed where thick ice and limited groundwater inputs were observed during winter baseline surveys (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**). Despite freezing conditions, riffles and glides with good substrate complexity can remain ice free under some conditions in some winters. To recognise this, these habitats were rated as below average (not zero) quality for rainbow trout juvenile overwintering (**Table 6-1**). These habitats particularly occur in the lower to mid reaches of Davidson Creek and Creek 661, where groundwater influence may occur. Published literature also indicates that juveniles may move into substrates to overwinter (**Section 3.1.4**).

Kokanee fry migrate downstream to lake habitats and thus no HSI was developed for kokanee overwintering in stream habitats.

6.2 Lake Models

Habitat suitability index models applied to adult and juvenile rainbow trout in headwater lakes in the Davidson Creek and Creek 705 watersheds recognized the importance of littoral and pelagic habitats and seasonal differences in habitat use. Littoral habitats are used by both juvenile and adult trout for foraging and both life stages use cover provided by shoreline habitat structure (i.e., large woody debris, boulders, and/or riparian and aquatic vegetation).

Rainbow trout make daily and seasonal movements between littoral and pelagic habitats in lakes. Daily movements are typically in response to movements of prey and to their different susceptibility to predators between night and day. Seasonal movements are typically in response to water temperature and dissolved oxygen concentrations. In summer, rainbow trout move throughout the lake but will actively select the water depth that maximizes their growth and survival (on a seasonal and daily basis). In winter, trout are less active but must generally avoid deeper areas where dissolved oxygen concentrations fall below 3 mg/L.

Three different classes of lake habitat were defined for headwater lakes in the study area (**Table 5-1**). Habitat suitability ratings were assigned for the three life stages of rainbow trout that occur within these lakes (juvenile summer rearing, adult summer foraging and overwintering).

The highest habitat quality for juvenile summer rearing occurs in stream habitats (preceding sections), but shallow (0 to 3 m) and deep water (3 to 6 m) littoral zones provide an alternative of above average quality (**Table 6-1**). This is because these habitats are associated with cover and feeding opportunities, including inputs from the riparian zone around the margin of the lake. This rating also reflects diurnal movements between these zones to optimize feeding opportunities. Pelagic habitats (>6 m) provide more limited opportunities for juvenile summer rearing.

Pelagic (>6 m) and deep water littoral habitats (3 to 6 m) provide above average habitat conditions for adult foraging. These habitats provide a good combination of deep water habitat, cover and reduced predation risk, while maintaining access to prey. Shallow littoral habitats are of lower quality for foraging adults (**Table 6-1**).

Suitable depth and late winter dissolved oxygen concentrations above the thermoclines provide good overwintering opportunities in the headwater lakes near the Project. Thermoclines during winter in three headwater lakes slightly vary and range between 3 m and 6 m in depth (**Section 5.1.2.6** and **Appendices 5.1.2.6A** and **5.1.2.6B**). Optimal habitat suitability ratings were therefore assigned to pelagic and deep water littoral habitats. Above average quality (**Table 6-1**) exists in shallow littoral habitat, because availability and quality of habitat is reduced by ice formation.

6.3 Food and Nutrient Production

The species- and life stage-specific HSIs integrate all factors hat contribute to the relative quality of a habitat type, including characteristics such as depth, cover, water velocities, substrate suitability, and food availability. These characteristics reflect the physical and biological processes that drive habitat quality, including factors such as location within the watershed,

gradient, sediment supply, upstream habitat characteristics, groundwater supply, and terrestrial inputs. Relative food and nutrient value for each species and life stage is reflected in habitat selection by fish, and is inherent in the HSI models. However, fish HSI models are not applied to stream reaches that do not support fish. These reaches influence downstream fish habitat by exporting food, nutrients and sediment. The food and nutrient HSI specifically addresses the contribution of water, nutrients, riparian inputs and benthic invertebrate drift.

Optimal food and nutrient production (i.e. HSI = 1.0) occurs in stable (i.e., Class 2 and 3) riffles. Aquatic invertebrates are most abundant and diverse in riffle areas with rubble substrate and on submerged aquatic vegetation (Hynes, 1970). Class 2 and 3 riffles are also characterized by medium and high cover, much of which is provided by the riparian zone in the form of canopy cover, woody debris and overhanging vegetation.

Glides with cobbles/boulder substrates also provide above average habitat suitability (**Table 6-1**). Glide and riffle habitats with smaller less stable substrates (i.e., Class 1 glides and riffles) are more prone to bed load transport, support lower densities of benthic invertebrates and less aquatic vegetation, have low cover, and were assigned lower suitability values (i.e., HSI = 0.50) than were Class 2 and 3 glide and riffle habitats (i.e., HSI = 0.75). The latter three types of habitat are characterized by medium and high cover, much of which is provided by the riparian zone.

Cascade habitats provide turbulent but productive environments for the production of aquatic food and nutrient values, and were assigned intermediate quality (**Table 6-1**).

Most of the remaining stream habitats, including the headwater ‘Tributary Streams’ habitat category, are relatively unproductive and were therefore assigned a relative habitat suitability rating of below average. Headwater streams are generally unproductive because most energy inputs are in the form of allochathomus materials, such as riparian vegetation and insects (Raleigh et al., 1984). Similarly, the ‘Other’ habitat category was rated as below average since the presence of fines >10% of the total substrate composition reduces invertebrate production (Crouse et al., 1981).

Shallow littoral zones in lakes were considered above average for food and nutrient production. Good light penetration generates high primary productivity (i.e., aquatic macrophytes, benthic production), with productivity decreasing with depth across this zone. Light penetration and productivity are lower in deep water littoral zones and the relative habitat suitability is below average. Food and nutrient contributions provided by pelagic habitats were assumed to be negligible.

REFERENCES

Bradford, M.J., and P.S. Higgins. 2001. Habitat-, season-, and size-specific variation in diel activity patterns of juvenile chinook salmon and steelhead trout. Canadian Journal of Fisheries and Aquatic Sciences 58: 365-374.

Crouse, M.R., C.A. Callahan, K.W. Maleug, and S.E. Dominguez. 1981. Effects of fine sediments on growth of juvenile coho salmon in laboratory streams. Transactions of the American Fisheries Society 110(2): 281-286.

Cunjak, R.A., 1996. Winter habitat of selected stream fishes and potential impacts from land-use activity. Canadian Journal of Fisheries and Aquatic Science (Supplement 1): 267-282.

Ford, B.S., P.S. Higgins, A.F. Lewis, K.L. Cooper, T.A. Watson, C.M. Gee, G.L. Ennis, and R.L. Sweeting. 1995. Literature Reviews of the Life History, Habitat Requirements, and Mitigation/Compensation Strategies for Thirteen Sport Fish Species in the Peace, Liard, and Columbia River Drainages in British Columbia. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2321. 342 pp.

Hynes, H.B. 1970. The Ecology of Running Waters. University of Toronto Press, Toronto. 555 pp.

Johnston, N.T., and P.A. Slaney. 1996. Fish habitat assessment procedures. Prepared for the BC Ministry of Environment, Lands and Parks and the BC Ministry of Forests, Vancouver, BC.

McPhail, J.D. 2007. The Freshwater Fishes of British Columbia. The University of Alberta Press.

Muhlfeld, C.C., D.H. Bennett, and B. Marotzs. 2001. Summer and winter habitat use by Columbia River redband trout in the Kootenai River drainage in Montana. North American Journal of Fisheries Management 21: 223-235.

Raleigh, R.F., T. Hickman, R.C. Solomon and P.C. Nelson. 1984. Habitat Suitability Information: Rainbow Trout. U.S. Fish and Wildlife Service FWS/OBS-82/10.60. 64 pp.

Resource Inventory Standards Committee (RISC). 2001. Fish and Fish Habitat Inventory: Standards and Procedures. Version 2.0. Province of British Columbia, Victoria, BC. April 2001.

Roberge, M, J.M.B. Hume, C.K. Minns, and T.L. Slaney. 2002. Life History Characteristics of Freshwater Fishes Occurring in British Columbia and the Yukon with Major Emphasis on Stream Habitat Characteristics. Canadian Manuscript Report of Fisheries and Aquatic Sciences Number 2611. 248 pp.

Porter, M., and J. Rossenfeld. 1999. Microhabitat Selection and Portioning by Assemblage of Fish in the Nazko River. BC Ministry of Fisheries, Victoria. Fisheries Project Report Number RD77. 28 pp.

Terrell, J.W., T.E. McMahon, P.D. Inskip, R.F. Raleigh, and K.L. Williamson. 1982. Habitat Suitability Index Models: Appendix A. Guidelines for riverine and lucustrine applications of fish HSI models with the Habitat Evaluation Procedures. Fisheries and Wildlife Service FWS/OBS-82/10.A. 54 pp.

U.S. Fish and Wildlife Service. 1981a. Habitat Evaluation Procedures (HEP). Ecological Services Manual (ESM) 102. Division of Ecological Services, US Fish and Wildlife Service, Department of the Interior, Washington, DC.

U.S. Fish and Wildlife Service. 1981b. Standards for the Development of Habitat Suitability Index Models. Ecological Services Manual (ESM) 103. Division of Ecological Services, US Fish and Wildlife Service, Department of the Interior, Washington, DC.

Annex D

Summary of Regulatory Consultations for Fisheries Mitigation and Offset Planning

Regulatory Consultation Meetings on Fisheries Mitigation and Offsetting Planning

#	Meeting Date	Subject	Participants
1.	January 23, 2013	Blackwater Fish Habitat Compensation Planning	1. Shelley Murphy (BC Environmental Assessment Office) *(absent)* 2. Stefan Martensson (BC Environmental Assessment Office) 3. May Darling (BC Environmental Assessment Office) 4. James Jacklin (BC Ministry of Environment) 5. Susan O'Bryan (BC Ministry of Environment) 6. Zsolt Sary (BC Ministry of Forests, Lands and Natural Resources Operations) 7. Christal Nieman (Canadian Environmental Assessment Agency) 8. Jeska Gagnon (Fisheries and Oceans Canada) 9. Ryan Todd (New Gold Inc.) 10. Tim Bekhuys (New Gold Inc.) 11. Keith Ferguson (Sustainability Engineering) 12. Alvaro Paredes (AMEC) 13. Michael McGurk (AMEC) 14. Brett McLeod (AMEC) 15. Pier van Dishoeck (AMEC)
2.	August 14, 2013	Blackwater Fish Habitat Mitigation and Compensation Planning	1. Shelley Murphy (BC Environmental Assessment Office) 2. Kate Haines (BC Environmental Assessment Office) 3. James Jacklin (BC Ministry of Environment) *(regrets)* 4. Zsolt Sary (BC Ministry of Forests, Lands and Natural Resources Operations) 5. Christal Nieman (Canadian Environmental Assessment Agency) 6. Jeska Gagnon (Fisheries and Oceans Canada) 7. Tim Bekhuys (New Gold Inc.) 8. Ryan Todd (New Gold Inc.) 9. Nigel Fisher (New Gold Inc.) 10. Brett McLeod (AMEC) 11. Alvaro Paredes (AMEC) 12. Michael McGurk (AMEC) 13. Pier van Dishoeck (AMEC)
3.	August 14, 2013	Discuss permitting and fish habitat compensation plan	1. Jeska Gagnon (Fisheries and Oceans Canada) 2. Nigel Fisher (New Gold Inc.)
4.	September 11, 2013	Blackwater site tour	1. Jeska Gagnon (Fisheries and Oceans Canada) 2. Corrine Gibson (Fisheries and Oceans Canada) 3. Zsolt Sary (BC Ministry of Forests, Lands and Natural Resources Operations) 4. Kevin Mernickle, (BC Ministry of Environment) 5. Barb Beyer, (BC Ministry of Environment) 6. James Jacklin, (BC Ministry of Environment) 7. Nigel Fisher (New Gold Inc.)
5.	November 22, 2013	The 2012 Fisheries Act, Policy and Guidance with regards to the Blackwater Project	1. Steve Burgess (Fisheries and Oceans Canada) 2. Andrew Stewart (Fisheries and Oceans Canada) 3. Justyn Laurie-Lean (Mining Association of Canada) 4. Nigel Fisher (New Gold Inc.)

#	Meeting Date	Subject	Participants
6.	December 12, 2013	Fish Habitat Evaluation and Instream Flow	1. Christal Nieman (Canadian Environmental Assessment Agency) 2. Shelly Murphy (BC Environmental Assessment Office) 3. Jeska Gagnon (Fisheries and Oceans Canada) 4. Jennifer Puhallo (BC Ministry of Environment) 5. James Jacklin (BC Ministry of Environment) 6. Neil Gauthreau (Lhoosk'uz Dene Nation) 7. Zsolt Sary (Ministry of Forest Lands and Natural Resource Operations) 8. Anna Regnier (Ministry of Forest Lands and Natural Resource Operations) 9. Vince Sewell (Ministry of Forest Lands and Natural Resource Operations) 10. Nigel Fisher (New Gold Inc.) 11. James McCarthy (AMEC) 12. Alvaro Paredes (AMEC) 13. Brad Horne (AMEC) 14. Pier van Dishoeck (AMEC)

Annex E
Fisheries Management Objectives

1.0 INTRODUCTION

This section provides a description of the federal, provincial, and regional government fisheries management objectives in the Nechako Watershed. These objectives were summarized into two broad management objectives for use in reviewing potential mitigation and compensation options. The objectives are:

- Protect and increase freshwater fish stocks for recreational and aboriginal fisheries
- Rehabilitation of habitat used by freshwater fish that contribute to a recreational or aboriginal fishery

2.0 METHODS

Fisheries management objectives from federal, provincial and regional fishery managers were obtained by conducting a review of policy information from various sources in December 2013. Department websites were searched for policy documents, along with strategic plans. Local fisheries conservation and management groups were also reviewed for strategic plans and policy recommendation documents.

2.1 Federal

Fisheries and Oceans Canada (DFO) sets management objectives for freshwater and marine fisheries and for the habitats that support them. Changes were made to the *Fisheries Act* by the federal government in June 2012. In Section 6.1 of the *Fisheries Act* , it sets out the purpose of the fisheries protection provisions “to provide for the sustainability and ongoing productivity of commercial, recreational and Aboriginal fisheries.” (DFO 2013). This broad objective guides the management of all fisheries across Canada.

2.2 Provincial

The province of BC is responsible for the management of non-salmon freshwater fisheries. The goal of the BC Freshwater Fisheries Program is to conserve the natural diversity of fish and fish habitat and to sustainably manage recreational fishing in BC. As part of the Freshwater Fisheries Program Plan (MOE 2007), BC has developed the following goals and priorities:

- Establish governance approaches that are strategic, effective and efficient.
    - Maintain and improve a regulatory framework to protect and manage habitat, freshwater fisheries, and aquatic ecosystems
    - Promote regulatory compliance through education, verification and enforcement
    - Develop collaborative relationships with First nations in the management of freshwater fisheries
    - Obtain and use the best available science to support better decision making
    - Obtain, manage and deliver fishery resource information
- Conserve wild fish and their habitats
    - Conserve and restore freshwater fish populations and their habitats

    - Protect and recover freshwater fish species at risk
    - Promote stewardship of fish, fish habitat and aquatic ecosystems
- Optimize recreational opportunities based on the fishery resource
    - Maintain and develop diverse and sustainable opportunities for fishery resource users
    - Integrate stakeholder values into freshwater fisheries management decision-making

In 2009 after a review of fish passage and culverts related to forestry roads in the province, the Forest Practices Board recommended the following (FPB 2009):

- The Board recommends that government take the necessary actions to ensure fish access to valuable habitat is maintained and restored.

The provincial government has made the rehabilitation of pre-code culverts a priority to restore fish passage in watersheds (FPTWG 2012).

Regional

Historically the Nechako River watershed has been managed to provide for recreational fishing opportunities for resident sport fish (Ableson 1985). Areas in the watershed such as the Murray Cheslatta system have been prioritized for restoration of depressed stocks to restore the sport fish productive capacity and develop lake fisheries (Hamilton and Schmidt 2005). Parks in the region, such as Finger-Tatuk park are also managed to provide recreational fishing opportunities, with management objectives including maintaining healthy and viable fish stocks and maintaining quality recreational fishing opportunities (Triton 2003, B.A. Blackwell and Associates Ltd. 2000).

In 1997 the Vanderhoof Land and Resource Management Plan (LRMP) was approved, providing guidance for management of the land and resources in the Vanderhoof region (BC 1997). The LRMP recommends maintaining the physical and biological diversity of fish and aquatic habitats in accordance with the Forest Practices Code (now Forest and Range Practices Act). General objectives also include:

- Endorse restoring degraded stream habitats and maintaining healthy stream habitats through promotion of improved land management practices and through bank stabilization, revegetation and other stream rehabilitation techniques.
- Endorse conducting fish habitat inventories to identify fisheries sensitive/critical areas that require protection and site-specific management actions.
- Endorse the recommendation that the cumulative rate of development (forestry, urbanization, agriculture, mining, etc.) within specified watersheds should be balanced with fish habitat requirements.
- Manage to maintain the natural diversity of aquatic habitat elements. Manage to maintain and/or enhance water quality and quantity for instream uses.

- Endorse identifying watersheds or stream reaches that require enhanced management in order to maintain or rehabilitate water quality or habitat.
- Endorse protecting streamside and riparian areas by providing adequate buffer zones and applying appropriate riparian management.
- Support enhancing salmon habitat and stocks through projects or activities identified in the RMZs.

As a supplement to the Vanderhoof LRMP, a series of management objectives and strategies were prepared for salmon resources in the LRMP region and also by watershed (MacDonald and et. 1995). The general objectives and strategies are intended to satisfy the goal of protecting the salmon resource by ensuring that a net gain in the productive capacity of fish habitat is achieved. The management objectives and strategies are outlined in Tables 1 and 2.

Table 1: General Objectives and Strategies for Salmon Resources

Objectives	Strategies
Maintain rebuild and or enhance salmon stocks	Apply sustainable fish harvest strategies
Maintain and/or enhance water quality and water quantity for instream uses	Conduct fish habitat inventories to identify fisheries sensitive/critical areas that require protection and site specific management actions
Maintain and restore watershed and stream channel integrity and stability	Assess present and potential development impacts in fisheries watersheds (Watershed Assessment Procedure) and implement integrated watershed management plans to minimize the cumulative impacts to land use activities
Ensure that the cumulative rate of development within specified watersheds (forestry, urbanization, agriculture, mining, etc.) does not adversely impact fish habitat	Identify watersheds or stream reaches that require enhanced management prescriptions
Ensure consistency in resource planning in: -administrative boundaries -hierarchical plans (strategic, operational) -management goals, objectives, strategies, and indicators	Determine adequate instream flows for fish
Protect streamside and riparian areas by providing adequate buffer zones and through proper riparian management	Restore degraded stream habitats through promotion of improved land management practices and through bank stabilization, revegetation and other stream restoration techniques.
Provide an adequate level of monitoring that will ensure proper compliance and provide an evaluation tool for refinement of management strategies, prescriptions and resource targets	Monitor and enforce compliance to environmental standards/guidelines and evaluate their effectiveness
Maintain existing “no staking placer reserve” designations	Enhance salmon habitat and stocks through specifically identified projects or activities
Ensure Forest Practices Code provisions are applied as a minimum standard in all watersheds	

Objectives	Strategies
Ensure other development guidelines such as the Land Development Guidelines, Placer Mining Regulations and Guidelines, Guidelines for Mineral Exploration and Reclamation, and Agricultural Guidelines are followed.	
Maintain the natural diversity of aquatic habitat elements.	

Table 2: Specific Objectives and Strategies for the Salmon Resources in the Nechako Watershed for the Vanderhoof LRMP

Specific Objectives	Specific Strategies
Follow the terms of the Kemano Settlement Agreement and Nechako Fisheries Conservation program	Apply the Nechako Fisheries Conservation Program strategies
Maintain the structural and functional integrity of riparian areas	Apply the Watershed Assessment Procedures (WAP) to assess past and potential for future impacts of lands use activities on tributaries
Maintain slope stability	Apply the Land Development Guidelines to residential and industrial developments
Maintain or improve water quality	Conduct detailed stream channel stability assessment on tributaries
Protect stream channels and floodplains from influences of development activities	Conduct and maintain fisheries, habitat (critical) and enhancement inventories. Identify limiting factors
Ensure the protection of headwater, ephemeral, and intermittent channels; recognizing their influence on watershed stability, hydrology and water quality	Conduct detailed gully assessments in tributaries for specified sensitive channels identified in development plans
Ensure protection of critical aquatic habitats including: floodplain, off-channel sites, non-natal tributaries and other areas of biological significance.	Conduct foreshore inventory and classification of Nechako mainstem for delineation of fisheries sensitive zones (FSZ) prior to development
Ensure the intensity of development activities does not negatively impact the natural watershed ecological process through site specific or cumulative development	Design high elevation forest cutblocks to optimize snow accumulation and retention similar to unharvested or undisturbed areas
Ensure the inventory, assessment and implementation of stream restoration and enhancement programs	Develop Access Management Plans (AMP) for review and direction
Improve inventories of aquatic resources	Develop a detailed riparian management plan (RMP) from Nautley to Prince George identifying areas requiring site specific prescriptions (urban/agriculture)
Support existing fisheries enhancement programs and activities	Develop a riparian management plan to protect and restore tributary stream habitat in cooperation with agricultural and ranching communities
Improve fish passage in the watershed.	Develop a Water Management Plan (WMP) that includes a determination of water demand, fisheries/minimum low flow of water storage opportunities and potential impacts of water extraction

Specific Objectives	Specific Strategies
	Distribute timber harvesting opportunities throughout the available range in elevation to maintain natural hydrologic conditions in tributaries
	Document, map and assess tributary terrain and soils conditions and their hazard risk
	Ensure that rate of development in the tributaries (forestry urban, agriculture, etc) is balanced against hydrologic recovery to maintain ECA at or below 25%
	Maintain designated “No Staking Placer Reserves” for placer mining where identified.
	Implement a water drainage management plan for sensitive soils, stream crossings or other areas specified in development plans
	Initiate a watershed restoration assessment inventory for development of a Watershed Restoration Plan
	Implement watershed restoration plan recommendations from assessment and inventory reports
	Initiate restoration, re-vegetation and stabilization measures on linear developments
	Provide Streamside Management Plans (SMP) for harvesting areas identified in the annual forest development plan update
	Restrict or control development within or along tributary confluences, alluvial fans, floodplains or areas of slope instability (e.g. valley walls)
	Retain riparian reserves along specified S4-S6 (FPC riparian class) stream channel reaches in high sensitivity areas or channels identified as having stream temperature concerns
	Review and document potential habitat improvement, habitat development and habitat restoration opportunities
	Review resource development plans for compatibility with sensitive habitats in terms of hydrology, water quality, channel stability and riparian condition

REFERENCES:

Ableson, D.H.G. 1985. Fisheries Management Plan Upper Nechako River Watershed: Including Murray and Cheslatta Lakes. BC Ministry of Environment, Fisheries Branch. Prince George, BC.

B.A. Blackwell and Associates Ltd. 2000. Finger Tatuk Ecosystem Management Plan. Submitted to Ministry of Environment, Lands and Parks.

BC Provincial Government (BC). 1997. Vanderhoof Land and Resource Management Plan.

BC Ministry of Environment (MOE). 2007. Freshwater Fisheries Program Plan.

Fish Passage Technical Working Group. 2012. Towards Restoring Fish Habitat Connectivity in BC. Fish Passage Technical Working Group Progress Report, February 2012.

Fisheries and Oceans Canada (DFO). 2013. Fisheries Protection Policy Statement. October, 2013.

Forest Practices Board (FPB). 2009. Fish Passage at Stream Crossings.

Hamilton, J.D., and N. Schmidt. 2005. Background information report on Murray-Cheslatta River System. Report for Nechako Enhancement Society. Prepared by Golder Associates Ltd.

Mac Donald, L.B., F.N. Leone, and D.E. Rowland. 1995. Salmon watershed planning profiles for the Fraser River basin within the Vanderhoof land and resource management plan. Prepared for Department of Fisheries and Oceans Fraser River Action Plan and Habitat Management Unit.

Triton Environmental Consultants Ltd. 2003. Finger-Tatuk Provincial Park Monitoring Plan Framework and Protocols. Prepared for Ministry of Water, Land and Air Protection, Environmental Stewardship Division, Omineca Region.

Annex F
Preliminary Screening and Evaluation of Offsetting Options

Annex F: Summary of Preliminary Screening and Evaluation of Offsetting Options

		Regulatory			Technical Feasibility			Stability and Permanence		Biological Relevance		
No.	**Offsetting Option**	**Position on DFO's guiding principles (Section 7.1.1)**	**Consistency with Regional Fish Management Objectives**	**Consistency with First Nations TK and TLU**	**Limitations to Successful Construction/Implementation**	**Potential for Ancillary Impacts**	**Relative Economic Feasibility**	**Risk of Structural Failure**	**Frequency of Maintenance Required**	**Likelihood of Alleviating Habitat Bottleneck**	**Likelihood of Increasing Productive Capacity**	**Benefits to Other Species**
	On-Site Options											
1	**Lake 01682LNRS Enlargement**	Medium. Creates unlike habitat in the same ecological unit.	Unknown.	Unknown.	Assumed that increase in lake surface area will increase rainbow trout productivity in proportion	Potential for mercury methylation due to flooding of vegetation and soils addressed by mitigation measures. Potential flow effects addressed by diversion.	High value relative to net gains	Low; TSF is downstream of the end of lake; overflow and will be built to provincial dam construction standards.	Low.	Option intended to expand availability of productive lake habitat.	Likely to increase productive capacity of lake.	Introduction of longnose sucker from Lake 1538UEUT to Lake 01682LNRS.
2	**Lake 01682LNRS Diversion**	High. Creates like habitat in same ecological unit (rearing and spawning in outlet stream).	Unknown.	Unknown.	Low gradient limits potential to construct spawning habitat. Ground water elevation is unknown; channel lining may be required to ensure no leakage to ground.	Potential impacts of increased flows on Creek 705 drainage.	High value relative to net gains	Moderate risk. Channel lining could fail over time and lead to dewatering of channel sections.	New channel may require adjustments for up to 5 years post construction; periodic maintenance of spawning gravels may be required.	Potential to increase spawning and rearing habitat quantity within for enlarged Lake 01682LNRS and for Creek 705.	Habitat in channel expected to support increased productive capacity.	Introduction of longnose sucker from Lake 1538UEUT to Lake 01682LNRS.
3	**Creek 688328 Pond – Overwintering Habitat Creation**	Medium. Creates unlike habitat in the same ecological unit.	Unknown.	Unknown.	Moderate. Area where ponds proposed has high spawning potential; design will consider existing high quality habitat. Potential biological feasibility constraints to be addressed in field.	Low, no known ancillary impacts.	Moderate value relative to net gains.	Low	Low - moderate. Sediment may slowly accumulate in pond and potentially block access to off-line pond.	Likely to alleviate overwintering habitat bottleneck for Project area rainbow trout.	Potential to increase productive capacity in upper watershed .	Target is rainbow trout habitat only.
4	**Upper Creek 700 Pond**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	No limitations to successful construction given current understanding. Potential biological feasibility issues and constraints.	Potential wetland impacts.	Moderate value relative to net gains.	Low. Off-channel pond is considered low risk.	Low. Sediment may accumulate in overwintering pond.	Potential to alleviate overwintering bottleneck if limiting factor.	Moderate. Potential to increase productivity of Creek 700 drainage.	Target is rainbow trout habitat only.
5	**Creek 700 Channel Enhancements and Surge Pond**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Requires multiple access points into Creek 700. Potential biological feasibility issues and constraints.	Increased flows. Disturbance from access. Potential impacts to wetlands.	Low value relative to net gains.	Moderate. Potential instability of instream structures from increased flows and flooding.	High. Maintenance requirements expected to be high. Sediment may accumulate in surge/overwintering pond.	Potential to alleviate overwintering bottleneck.	Moderate. Potential to increase productivity of Creek 700 drainage.	Target is rainbow trout habitat only.
6	**Upper Turtle Creek Pond**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	No limitations to successful construction and implementation given current data.	Low. Potential impact to wetlands.	Moderate value relative to net gains.	Low.	Low. Sediment may accumulate in overwintering pond.	Potential to alleviate overwintering bottleneck	Moderate. Potential to increase productivity in Turtle Creek.	Target is rainbow trout habitat only.
7	**Mid Turtle Creek Pond**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	No limitations to successful construction and implementation given current data.	Low. Potential impact to wetlands.	Moderate value relative to net gains.	Low	Low. Sediment may accumulate in overwintering pond.	Potential to alleviate overwintering bottleneck	Low to moderate.	Target is rainbow trout habitat only.
8	**Mid Turtle Creek Pond**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Few limitations to successful construction and implementation given current data.	Low. Potential impact to wetlands.	Moderate value relative to net gains.	Low.	Low. Sediment may accumulate in overwintering pond.	Potential to alleviate overwintering bottleneck	Moderate. Potential to increase productivity in Turtle Creek.	Target is rainbow trout habitat only.
9	**Lower Turtle Creek Off-Channel Pond**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Potential constructability issues. Site very wet and boggy, may be problematic for heavy equipment operation. Recommend considering other sites before developing this site.	Potential wetland impacts.	Moderate value relative to net gains.	Low. Off-channel pond is considered low risk.	Moderate. More maintenance expected at this site since pond could be overtopped during freshet.	Potential to alleviate overwintering bottleneck Some existing deep water habitat in lower drainage but limited winter cover and depths.	Low - moderate.	Target is rainbow trout habitat only.
10	**Lower Turtle Creek Channel Enhancement**	Low. Creates unlike habitat in different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	No major limitations identified. Potential biological feasibility issues and constraints.	Potential wetland impacts.	Low value relative to net gains.	Moderate. Potential flooding of the channel could result in disturbance to any remedial works.	Moderate. Potential maintenance activities will be expected if flooding disturbances occur.	Unlikely. Further studies required to determine if access to overwintering or rearing habitats under low flow conditions is a limiting factor.	Low-moderate. Potential to increase productive capacity in lower Turtle Creek from improvements to overwintering, rearing and migration habitats.	Target is rainbow trout habitat only.

		Regulatory			Technical Feasibility			Stability and Permanence		Biological Relevance		
11	**Dykam Ranch Rehabilitation**	Low. Rehabilitation of like habitat within different ecological unit (assumes populations are distinct between Davidson and Chedakuz creeks).	Rehabilitation of habitat used by fish that contribute to a recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Requires cooperation with ranchers and local stakeholders.	Fencing will prevent cattle from freely accessing creek for watering. Provision of cattle watering facility will be required. No other ancillary impacts expected.	Low value relative to net gains.	Low	Fencing may need periodic maintenance. Riparian planting will require monitoring and likely some replanting will be required (if trees/shrubs fail to establish).	Unlikely. Current limiting factors in this section of Chedakuz Creek are unknown. Option contributes to protection of fish habitat.	Likely. No fish habitat evaluations completed in this section of Chedakuz Creek. If spawning gravels are present in areas with cattle access, then fencing and riparian planting will likely increase productive capacity.	Fencing to exclude cattle will benefit all species that inhabit this section of Chedakuz Creek including kokanee and rainbow trout.
12	**Kokanee Spawning Channel in lower Chedakuz Creek**	High. Creates like habitat in the same ecological unit (assumes use by Davidson Creek kokanee population).	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Access to private land is required. Further studies required to address biological and engineering constraints.	No major ancillary impacts expected.	High value relative to net gains.	Moderate. Located in Chedakuz Creek; potential flooding of channel and siltation of spawning gravels	Moderate - High. Spawning channels require annual or semi-annual maintenance, in particular to address compaction of gravels with fine sediments. Annual or semi-annual scarification of spawning gravels may be required.	Unknown whether kokanee spawning habitat is limiting factor.	High. Additional kokanee spawning habitat expected to increase productive capacity.	Rainbow trout may use the channel for spawning by design or incidentally. Potential use by other species in Chedakuz Creek.
13	**Creek 428073 Pond**	Medium. Creates unlike habitat in the same ecological unit	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	No limitations to successful construction and implementation given current data.	Low. Potential impact to wetlands.	Moderate value relative to net gains.	Low.	Low. Sediment may accumulate in overwintering pond.	Potential to alleviate overwintering bottleneck.	Moderate. Potential to increase productivity in Davidson Creek.	Target is rainbow trout habitat only.
14	**Three Ponds – Creek 661 Habitat Creation**	Medium. Creates unlike habitat in the same ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Further studies required to address biological and engineering constraints. Need clarification of DFO's acceptance of creating access to existing open water areas as offsetting.	Potential wetland impacts.	Low value relative to net gains.	Low.	Low-moderate. Limited maintenance of connector channel expected.	Unlikely. Rearing habitat is likely not a limiting factor in Creek 661. Potential to alleviate overwintering habitat bottleneck if construction possible.	Low-moderate. Potential to increase productive capacity in Creek 661 Watershed.	Target is rainbow trout habitat only.
15	**Three Ponds Water Storage Complex**	Medium. Creates unlike habitat in the same ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Several limitations; water supply, groundwater level; sensitive areas (wetlands), post closure operation.	Potential wetland impacts.	Low value relative to net gains.	Moderate	High	Moderate-High. Overwintering habitat created could address habitat bottleneck in Davidson Creek.	Moderate-High. Potential to increase productivity of lower Davidson Creek	Target is rainbow trout habitat only.
16	**Creek 505659 Pond**	Medium. Creates unlike habitat in the same ecological unit	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	No limitations to successful construction and implementation given current data.	Low. Potential impact to wetlands.	Moderate value relative to net gains.	Low.	Low. Sediment may accumulate in overwintering pond.	Potential to alleviate overwintering bottleneck if limiting factor.	Moderate. Potential to increase productivity in Creek 661.	Target is rainbow trout habitat only.
17	**Habitat Rehabilitation at Mills Ranch**	High. Rehabilitation of like habitat within the same ecological unit.	Rehabilitation of habitat use by freshwater fish that contribute to a recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Requires cooperation with ranchers and First Nations; this section of Davidson Creek is located near a First Nations Reserve.	Fencing will prevent cattle from freely accessing creek. Provision of cattle watering facility will be required. . No other ancillary impacts expected.	High value relative to net gains.	Low risk that instream structures will fail. Rehabilitation techniques are well proven.	Fencing may need periodic fixing. Riparian planting will require monitoring and likely some replanting will be required (if trees/shrubs fail to establish).	Unknown. Current limiting factor of production is unknown. Option contributes to protection of fish habitat.	High. Rehabilitation and protection of spawning gravels are expected to increase productivity.	Rainbow trout, mountain whitefish and kokanee will benefit from this option.
18	**Upper Davidson Creek Watershed Diversion**	High - Channel. Creates like for like habitat in the same ecological unit.	Protection of freshwater fish stocks for recreational fishery in Tatelkuz Lake	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Several limitations; surface or groundwater sources along the alignment, water supply requirements for TSF	Increased flows in Creek 700, potential impacts to wetlands in Creek 700.	Low value relative to net gains.	High	Moderate	None. Migratory corridor. Sufficient stream habitat in Creek 700.	Low. Potential to increase productive capacity in Creek 700 watershed, only minor.	Target is rainbow trout habitat only.
19	**Snake Lake Diversion**	Medium - Channel. Creates like for like habitat in the same ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Tatelkuz Lake.	Aboriginal fishery in Tatelkuz Lake and Chedakuz Creek.	Several limitations; water supply, groundwater level; sensitive areas (wetlands), post closure operation.	Potential lake drawdown, wetland impacts downstream.	Low value relative to net gains.	Moderate	High	None. Sufficient stream habitat exists in Davidson Creek.	High. Channel could have all types of habitat-spawning, rearing incorporated	None. Target is rainbow trout habitat. However, kokanee may utilize for spawning if habitat conditions permit.

		Regulatory			Technical Feasibility			Stability and Permanence		Biological Relevance		
No.	**Offsetting Option**	**Position on DFO's guiding principles (Section 7.1.1)**	**Consistency with Regional Fish Management Objectives**	**Consistency with First Nations TK and TLU**	**Limitations to Successful Construction/Implementation**	**Potential for Ancillary Impacts**	**Relative Economic Feasibility**	**Risk of Structural Failure**	**Frequency of Maintenance Required**	**Likelihood of Alleviating Habitat Bottleneck**	**Likelihood of Increasing Productive Capacity**	**Benefits to Other Species**
	Off-site options											
1	**Enhancement of Finger-Tatuk Watershed Habitats**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Finger-Tatuk lakes.	Likely consistent due to potential benefits for kokanee and rainbow trout.	Some of the restoration concepts are typical, well understood and of low risk; others are higher risk. Low flow augmentation may work if water is taken directly from a lake source. Beaver dam removal maybe short term and may not solve low flow concerns. Proposed channelization of wetlands may exacerbate low flow conditions.	Unknown	Unknown.	Unknown, but likely variable and dependent upon reliability of water source and current sediment supply sources and issues.	Likely moderate maintenance requirements for any low flow augmentation or spawning habitat enhancement aspects. Beaver presence will require frequent and long term management.	High	High	Potential benefits to both rainbow trout and kokanee.
2	**Creation and Maintenance of Sutherland River Watershed Habitats**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Unknown.	Likely consistent.	Spawning channel creation: possible but hard to justify in a remote location. Cut block sediment traps; unusual proposal; proper land use practices will likely be the preferred approach to this problem. Mainstem flow regulation strategies: all techniques are typical but questionable as to whether they will mitigate peak flows.	Unknown.	Unknown.	High.	High.	Unknown, but likely low.	Unknown.	Concept will benefit multiple species in the Sutherland River.
3	**Murray Creek Rehabilitation**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent; both BC MOE and DFO are partners in the initiative.	Likely consistent due to potential benefits to salmon and sturgeon. However, First Nations are not listed as an active partner in the Murray Creek Restoration Project (MCRP).	Few limitations expected as all restoration techniques are well understood and proven.	Unknown.	Unknown.	Highly dependent upon site and restoration technique employed.	Variable; will require individual site assessment to determine maintenance requirements.	High.	High.	Concept will benefit multiple species in Murray Creek watershed and, ultimately, the Nechako River. These species include chinook, sockeye, and coho salmon.
4	**Nechako Environment and Water Stewardship Society (NEWSS)**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent; both BC MOE and DFO are partners in the initiative.	Unknown. First Nations are not listed as an active partner in NEWSS.	Current specific initiative identified or funding commitments. Priority activity of NEWSS is to restore stream reaches and improve stream crossings in agricultural areas within 30 sub-basins in the Nechako-Plateau. Potential opportunities for New Gold Inc. to partner with NEWSS to develop habitat creation/enhancement projects	Unknown.	Unknown	Highly dependent upon site and restoration technique employed.	Variable; will require individual site assessment to determine maintenance requirements.	High.	High.	Concept will benefit multiple species in Murray Creek watershed including Chinook, sockeye, and coho salmon as well as rainbow trout.
5	**Nechako White Sturgeon Recovery Initiative**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent; both BC MOE and DFO are partners in the initiative.	Likely consistent; the Carrier Sekani Tribal Council and Lheidli T'enneh First Nations are participants in the initiative.	Construction of the recovery facility is moving forward with secured funding and approval from agencies, First Nations and other stakeholders. Expected that any projects will be large in scope and require expertise specific to white sturgeon in the Nechako River and large river engineering.	Unknown	Considered feasible with secured funding from agencies, First Nations and other stakeholders. Potential opportunities for New Gold Inc. include a one time or annual funding of various recovery initiatives, including funding of the Conservation and Interpretive Centre proposed in Vanderhoof	Low	Variable; will require individual site assessment to determine maintenance requirements.	High.	Considered biologically relevant, and overall beneficial to local fish productivity.	Target species is endangered Nechako River white sturgeon.
6	**Restoration of Fish Passage in the Ft. St. James District**	Low. Increasing access to existing upstream habitat in a different ecological unit.	High; replacement of pre-code culverts to improve fish access is a provincial priority.	Unknown.	Few limitations; restoration techniques are well understood and proven.	Low.	Unknown.	Low.	Low.	High.	Will increase access to additional habitat.	Could benefit multiple species including salmon and trout.
7	**Nechako Fisheries Conservation Program (NFCP)**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent.	Likely consistent.	The NFCP is designed to evaluate the decline in chinook and sockeye salmon population declines in the Nechako River watershed. Multiple programs ranging from 1 to 13 years old are in place to research, monitor and apply remedial measures including habitat enhancement in the watershed. There are	Low.	Potential opportunities for New Gold Inc. to fund both existing and proposed projects that will count towards habitat offsetting provision requirements.	Highly dependent upon site and restoration technique employed.	Variable; will require individual site assessment to determine maintenance requirements.	High.	Unknown.	Target species is Chinook and sockeye salmon in the Nechako River watershed.

		Regulatory			Technical Feasibility			Stability and Permanence		Biological Relevance		
8	**Nulki-Tachik Watershed Restoration Program**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent.	Consistent as project is run by the Carrier Sekani Tribal Council.	Few limitations: Carrier Sekani Tribal Council, Saik'uz First Nation previously implemented a large scale watershed restoration project within the Nulki-Tachik watershed. This project has been recommended to continue to add more restoration habitat and increase stocking efforts to benefit all life stages of rainbow trout.	Low.	Potential opportunities for New Gold Inc. to partner with the Carrier Sekani Tribal Council to develop habitat creation /enhancement opportunities.	Highly dependent upon site and restoration technique employed.	Variable; will require individual site assessment to determine maintenance requirements.	High. The construction of rearing sites (large woody debris structures), riparian restoration and fishing pressure monitoring.	High.	Target is native salmonids, in particular rainbow trout.
9	**Restoration of Fish Passage in the Vanderhoof Forest District**	Low. Increasing access to existing upstream habitat.	Likely consistent; replacement of pre-code culverts to improve fish access is a provincial priority.	Unknown.	Few limitations; restoration techniques are well understood and proven.	Low.	Unknown.	Low.	Low.	High.	Will increase access to additional habitat.	Could benefit multiple species including salmon and trout.
10	**Stoney Creek Rehabilitation Project**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent.	Likely consistent.	Several limitations; periodic and unpredictable back flooding by Nechako River. Current lawsuit between Saik'uz and Stellat'en First Nations and Rio Tinto Alcan.	Unknown.	Unknown.	Low.	Low.	Unknown.	Unknown.	Concept will benefit multiple species using lower Stoney Creek including rainbow trout and mountain whitefish.
11	**Mathews Creek Watershed Rehabilitation**	High. Creates like habitat (spawning and rearing) in same ecological unit.	Potential to increase freshwater fish stocks for recreational fishery in Mathews and Fawnie Creeks as well as Laidman Lake.	Unknown	No limitations to successful construction and implementation given current data.	Low potential impacts.	Moderate value relative to net gains.	Low	Low. Designed to be permanent or self-sustaining.	Moderate: Potential to enhance existing spawning and rearing habitat quantity and quality within Mathews Creek.	Moderate. Potential to increase productivity in Mathews Creek.	Target is rainbow trout but will also benefit other aquatic and terrestrial species.
12	**Swanson Creek Watershed Rehabilitation**	Low. Increasing the productive capacity of like habitat in a different ecological unit.	Likely consistent. Previous restoration efforts exist within this creek as part of provincial Watershed Restoration Program (WRP).	Consistent. Representatives of the Saik'uz First Nation identified Swanson Creek as a high priority because of its degraded habitat and historic production of chinook salmon.	Maintenance required for previous restoration work due to high flow events. This concept will require partnerships and agreements with landowners.	Low. Offsetting efforts required along off-channel habitats. Request to use low impact heavy machinery, manual, and horse power.	High value relative to net gains.	Moderate. Stream is susceptible to high flows.	Riparian and gravel bar planting will require monitoring and likely some replanting will be required (if trees/shrubs fail to establish).	Potential to re-establish stream stability and habitat quality.	Moderate. Potential to restore spawning and rearing habitat within channel and off-channels.	Targets chinook salmon, rainbow trout and mountain whitefish along Swanson Creek.

Annex G

Summary and Rationale for Offsetting Options No Longer Included

Annex G: Summary of Offsetting/Mitigation Options No Longer Included in Fish Habitat Mitigation and Offsetting Plan

No.	Mitigation/Offsetting Option	Type	Option Location	Description of Concept	Current Status/Rationale
3	Creek 688328 Pond - Overwintering Habitat Creation	Offsetting/ Mitigation	On-Site	TSF development will isolate fish habitat in Creek 688328 (upper tributary to Davidson Creek), prevent in/out migration and access to good quality overwintering habitat in lower Davidson Creek. The persistence of a self-sustaining population of rainbow trout upstream will require habitat to support all life stages. To mitigate habitat loss, the construction of overwintering ponds was considered a potential option for the maintenance of an isolated fish population based on initial surveys. Overwintering pools in the upper watershed will also contribute to habitat gains for offsetting purposes.	Field studies competed in 2012 determined spawning habitat in Creek 688328 was limited. Furthermore, there was no evidence of spawning (i.e., fry presence) or habitat use by juvenile fish in summer 2012. Evidence suggests that both overwintering and spawning habitats are factors that potentially contribute to limit fish production in the upper reaches. There were also no opportunities for spawning enhancements or a long-term supply of gravel recruitment. The ability to successfully create all habitat requirements and maintain a self-sustaining population of rainbow trout upstream of the TSF was considered high risk from a biological perspective. This option is no longer considered for these reasons.
4	Upper Creek 700 Pond	Offsetting	On-Site	The construction of a large 2.5 ha overwintering pond in the upper Creek 700 watershed to address potential overwintering limitations in the upper drainage.	Baseline field surveys completed in 2011-2012 demonstrated limited habitat use in middle to upper reaches of Creek 700. The lack of overwintering habitat may account for the low fish habitat utilization. However, steeper stream gradients in the middle reaches of Creek 700 (Reach 3) likely reduce rainbow trout access to the upper reaches and contribute to low habitat use. Sub-surface flows and undefined channel sections in Reach 4 further limit fish access and habitat use in the upper drainage. Given the access constraints, there is high risk that the construction of overwintering habitat will not increase the productive capacity of the upper drainage. This option is no longer considered biologically necessary.
5	Creek 700 Channel Enhancements and Surge Pond	Offsetting	On-Site	This concept is a component of the "*Upper Davidson Creek Watershed Diversion"* described above. To mitigate increased discharge and potential changes in channel morphology in Creek 700, a 2.5 hectare surge-suppression pond downstream of the north TSF saddle dam and 4.9 km of channel stabilization works will be constructed. The surge pond will be designed to support juvenile overwintering and rearing opportunities for rainbow trout. Some channel works in this section will be considered mitigation (i.e., channel stabilization) and others offsetting (i.e., fish habitat creation).	No longer need to provide channel stabilization works in Creek 700 without the *'Upper Davidson Creek Watershed Diversion'*. The surge pond component was replaced by the "*Upper Creek 700 Overwintering Pond"* concept below when stabilization/enhancement works were determined not a necessity.
6, 7, 8	Mid and Upper Turtle Creek Off-Channel Ponds	Offsetting	On-Site	The construction of a three 0.3-0.75 ha overwintering ponds in the mid-upper Turtle Creek watershed were proposed to address potential trout overwintering habitat limitations in the upper drainage. Ponds will be located in areas of known and sufficient surface or ground water sources that will maintain water quality during low flow and winter periods. Ponds will be connected to the Turtle Cr. mainstem with an outlet channel, or both and inlet and outlet channels.	Field surveys in 2013 found that sites 2-4 are located in a creek section with aggressive beaver dam construction activity. The same areas that were considered acceptable in initial and subsequent surveys in 2011-12 when beavers were absent were deemed unacceptable during 2013 since the proposed pond habitat to be created was identical in biological function to that created by the beaver dams in 2013. Construction of additional pond habitat in this section will not increase biological productivity as this habitat type is now abundantly available.
9	Lower Turtle Creek Off-Channel Pond	Offsetting	On-Site	An off-channel pond in lower Turtle Creek was considered in a large wetland area in Reach 1 to create high quality juvenile overwintering and rearing habitat for rainbow trout. Shallow water, poor winter cover and low winter flows contribute to the limited distribution of good overwintering habitat in this section of Turtle Creek. This concept consisted of deep water habitat (2.5 -3 m) with shallow water benches around the perimeter and cover.	Field surveys in 2012 indicated that the majority of this site location is too wet and the predominantly organic material will not support heavy excavation and hauling equipment on swamp mats even during winter months. In addition, site isolation from standing and moving water will be challenging to implement and maintain throughout construction and reclamation phases. Alternative locations were investigated due to the constructability issues at this site.
10	Lower Turtle Creek Channel Enhancement	Offsetting	On-Site	Aerial surveys completed in 2011 identified potential opportunities for habitat enhancements in the lower reach of Turtle Creek downstream of the Kluskus FSR. The creek flows through a large, inactive, alluvial fan and slowly infiltrates into the ground through many small shallow and intermittent channels. This concept consisted of creating a single, well defined channel with fish habitat features that enhance fish habitat and migration to/from Chedakuz Creek and Turtle Creek under low flow conditions. Improvements to fish habitat and migration will be expected to benefit rainbow trout seeking overwintering refuge and rearing habitat during the low flow periods.	Field surveys completed in 2012 determined that there are no in/out migration issues in lower Turtle Creek. Furthermore, the creek section has adequate existing fish habitat complexity such that additional habitat enhancements will result in marginal increases in fish productivity. This concept is no longer being considered given the lack of biological relevance.
11	Dykam Ranch Rehabilitation	Offsetting	On-Site	Riparian and river bank degradation was identified near a ranch located downstream of the Kluskus FSR along Chedakuz Creek. Habitat degradation issues include land clearing and cattle grazing and trampling of riparian and instream habitat. This has lead to bank erosion, soil disturbance, reduce water quality, degraded riparian areas, and siltation of kokanee and rainbow spawning habitat . Habitat enhancement opportunities consist of applying livestock management plans (i.e., fencing, off-channel watering), bank stabilization and riparian plantings.	This option was considered technically feasible with predictable outcomes. However, no support from local stakeholders was obtained during consultations at the detailed evaluation stage.
12	Kokanee Spawning Channel in Lower Chedakuz Creek	Offsetting	Off-Site	A potential site for a kokanee spawning channel was identified within the ranch adjacent to Chedakuz Creek downstream of the Davidson Creek confluence. Easily accessed land, appropriate gradients (0.1-0.15%), potentially high ground water inputs, and a sediment-free water source (Tatelkuz Lake outflow) make this option potentially feasible. Constructed habitat will also be used by various other species and life stages due to the proximity to Tatelkuz Lake. Further studies will be required to assess the technical feasibility.	This option was considered technically feasible but with a relatively high degree of uncertainty regarding effectiveness. Support from local stakeholder was not obtained during consultations at the detailed evaluation stage.
14	Three Ponds – Creek 661 Habitat Creation	Offsetting	On-Site	This concept involves connecting three isolated ponds to the Creek 661 mainstem through the construction of a connector channel. This will provide fish access and additional fish habitat that will contribute to productive capacity in Creek 661. These groundwater-fed ponds are isolated from each other and the Creek 661 mainstem by a number of small esker features. These ponds will provide good opportunity for off-channel rearing and overwintering of juvenile rainbow trout. Additional habitat could be created in the connector channel to Creek 661.	Based on past precedents, DFO has generally opposed creation of access into existing open water habitat as offsetting. There are few examples where they have accepted this practice with limitations on the amount of offsetting habitat gains credited. For this reason, this option is no longer being pursued.
15	Three Ponds Water Storage Complex	Offsetting/ Mitigation	On-Site	The creation of additional water storage on a small drainage system (Creek 428073) connected to Davidson Creek which will be released, particularly during low flows or sensitive fisheries windows, to mitigate potential flow reductions from construction of the Project. Low level dams constructed at the outlets of three small ponds will create additional storage capacity to support water releases while enlargement and habitat enhancements within the ponds and outlet channels will provide offsetting opportunities.	Field surveys determined that the East and West ponds have limited additional storage capacity or the ability to fill to capacity if small dams were constructed. Inflows into both ponds are minimal and will not provide adequate storage volume to supplement low flows in Davidson Creek. The mitigation function of this concept was superseded by the FSS from Tatelkuz Lake to maintain conservation flows in Davidson Creek.
17	Habitat Rehabilitation at Mills Ranch	Offsetting	Off-Site	This concept consists of rehabilitating degraded channel sections along lower Davidson and Chedakuz Creeks at the ranch located on the northwest side of Tatelkuz Lake. Historical land clearing and uncontrolled cattle access has caused bank erosion, soil disturbance, reduce water quality, degraded riparian areas, and siltation of kokanee and rainbow spawning habitat. Habitat enhancement techniques consists of a livestock management plan, which includes restricted cattle access (i.e., fencing) and off-channel watering, and instream and riparian enhancements.	This option was considered technically feasible with predictable outcomes although support from local stakeholder was not obtained during consultations at the detailed evaluation stage. This option is no longer being pursued.
18	Upper Davidson Creek Watershed Diversion	Offsetting/ Mitigation	On-Site	To maintain fish habitat use and in/out fish migration opportunities within Creek 688328 (upper tributary of Davidson Creek), this concept consisted of diverting water through a 3.0 km constructed channel into Creek 700, a tributary of Turtle Creek to the north. Fish habitat features could be incorporated into the diversion channel design. Remedial (channel stabilization) and habitat enhancement measures to mitigate predicted flow increases in Creek 700 will need to be considered in the design (see below *"Creek 700 Channel Enhancements and Surge Pond"*).	Aerial surveys completed in spring 2012 indicated that the topography was unsuitable (i.e., steep slope) and no surface and groundwater resources along the diversion route were present. Local topography and lack of water along the alignment limited the technical feasibility, constructability and reduced the likelihood of success. In addition, surface water in Creek 688328 is required to fill and maintain water levels in the TSF during operations through the post-closure periods. This option is no longer being pursued.
19	Snake Lake Diversion	Offsetting/	On-Site	This concept involves diverting water from a relatively large, esker-confined lake (locally known as Snake Lake) into the Davidson Creek	Field surveys determined that there were limited surface water inflows and lake levels were mainly driven by groundwater inputs.

No.	Mitigation/Offsetting Option	Type	Option Location	Description of Concept	Current Status/Rationale
		Mitigation		mainstem through a new 3.0 km constructed channel. Two alignments were considered along with an alternative to construct a secondary channel and divert water from a small unnamed lake to the northeast. Diverted water was intended to mitigate potential flow reductions in Davidson Creek from construction of the Project. Offsetting could be achieved from fish habitat in the new constructed channel and from potential lake habitat enhancement opportunities in Snake Lake itself.	Long-term water supply and potential lake drawdown from the diversion were primary concerns that rendered this concept high risk when assessed during the detailed evaluation stage. The mitigation function of this concept was superseded by the freshwater supply pipeline from Tatelkuz Lake to maintain conservation flows in Davidson Creek. This option is no longer being pursued.

No.	Mitigation/Offsetting Option	Type	Option Location	Description of Concept	Current Status/Rationale
1	Enhancement of Finger-Tatuk Watershed Habitats	Offsetting	Off-Site	Regionally important spawning habitats for kokanee and rainbow trout spawning habitats have been reported in Finger and lower Cabin Creeks. Previous studies identified habitat enhancement opportunities to increase spawning habitat in Finger Creek and the restoration of overwintering and spawning habitat in Cabin Creek. A number of flow enhancement strategies (i.e., beaver dam and debris jam removal, channelizing drainages and wetlands, flow enhancement structure) combined with potential gravel substrate placement have been proposed to enhance fish habitat for kokanee and rainbow trout. Increased flows are intended to maintain spawning gravels within these reaches and prevent dewatering and improve wintering habitat in Cabin Creek	Field surveys conducted in 2012 determined that lower Cabin Creek was completely dewatered at the time of survey. As a result, any of the proposed water augmentation projects at this location are considered high risk and will require on-going maintenance and monitoring. Water levels in Finger Creek were low at the time of survey but sufficient to support spawning activities in discrete gravel pockets. Many kokanee carcasses, redds, and other indicators were apparent that demonstrated a highly successful kokanee spawning run during the dry summer/fall of 2012. The installation of a flow enhancement structure was considered technically possible but unlikely to significantly increase the productive capacity of the available spawning habitat. This option is no longer considered biologically viable.
2	Creation and Maintenance of Sutherland River Watershed Habitats	Offsetting	Off-Site	Sutherland River supports a limited amount of critical fish habitat, a rare type of large-bodied rainbow trout, as well as kokanee and other salmon that utilize this habitat. The lack of rainbow trout and kokanee spawning sites in the lower 25 km has been attributed to beaver dams, extensive wetlands, and meandering slough like morphology. Enhancement opportunities that have been identified include the creation of spawning habitat in artificial channels, working with BC Timber sales to establish proper drainage and sediment control structures, and mainstem flow regulation strategies (i.e., bendway weirs, defection spurs, artificial log jams) to control peak flows caused by logging.	Poor road access is reported to be the most challenging aspect of project. Therefore, any work will be difficult to justify until access improves from logging. Sediment inputs and other logging impacts will need to be managed through proper land management practices by BC Timber sales. Artificial spawning channels and mainstem flow regulation techniques are typical but potentially ineffective at managing issues associated with peak flows. These techniques have a high risk of structural failure and often require substantial maintenance. For these reasons, this option is no longer being considered.
5	Nechako White Sturgeon Recovery Initiative	Offsetting	Off-Site	Nechako White Sturgeon Recovery Initiative (NWSRI) is responsible for identifying the reasons why white sturgeon are no longer successfully spawning and surviving in the Nechako watershed. They are also responsible for the design and implementation of habitat protection, restoration and management objectives. Two main opportunities are: a) funding to construct and operate a conservation aquaculture or 'recovery' facility in Vanderhoof, and b) funding to support active investigations of habitat requirements, communication programs, and potential habitat rehabilitation, enhancement, and habitat creation projects.	Consultation will be required to determine timelines, partnership and funding opportunities, and potential priorities and/or candidate sites that have been identified for completing fish habitat enhancements/restoration projects. Recently, full funding has been received for a white sturgeon hatchery in Vanderhoof on the Nechako River. Other funding and habitat enhancement opportunities may exist but will be dependent on acceptance by regulators. This option is more monetarily or research-based and is therefore no longer considered applicable to offsetting the Project.
6	Restoration of Fish Passage in the Fort St. James District	Offsetting	Off-Site	In 2005/2006 a fish passage culvert assessment study conducted in the Fort St. James Forest District for the Ministry of Forests identified potential stream crossing barriers and assessed habitat in anticipation of future funding through the Forest Investment Account. Thirty-two out of the 35 originally identified sites still require restoration. This alternative will include implementing enhancement measures to existing problem culverts to remove blockages, decrease velocity/perching barriers, or removing and replacing closed-bottom culverts with open-bottom structures where enhancements will not be effective.	This option is technically feasible. However, the Fort St. James Forest District is much further away from the Project than the Vanderhoof Forest District where fish-barrier culverts are being included as part of the offsetting plan. For this reason, this option is no longer being considered.
7	Nechako Fisheries Conservation Program (NFCP)	Offsetting	Off-Site	The Nechako Fisheries Conservation Program (NFCP) was designed to evaluate and manage the decline in chinook and sockeye salmon populations in the Nechako River watershed, as a result of changes to flow from construction and operation of the Kenney Dam. Multiple programs that range from 1 to 13 years old have been established to monitor, apply remedial measures, and research populations of chinook and sockeye. There are potential funding and habitat enhancement opportunities for both existing and proposed projects that could be used to meet offsetting requirements for the Project.	Consultation will be required to determine timelines, partnership and funding opportunities, and potential priorities and/or candidate sites that have been identified for completing fish habitat enhancements/restoration projects. Funding and habitat enhancement opportunities may exist but are dependent on acceptance by regulators and ability to contribute benefits towards offsets.
8	Nulki-Tachik Watershed Restoration Program	Offsetting	Off-Site	The Carrier Sekani Tribal Council, Saik'uz First Nation initiated a large scale watershed restoration project in the 1990's within the Nulki-Tachik watershed to restore habitat for native salmonids, in particular rainbow trout. This project focused on obtaining viable fisheries population data and habitat restoration through the construction of rearing sites (large woody debris structures), riparian restoration and fishing pressure monitoring. There may be potential funding and partnership opportunities with the Carrier Sekani Tribal Council/Saik'uz First Nation to develop habitat creation/enhancement opportunities.	Consultation with First Nations will be required to understand the current status of this program and potential opportunities. Habitat enhancement opportunities may exist but nothing specific has been identified to date. This potential option is far from the Project and is no longer being considered at present but could be re-visited as a contingency option pending consultations with the Saik'uz First Nation and DFO.
10	Stoney Creek Rehabilitation Project	Offsetting	Off-Site	Offsetting opportunities were investigated in Stoney Creek with a steering member of NEWSS during 2012 aerial surveys near Vanderhoof, BC. Five road crossings with large culverts that may limit upstream passage under some flow conditions were found in the lower 10 km section of Stoney Creek. Fish habitat restoration options in this section include: enhancing migration opportunities through some or all of the culverts; constructing rearing habitat through the agricultural section and the Nechako River floodplain; and, possible spawning habitat development or improvement in the section between the agricultural area and the impassable falls.	Successful fish habitat rehabilitation in the lower Stoney Creek watershed may be complicated by periodic and reportedly unpredictable back flooding by the Nechako River. It is unclear without further study whether fish habitat rehabilitation will be successful under these conditions. In addition, a lawsuit between the Saik'uz and Stellat'en First Nations and Rio Tinto Alcan that includes alleged degradation of fish habitat in Stoney Creek due to the regulation of Nechako River discharge is on-going and may complicate efforts to rehabilitate fish habitats. For these reasons, this option is no longer being considered.

Annex H

Case Histories of Overwintering Pond Success for Rainbow Trout

MEMORANDUM

DATE: April 2, 2014

TO: Brad Horne M.Sc., R.P.Bio

FROM: Alan Thomson MRM P.Eng

REFERENCE: Juvenile rainbow trout utilization of overwintering ponds in northern BC

1. INTRODUCTION

Compensation for the loss of fish habitat due to mine footprint and operations will be required at New Gold's proposed Blackwater project in the central Interior of British Columbia. One of several fish habitat compensation project types proposed in a preliminary submission (AMEC, 2013a) to Fisheries and Oceans Canada is the creation of three large overwintering ponds for use by rainbow trout (Oncorhynchus mykiss). These ponds are located in the mid sections of Davidson Creek watershed, and in the upper 661 Creek watershed.

During an onsite visit involving New Gold representatives and Ministry of Environment officials, the officials requested additional information concerning the effectiveness of overwintering ponds for rainbow trout. The purpose of this memo is to provide a summary of the current understanding of rainbow trout use of lacustrine habitats in winter and to provide case histories of overwintering pond use by rainbow trout in northern BC and Alberta.

2. BACKGROUND INFORMATION

2.1 Literature Review of Rainbow Trout Overwintering Habitat Requirements

Rainbow trout select overwintering habitats that reduce energy expenditure to maximize survival in harsh conditions. Preferred habitats are in stream sections with low water velocities, pool depths deep enough to provide cover in low discharge conditions, and areas with a reasonably accessible food supply (Anderson, 2002). Juvenile trout tend to hide in the interstitial spaces in the substrate in winter (Bjornn and Reiser, 1991) and the interstitial spaces between larger substrates are preferred (Gregory and Griffith, 1996). Under-yearling rainbow trout are known to rear in seepage-fed ponds and side channels when these habitats are available (Slaney, 1997).

Low flow conditions in winter and summer are often cited the factor most limiting trout production in streams. Refuge from low water temperatures, ice formation, and low flows during winter may be equally or more critical than the availability of summer rearing habitat during low flows (Raleigh et al. 1984).

A critical variable for overwintering trout is dissolved oxygen (DO) concentrations. Dissolved oxygen concentrations <3 mg/L are lethal for rainbow trout (Alabaster et al. 1957; Davis 1975) although there are local examples of fish overwintering in small lakes and ponds with DO concentrations <3mg/L (see Sections 2.3, 4.3 and 4.4 below). Growth and survival of rainbow trout increases significantly at DO concentrations >5 mg/L (Bjornn and Reiser, 1991; Raleigh et al. 1984) and DO

concentrations >7 mg/L or near saturation are preferred (Ford, 1995). Sources of oxygenated water in winter include open-water areas upstream or groundwater seepage (Anderson, 2002).

Based on these criteria, ideal overwintering habitat for juvenile rainbow trout are deep (>2 m) pools with cobble/boulder substrates, overhead and in-water cover, and a source of oxygenated water. This type of habitat is naturally available in streams with adequate and consistent winter discharge and deep pools or in ponds with adequate dissolved oxygen concentrations.

2.2 Rainbow Trout Life History – Blackwater Project Area

Rainbow trout populations typically fall into one of three life history types: populations that spawn in small streams and move to larger streams to mature; those that spawn and remain in small streams their entire lives; and those that spawn in streams and migrate to lakes to rear and mature. Fisheries studies in the watersheds at the Blackwater Project site have determined that rainbow trout found in Davidson Creek and Creek 661 in summer and winter are juveniles of a lake resident rainbow trout population that resides in Tatelkuz Lake or Chedakuz Creek (AMECb, 2013). Adults enter Davidson Creek and Creek 661 in spring to spawn and then return downstream to forage and overwinter (AMECb, 2013). Following emergence, juvenile rainbow trout spend one or two years in Davidson Creek and Creek 661 before moving downstream to Tatelkuz Lake or Chedakuz Creek to grow, mature and overwinter. This behavior is particularly common for fry in outlet streams (Ford, 1995) such as Davidson Creek. Sampling data suggest that stream resident populations of rainbow trout are absent in Davidson Creek and Creek 661 (AMEC, 2013).

2.3 Overwintering Habitat – Blackwater Project Area

Overwintering conditions in various pool locations in Davidson Creek and Creek 661 watersheds were investigated in March 2012 (AMECb, 2013). Sites were located in pools identified during the summer surveys as those most likely to provide overwintering habitat for trout.

Based on under-ice dissolved oxygen concentrations, four of the five stream sites sampled in the Davidson Creek Watershed in March 2012 had good quality overwintering habitat (i.e., mean DO concentrations greater than 7 mg/L) for rainbow trout (Table 1). The exception was the site in Creek 428073, a pond site in a tributary to Davidson Creek, where overwintering habitat quality was poor because of dissolved oxygen concentrations <5 mg/L.

Table 1: Overwintering Conditions 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

Although dissolved oxygen concentrations were suitable for rainbow trout at most sites sampled, the mean depth of water beneath the ice was low, ranging from 0.15 to 0.60 m. Because these sites were specifically selected in pools most likely to provide depths suitable for overwintering fish, the total volume of overwintering habitat available to juvenile rainbow trout in Davidson Creek is assumed to be low. More overwintering habitat is available in Chedakuz Creek by comparison.

Mean DO concentrations exceeded 9 mg/L in a pond in Creek 661 and in pool habitat in Creek 505659, a Creek 661 tributary in March 2012 (Table 2). Based on these results, both sites were rated as having good quality overwintering habitat for rainbow trout. A third site, in another Creek 661 tributary, had no overwintering habitat due to the absence of water.

Table 2: Overwintering Conditions 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

Mean water depth under the ice was <0.1 m in the site in the Creek 661 mainstem and 0.85 m at the site in Creek 505659 (Table 2). Because of this, the total volume of overwintering habitat available to juvenile rainbow trout in Creek 661 was assumed to be low, similar to Davidson Creek.

3. OVERWINTERING POND DESIGN CONSIDERATIONS

Hartman and Miles (2001) conducted a review of trout habitat management in BC in order to determine the effectiveness of compensation measures used to create rainbow trout habitat. As part of the review, they examined trout use of constructed pond habitats. Although Hartman and Miles omit detailed descriptions of each project, they list some of the factors affecting project success that are relevant to the proposed ponds at the Blackwater Project site:

- Stable water supply and water level;
- Presence of groundwater inflow;
- Presence of both an inflow and outflow channels;

- Riparian vegetation and reclamation activities that provide a source of nutrients;
- Adequate water quality;
- Sufficient littoral area that provides primary production. Excessive littoral area results in warm water temperatures and increased frequency of winterkill.
- Physical stability of the littoral areas; and
- Suitable inlet and outlet spawning habitats.

4. OFF-CHANNEL OVERWINTERING HABITAT –CASE HISTORIES

In northern BC, there are few examples of where overwintering ponds have been developed specifically for rainbow trout that are self-sustaining and do not require periodic stocking. However there are numerous examples of pond development in BC for other fish species.

4.1 Salmon Restoration - Coastal BC

Pond creation for overwintering of juvenile anadramous species (particularly coho and chum salmon) is common in coastal watersheds (Slaney, 1997) and is often highly successful. Many off-channel ponds and side-channels have been constructed in the lower mainland area, on Vancouver Island, and in the Squamish area (Slaney, 1997). Such ponds are typically groundwater fed and are complexed with large wood and boulders. Juveniles overwinter for 1-2 years before out-migrating to marine environments. Many coastal ponds differ from northern BC ponds in that they remain ice-free except for brief and infrequent periods when the air temperature remains below freezing.

4.2 Lacustrine habitat development for rainbow trout in Alberta

In a literature review of compensation project creation for rainbow trout, Hartman and Miles (2001) found several examples of successful creation of lacustrine trout habitat in coal mine end pits in Alberta. Of the six projects examined, 83% were considered either a moderate (50%) or outstanding (33%) success. The factors that contributed to the success of these projects are those listed in Section 2.

4.3 Rainbow Trout Overwintering – Galore Creek Mine Project

In northern BC, a recent overwintering 4,500 m^2 pond targeting Dolly Varden was recently developed in the More Creek watershed as fish habitat compensation at the Galore Creek mining project. Initial effectiveness monitoring of the overwintering pond indicate that Dolly Varden are successfully using the pond to overwinter (RTEC, 2012) and that water quality parameters are above lethal limits in most pond sections.

Dolly Varden are not commonly observed overwintering in ponds although Dolly Varden are more abundant in off-channel habitats in northern streams (Slaney, 1997). Dolly Varden are also known to extensively use beaver dam impoundments in southern Alaska (Slaney, 1997).

4.4 Rainbow Trout Overwintering – Mt. Milligan Project

An example of a recently constructed overwintering pond for rainbow trout is at Thompson Creek Metal's Mount Milligan project located 120 km north of Vanderhoof in the Nation River watershed. Three off-channel overwintering ponds that target rainbow trout in the upper watershed are part of the suite of compensation projects accepted by agencies as appropriate compensation for lost rainbow trout habitat in King Richard Creek.

Two off-channel overwintering ponds of approximately 12,444 m^2 (Upper Rainbow Cr. Pond) and 9,514 m^2 (Lower Rainbow Cr. Pond) each have been constructed to date within the Rainbow Creek floodplain. Both ponds rely on groundwater as their primary water source although both have minor surface flow inputs. Both ponds are flushed in spring by over-flow from the adjacent Rainbow Creek.

In the upper Rainbow Creek overwintering pond dissolved oxygen concentrations at depth decreased from December to March during the winter of 2012/2013 (AMEC 2012c; Table 3). In December 2012, average DO concentrations ranged from 6.0 mg/L just below the ice to 2.2 mg/L near the bottom of the pond. Average DO concentrations had decreased to 2.3 mg/L below the ice and to <1 mg/L near the bottom by March 2013. Similar results are not yet available for the lower Rainbow Creek overwintering pond as this pond has yet to be connected to Rainbow Creek.

Although DO concentrations were below the published lethal limit for rainbow trout in the upper Rainbow Creek pond in March 2013, rainbow trout were observed in the pond in the spring/summer of 2013. The presence of these fish indicate that rainbow trout were able to survive in the pond during the winter of 2012/2013. Similar survival of rainbow trout at near anoxic conditions has also been observed in Alpine Lake, a small headwater lake of Rainbow Creek located adjacent to the Mt. Milligan Tailings Impoundment. An estimated 1,270 ±174 rainbow trout reside in this lake despite winter dissolved oxygen concentrations < 3 mg/L each winter (AMEC, 2013d).

Table 3: Dissolved Oxygen Concentrations in Upper Rainbow Overwintering Pond at Mt. Milligan, winter 2012/2013

December 2012				January 2013				March 2013			
Depth under ice (m)	N	Average DO (mg/L)	DO Range (mg/L)	Depth under ice (m)	N	Average DO (mg/L)	DO Range (mg/L)	Depth under ice (m)	N	Average DO (mg/L)	DO Range (mg/L)
0.35	6	6.0	5.4-6.6	0.5	15	5.3	2.8-7.4	0.5	4	2.3	2.0-2.4
0.85	6	4.4	2.5-6.2	1.0	12	3.3	2.6-4.5	1.0	4	1.3	0.9-1.4
1.35	5	3.1	1.6-4.6	1.5	10	2.1	1.2-2.5	1.5	4	0.3	0.2-0.4
1.85	3	2.8	2.7-2.9	2.0	10	1.0	0.4-1.5	2.0	2	0.5	0.2-0.8
2.35	3	2.2	1.1-2.9	2.5	8	0.5	0..2-0.8				
				3.0	1	0.3	-				

Note: n = # of holes

5. SUMMARY

Development of overwintering ponds specifically for rainbow trout is not common in northern BC. Compensation projects typically focus on rehabilitating or restoring degraded stream habitats that can support spawning and rearing habitats. However, there are sufficient examples of lacustrine rainbow trout habitat development (Mt. Milligan and the six case studies examined by Hartman and Miles) to indicate that if located, designed and constructed properly, as described by Hartman and Miles (2001), development of lacustrine overwintering habitat for juvenile trout can be successful. The projects proposed for the Blackwater site all have good groundwater or surface water sources, a critical feature for maximizing the likelihood of pond use by trout. Suitable spawning areas also exist upstream and/or downstream of the pond locations. This increases the likelihood of fry or juvenile rainbow trout finding and entering the ponds. Lastly, littoral zones and in-pond features can be designed to ensure that an appropriate balance between littoral and pelagic environments is created to minimize low dissolved oxygen in winter resulting from excessive littoral zone macrophyte decomposition and oxygen demand.

6. REFERENCES

Alabaster, J.S., D.W.M. Herbert, and J. Hemens. 1957. The survival of rainbow trout and perch at various concentrations of dissolved oxygen and carbon dioxide. Ann. Appl. Biol. 45:177-188.

AMEC. 2013a. Blackwater Gold Project: Preliminary fish habitat mitigation and compensation plan. Prepared for New Gold Inc. Vancouver BC by AMEC Environment & Infrastructure, Burnaby, BC.

AMEC. 2013b. Fish and Aquatic Resources 2011-2012 Baseline Report. Appendix 5.1.2.6A of the Blackwater Project Environmental Application. New Gold Inc.

AMEC. 2013c. Fish Habitat Compensation Monitoring: Mt. Milligan Copper/Gold Project. A report submitted to Thompson Creek Metal Company by AMEC Environment & Infrastructure, Burnaby, BC.

AMEC. 2013d. 2012 Alpine Lake Monitoring Report. Submitted to Thompson Creek Metal Company by AMEC Environment & Infrastructure, Burnaby, BC.

Anderson, J. 2002. Overwintering use by stream-dwelling salmonids of small to mid-sized systems in the Peace Region: a literature review. A report prepared for Fisheries Renewal BC, Peace-Liard Watershed Council by J. Anderson, BC Conservation Foundation, Prince George, BC.

Bjornn, T.C., and D.W. Reiser. 1991. Habitat requirements of salmonids in streams. Chapter 4 in Influences of Forest and Rangeland Management of Salmonid Fishes and their Habitat. W. Meehan ed. American Fisheries Society Special Publication 19.

Cunjak, R.A., 1996. Winter habitat of selected stream fishes and potential impacts from landuse activity. Can. J. Fish. Aquat. Sci. 53(Suppl. 1):267-282.

Ford, B.S., P.S. Higgins, A.F. Lewis, K.L. Cooper, T.A. Watson, C.M. Gee, G.L. Ennis, and R.L. Sweeting. 1995. Literature reviews of the life history, habitat requirements, and mitigation/compensation strategies for thirteen sport fish species in the Peace, Liard, and Columbia river drainages in British Columbia. Can. Manu. Rep. Fish. Aquat. Sci. 2321. 342 p.

Hartman, G., and M. Miles. 2001. Assessment of techniques for rainbow trout transplanting and habitat management in British Columbia. Can. Manu. Rep. Fish. Aquat. Sci. No.2562.

McPhail, J.D. 2007. The freshwater fishes of British Columbia. The University of Alberta Press.

Raleigh, R.F., T. Hickman, R.C. Solomon and P.C. Nelson. 1984. Habitat suitability information: rainbow trout. U.S. Fish Wildl. Serv. FWS/OBS-82/10.60. 64 pp.

RTEC. 2012. Galore Creek Project: 2012 Fish Habitat Compensation Monitoring Report. Prepared for Galore Creek Mining Corporation by Rescan Tahltan Environmental Consultants: Smithers, British Columbia.

Slaney, P.A., and D. Zaldokas [editors]. 1997. Fish habitat rehabilitation procedures. Province of B.C., Ministry of Environment, Lands and Parks, and Ministry of Forests. Vancouver, B.C. Watershed Restoration Technical Circular No. 9:341p.

Annex I

Mathews Creek Baseline and Offsetting Opportunities Identification

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Blackwater Project

Mathews Creek Watershed Fish and Fish Habitat Baseline Assessment and Offsetting Plan

Prepared for

AMEC Environment & Infrastructure

December 6, 2013

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

*475 Howe Street, Suite 1030, Vancouver, BC V6C 2B3 **t** 604-629-9075*

December 6, 2013

Brad Horne, M.Sc., R.P.Bio.
Senior Fisheries Biologist
AMEC Environment & Infrastructure
4445 Lougheed Highway
Burnaby, BC V5C 0E4

Dear Mr. Horne,

Re: Blackwater Project: Mathews Creek Watershed Fish and Fish Habitat Baseline Assessment and Offsetting Plan

Palmer Environmental Consulting Group Inc. is pleased to submit the attached final report describing results of the Fish and Fish Habitat Baseline Assessment and Offsetting Plan for the Mathews Creek watershed, completed in support of the Blackwater Project.

This report characterizes the existing fish communities and habitat conditions within the Mathews Creek watershed, and provides a preliminary plan for fish habitat offsetting through restoration and enhancement of sections of Mathews Creek and its tributaries impacted by past agricultural activities.

If you or technical reviewers have any questions, please feel free to contact Rick Palmer at 604-629-9075 or at rick@pecg.ca.

We appreciate the opportunity to work with you on this interesting project and look forward to assisting further as the project advances into detailed design and permitting.

Yours truly,

Palmer Environmental Consulting Group Inc.

R. Palmer

Rick Palmer, M.Sc. R.P.Bio.
President, Senior Fisheries Biologist

Distribution List

# of Hard Copies	PDF Required	Association / Company Name
	Yes	New Gold
	Yes	AMEC

Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	R. Palmer (PECG)	November 8, 2013	Senior Review
2	B. McLeod (AMEC)	November 12, 2013	Prime Consultant Review
3	N. Fisher (New Gold)	November 13, 2013	Client Review

Signatures

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Report Reviewed By:



Rick Palmer, M.Sc., R.P.Bio.
President, Senior Fisheries Biologist

Executive Summary

AMEC Environment & Infrastructure is developing a Fish Habitat Mitigation and Offsetting Plan to be submitted as part of an Environmental Assessment and project application for New Gold's Blackwater Project, a gold-silver mine located approximately 160 km southwest of Prince George, in central British Columbia. The Mathews Creek Watershed Habitat Offsetting Plan has been identified as an opportunity to offset residual impacts to fish habitat and wetlands in the nearby project area. In support of habitat offset planning, Palmer Environmental Consulting Group Inc. has completed a reconnaissance-level fish and fish habitat baseline assessment for Mathews Creek and developed a preliminary fish habitat restoration and enhancement plan designed to maintain or enhance the ongoing productivity and sustainability of local fisheries.

Mathews Creek watershed is situated within the Nechako Plateau, an area exhibiting rolling terrain with forested or meadow-covered valleys and subalpine to alpine hilltops. Since the mid-20th century, human activity in the watershed has steadily increased. The most extensive disturbances occurred along the middle reaches of Mathews Creek, where past methods of cattle ranching has resulted in lowered groundwater tables through drainage ditch excavation, widespread removal of riparian vegetation, and trampling and collapse of channel banks. The objectives of the Mathews Creek Watershed Offsetting Plan are to restore and enhance in-stream, riparian and wetland habitat, in order to increase the productive capacity of habitats utilized by rainbow trout and other aquatic and terrestrial species.

Field work was completed along Mathews Creek and its minor tributaries in late September and early October, 2013. A reconnaissance-level assessment of the fish community in Mathews Creek was completed through electrofishing and minnow trapping at sites within, upstream and downstream of the ranchland. Fish habitat assessments were completed following either the *Fish Habitat Assessment Procedures* or the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory*. Baseline streamflow monitoring was initiated to document flow, water quality and stream temperatures. Geomorphic channel surveys were completed at key sites to support the design of habitat offsetting efforts. Georeferenced aerial videography of Mathews Creek was acquired from its mouth at Laidman Lake to its headwaters.

Three main opportunities for fish habitat offsetting have been identified and developed at a conceptual design level. First, restoration and enhancement of the most severely impacted sections of Mathews Creek within the former ranchland is proposed (15,380 m^2 potential habitat gain). Second, a sinuous, groundwater-fed tributary that has been trampled and nearly blocked with in-stream vegetation will be reconstructed, given its important contributions to baseflow and off-channel rearing opportunities (700 m^2 potential habitat gain). Third, a narrow drainage ditch descending a gentle, lower valley side will be replaced with a small, meandering tributary to convey groundwater flow and seasonal runoff (880 m^2 potential habitat gain). Several other drainage ditches on the north side of Mathews Creek are proposed to be filled in support of wetland restoration efforts, with mutual benefits anticipated for fish habitat along Mathews Creek.

Details on the proposed environmental management plan, construction and effectiveness monitoring, and cattle management will be prepared in association with detailed design and project permitting, building on the key principles identified in this report.

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1 Introduction

New Gold Inc. (New Gold) proposes to develop the Blackwater Project, a gold-silver mine located approximately 160 km southwest of Prince George, in central British Columbia (**Figure 1-1**). AMEC Environment & Infrastructure (AMEC) is developing a Fish Habitat Mitigation and Offsetting Plan (FHMOP) that will be submitted as part of an Environmental Assessment (EA) and project application for the Blackwater Project in January 2014. One of the habitat offsetting opportunities that has been identified is the rehabilitation of the Mathews Creek watershed, within which past agricultural activity has resulted in local impacts to aquatic and terrestrial ecosystems along Mathews Creek.[1]

In support of its FHMOP, AMEC retained Palmer Environmental Consulting Group Inc. (PECG) to conduct a reconnaissance-level baseline field program and develop a preliminary fish habitat offsetting plan for the Mathews Creek watershed. Fish habitat restoration and enhancement efforts are proposed to be integrated with wetland restoration and creation opportunities, which are currently being developed by AMEC in consultation with wetland ecologists from the British Columbia provincial government.

This document outlines the results of the baseline fish and fish habitat program and presents the preliminary fish habitat offsetting plan for the Mathews Creek watershed. In support of the project application, it demonstrates to Fisheries and Oceans Canada (DFO) New Gold's commitment to developing effective fish habitat offsetting strategies. Detailed designs for fish habitat offsetting measures will be provided to DFO in association with New Gold's subsequent request for authorization of a permanent alteration to, or destruction of, fish habitat.

1.1 Blackwater Project Overview

The Blackwater Project is a proposed open pit gold and silver mine situated approximately 110 km southwest of Vanderhoof (straight-line distance) in central BC, approximately 160 km southwest of Prince George (5893000 N and 375400 E) (**Figure 1-1**). The project is currently in the advanced exploration phase, with mine construction expected to begin in 2015 with mining operations commencing in 2017. The proposed project would represent an annual average production of 507,000 oz of gold and 2,039,000 oz of silver during 17 years of operations.

A summary of the proposed mine components and facilities is provided below and presented on **Figure 1-1**. Each of the following descriptions is based on "Blackwater Gold Project – Draft Application Information Requirements", soon to be submitted by New Gold to the British Columbia Environmental Assessment Office for the Application for an Environmental Assessment Certificate pursuant to the British Columbia *Environmental Assessment Act*:

[1] It is important to emphasize that while certain *past* agricultural activities have resulted in localized ecological impacts to Mathews Creek and its minor tributaries, responsible agricultural land use can certainly accommodate and support functional in-stream and riparian ecosystems.

364000 368000 372000 376000 380000 384000 388000 392000

5912000 5908000 5904000 5900000 5896000 5892000 5888000

Proposed Transmission Line
Proposed Airstrip
Proposed Mine Access Road
Tatelkuz Lake
Proposed Airstrip Access Road
Ootsa FSR
Davidson Creek
Proposed Water Pipeline Route
Freshwater Pumpstation
Snake lake
Top Lake
Seepage Collection Trench
Sand and Gravel Screening Plant
Esker
Borrow Source
Proposed Mine Footprint
Topsoil
Diversion Ditches
Freshwater Reservoir
Environmental Control Dam (ECD)
Fawnie Creek
Site C Main Dam Borrow Source
Pond
Topsoil Stockpile
Emergent Vegetation Wetland
Exploration Road
Bog/Wetland Area
Pond
Upland Beach
Construction Camp
Truck Shop
Site C West Dam
Construction Laydown 1
Plant Site
Proposed Mine Site
Operation Camp
Diversion Ditches
Low-Grade Stockpile
East Dump
West Dump
Open Pit
Explosive Facilities
Chedakuz Creek
Kuyakuz Lake
Mathews Creek

N

Legend

- Existing Road
- Ootsa FSR
- Exploration Road
- Proposed Airstrip Access Road
- Proposed Mine Site Access Road
- Proposed Transmission Line
- Contour (20 m)
- Stream
- Waterbody
- Proposed Mine Footprint
- Proposed Mine Site
- Bog / Wetland Area
- Dam
- Dump
- Embankment Fill
- Emergent Vegetation Wetland
- Environmental Control Dam (ECD)
- Borrow Source
- Fresh water Reservoir
- Low-Grade Stockpile
- Open Pit
- Plant Site
- Pond
- Tailings Beach
- Top Soil
- Topsoil Stockpile
- Upland Beach

KEY MAP



Scale:1:100,000

0 1 2 4

Kilometres

Reference

BC Government GeoBC Data Distribution

CLIENT: newgold

PROJECT: Blackwater Gold Project

Proposed Mine Site Facilities and Access Road Year 17

DATE:	ANALYST:	
November, 2013	MY	**Figure**
JOB No: VE52095	QA/QC: AP	PDF FILE: 10-100-188_site_facilities_17_minsite.pdf
GIS FILE: 10-100-188_site_facilities_17.mxd		
PROJECTION: UTM Zone 10	DATUM: NAD83	amec

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- **Mine Site** – Occupies approximately 4,400 ha and accommodates all mine, ore processing, mine waste, water supply and management, and on-site infrastructure;
- **Open Pit** – Footprint of approximately 238 ha with approximate dimensions of 2 km from east to west and 1.5 km from north to south, with an anticipated depth of 550 m below ground surface;
- **West Waste Rock Dump** – Footprint of approximately 172 ha to store 78 Mt of non-acid generating rock (NAG) 4, NAG 5 and overburden with an elevation of 1,535 m (160 m high);
- **East Waste Rock Dump** – Footprint of approximately 158 ha to store 57 Mt of Type 5 NAG and overburden with an elevation of 1,590 m (105 m high);
- **Low Grade Stockpile** – Footprint of approximately 76 ha to store 95 Mt of low-grade ore;
- **Construction Camp** – 8 ha with the capacity to accommodate 800 to 1,200 personnel during the construction phase;
- **Tailings Storage Facility (TSF)** – Footprint of approximately 1,117 ha comprising Cell C, which occupies 192 ha, and Cell D, which occupies 925 ha. The maximum elevation of the main dam for Cell D is 1,339 m (149 m high). The TSF is designed to store a total of 833 Mt of both tailings and Potentially Acid Generating (PAG) waste rock as follows:
    - 397 Mt of tailings;
    - 313 Mt of Type 1 (PAG1) waste rock;
    - 62 Mt of Type 2 (PAG2) waste rock; and
    - 61 Mt of Type 3 (NAG3) waste rock;
- **Plant Site** – Occupies approximately 35 ha with industrial buildings to process 60,000 t/d (22 Mt/y) of ore and produce 500,000 oz of ore. This surface includes the crusher and the conveyor. The plant site is located at an elevation of 1,425 m. The plant site will have an area for storage of hazardous materials (e.g., cyanide) and it will also include the core logging area;
- **Operations Camp** – Occupies approximately 5 ha with buildings to accommodate up to 400 personnel during the operations phase;
- **Topsoil Stockpile** – Footprint of approximately 10 ha distributed in two locations within the mine site;
- **Borrow Areas** – 73 ha comprising 30 ha for the Site C main dam and 43 ha for the Site D main dam. The borrow areas also include a sand and screening plant;
- **Transmission Line** – Occupies approximately 550 ha – 133 km long, 230 kV line over a right of way 40 m wide;
- **Mine Access Road** – Starting at km 25 of the Kluskus-Ootsa Forest Service Road and occupies approximately 28 ha – 15 km long over a right of way 20 m wide;

- **Freshwater Supply System** – Freshwater requirements will be met by pumping water from Tatelkuz Lake via a 20 km-long pipeline to a receiving area within the mine site. This water will be used for ore processing and flow maintenance in Davidson Creek. The pipeline will be placed adjacent to a road approximately 5 to 10 m wide, depending on local ground conditions. The pumping station will be located on the shores of Tatelkuz Lake, and during construction a laydown area will be required to support the construction activities. It is anticipated that the area required will be approximately 100 m x 100 m; and
- **Airstrip** – An approximately 2 km long and 200 m wide airstrip will be built in the proximity of the mine site with its location selected with consideration of existing land use, access and environmental conditions.

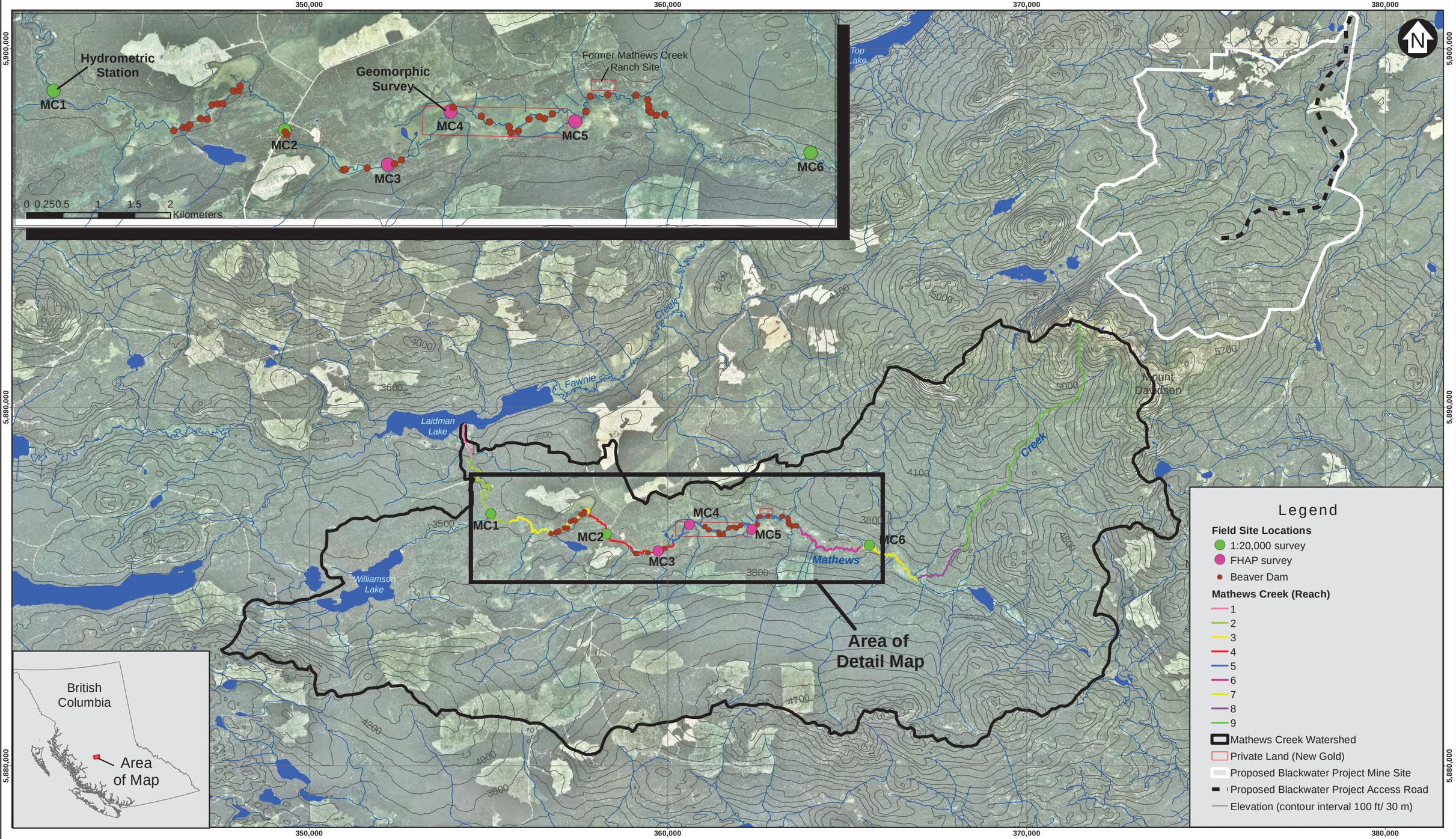
Further details are provided in the above referenced document and its accompanying appendices.

1.2 Mathews Creek Watershed Habitat Offsetting Plan

1.2.1 Fish Habitat Offsetting

The Mathews Creek Watershed Habitat Offsetting Plan has been identified as an opportunity for offsetting residual impacts to fish habitat and wetlands within the nearby Blackwater Project area. Mathews Creek watershed is west of, and adjacent to, the Davidson Creek watershed, within which most of the Blackwater Project is located (**Figure 1-2**). Past agricultural activity alongside the middle reaches of Mathews Creek (i.e., Reaches 3, 4 and 5, **Figure 1-2**), where the valley bottom is broad and nearly flat, has resulted in localized impacts to aquatic and terrestrial ecosystems. Impacts are primarily the result of vegetation clearing and drainage ditch excavation to accommodate agricultural activity, cattle trampling of the floodplain and channel banks, and little to no maintenance of bridges and fence lines (details on anthropogenic impacts are provided below in Section 3.2). The most severe impacts are concentrated within the valley bottom along Reach 5, around two areas of private land (**Figure 1-2**). New Gold recently purchased this private land, in part recognizing the opportunities it provides for fish habitat offsetting through well planned restoration and enhancement efforts.

The effectiveness of fish habitat offsetting measures within the Mathews Creek watershed requires an understanding of the local fish community and its utilization of existing habitats – undisturbed and impacted. PECG's role in this project was to gain the necessary understanding of baseline fish and fish habitat, and, based in part on this information, develop and prioritize opportunities to restore, create and enhance fish habitat. In particular, PECG's fall 2013 scope of work had several key objectives in support of fish habitat offsetting for the Mathews Creek Watershed Habitat Offsetting Plan:



PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

DESIGNED	RM
DRAWN	KP
CHK'D	RM
APP'D	RP
REV	-
DATE	28'10'13

NOTES:
1. BASE MAP: CanVec 920F2 and 920F3
2. PROJECTION: NAD 1983 UTM Zone 10N
3. COORDINATE GRID: Metres
4. ORTHOPHOTOGRAPY:From 2000/2001 from BC provincial government

0 2 4 6 8 10 12
KILOMETRES

newgold

Blackwater Project

Mathews Creek Watershed Overview

FIGURE 1-2

- Conduct a reconnaissance-level baseline program to document existing fish and fish habitat conditions and establish biological rationale for habitat offsetting measures;
- Provide an understanding of current fish habitat utilization (species composition, distribution and relative abundance) from both desktop review and fish sampling;
- Initiate baseline water quality sampling and stream flow data collection;
- Characterize the existing quantity and quality of habitat within the main impacted reach of Mathews Creek;
- Develop and prioritize habitat restoration and enhancement strategies for private and Crown land areas within the main impacted sections of Mathews Creek watershed; and
- Quantify the spatial area gained through habitat restoration, creation and enhancement opportunities.

For project-wide consistency, AMEC is responsible for incorporating the findings and recommendations of this report into its modeling of potential gains in offsetting habitat. AMEC is also leading the integration of mutually beneficial fish habitat and wetland restoration efforts.

1.2.2 Wetland Restoration

Wetland ecologists with the British Columbia provincial government have also identified the impacted sections of the Mathews Creek watershed as candidate areas for wetland restoration. AMEC is now leading the multi-disciplinary approach for integrating wetland restoration with the overall fish habitat offsetting strategies outlined in this report. Wetland restoration and fish habitat offsetting measures can be mutually beneficial when designed giving consideration to the priorities and constraints of the other. Accordingly, AMEC's wetland restoration team is undertaking a scope of work with the following main objectives:

- Improve water quality functions in wetlands that have been altered by human activities;
- Improve hydrologic processes in wetlands that have been altered by human activities;
- Improve wetland habitat that has been altered by human activities; and
- Improve fish habitat, water quality and thermal regulation in Mathews Creek.

1.3 Land Tenure

The opportunities for fish habitat offsetting and wetland restoration identified in this report are concentrated within two areas of private land owned by New Gold and extend into surrounding areas of Crown land (**Figure 1-2**). New Gold is working with the British Columbia Ministry of Forests, Lands and Natural Resource Operations (MFLNRO) to determine how the range tenure it now holds in this area, following its recent purchase of the Mathews Creek Ranch, will be reassigned.

1.4 Report Organization

This report has been prepared as a stand-alone document describing fish habitat offsetting opportunities associated with the Mathews Creek Watershed Habitat Offsetting Plan, to be appended to the overall FHMOP that will be submitted by AMEC as part of the EA for the Blackwater Project. Following this introduction (Section 1), it outlines the methods used in PECG's scope of work (Section 2) and describes existing conditions from watershed to site scale (Section 3). Descriptions and conceptual design drawings for each proposed habitat offsetting measure are provided in Section 4, following a statement regarding the rationale for the proposed work. Section 5 outlines the overall implementation strategy for the offsetting measures and acknowledges proactive measures for managing potential constraints.

2 Methods

The following sections describe the methods used by PECG to gain an understanding of existing fish and fish habitat, as a basis for developing habitat restoration and enhancement strategies.

2.1 Study Area

The overall study area selected for this project is the Mathews Creek watershed (**Figure 1-2**). Following initial desktop study and field reconnaissance, it was realized that consideration of only Mathews Creek itself would not sufficiently represent the existing limitations on habitat productive capacity or opportunities for habitat offsetting associated with tributaries or terrestrial ecosystems beyond the channel banks. The Mathews Creek watershed boundary depicted in **Figure 1-2** was provided by AMEC, based on regional topographic mapping. A reach break analysis was completed for Mathews Creek based on high-resolution aerial photography and a low-level helicopter fly-over, giving consideration to channel pattern, confinement, gradient, and bed and bank materials (in accordance with standards of the Resource Inventory Committee, 2001). Reaches were not distinguished solely according to changes in riparian vegetation and anthropogenic impacts. Of the nine identified reaches, one (Reach 5) was determined to encompass the most severe anthropogenic impacts warranting restoration.

2.2 Background Review

Compilation and review of pertinent background information provided a foundation for planning PECG's field program and important rationale for proposed habitat offsetting objectives and approaches. The review incorporated publically available information accessed from the British Columbia Fisheries Information Summary System (FISS), and a synthesis of literature pertinent to the identification of habitat offsetting opportunities. The aim of this database and literature review was to determine the existing environmental conditions of Mathews Creek, to better understand the scientific basis of ranchland-associated restoration activities, and to document evidence for previously successful and relevant habitat restoration projects.

PECG studied historical aerial photographs from 1964, 1975 and 1991 that covered the middle portions of the Mathews Creek watershed, in comparison to orthophotography from 2000/2001 covering the entire watershed. This review had several primary objectives: to characterize existing vegetation and channel conditions prior to anthropogenic activity, to determine the approximate timing and extent of vegetation clearing and other disturbances, and to assess channel stability along Mathews Creek and its main tributaries over the period of record. Surficial geology mapping from Plouffe et al. (2004), which encompasses the Mathews Creek watershed, was reviewed to gain an appreciation for the distribution of till and glaciofluvial sand and gravel, which greatly affect local infiltration rates and surface runoff patterns in the watershed.

2.3 Fish Community Assessment

2.3.1 Electrofishing

Electrofishing was conducted at five different sites along Mathews Creek between September 18 and 21, 2013, in order to determine fish species composition and, where possible, age class. Additional electrofishing was not completed during the early October field program because water temperatures had dropped below 5^{o}C, making electrofishing less effective at stunning fish. Electrofishing was performed by a two-person crew, one electrofisher and one netter, using a Smith-Root (LR-20B) backpack electrofishing unit. Electrofishing was conducted using either a single-pass method, in order to obtain general species composition data, or a three-pass method, in order to obtain density estimates, which can be used for future monitoring.

Single-Pass Electrofishing

Single-pass electrofishing was conducted at three stations (MC1, MC2 and MC6, **Figure 1-2**). The electrofishing crew entered the stream at a naturally shallow site (riffle section), then waded upstream for a distance of about 100 m, moving side to side in the channel to electrofish all habitat types. Special consideration was paid to areas of high cover, which likely attract fish attempting to evade the electrofishing survey. All fish captured were identified to species; total lengths in millimeters and weights in grams were recorded for each fish. After processing, all fish were released upstream of the survey area to re-disperse.

Three-Pass Electrofishing

Three-pass electrofishing was completed at two sites (MC3 and MC5, **Figure 1-2**), in conjunction with a *Fish Habitat Assessment Procedures* (FHAP) survey (Johnston and Slaney, 1996). A 100 to 200 m section of the creek was selected for electrofishing and isolated by installing stop nets at both the upstream and downstream ends to prevent fish from leaving the area. The electrofishing crew entered the site at the downstream end of the isolated creek section and waded upstream. All habitat types were sampled, with extra attention being paid to high cover areas. Once the first pass was completed, all fish captured were identified to species, with total lengths in millimeters and weights in grams recorded for each. After processing the catch from the first pass, fish were released outside of the stop-netted area,

and a second and third pass were conducted. Each successive pass was completed after a delay of 20 minutes, in order to ensure all fish had recovered and were active again.

2.3.2 Minnow Trapping

Gee-style wire mesh minnow traps were used at four field sites, as a secondary method of capture (MC1, MC2 and MC6) or where electrofishing would have been ineffective due to cool water temperatures (MC4) (**Figure 1-2**). Traps were baited using canned salmon, in a small, perforated plastic bag, and submerged in still water areas, under cover, for at least 12 hours. Upon retrieval of the traps, each captured fish was identified to species and measured for its length and weight before being returned to the stream.

2.3.3 Data Analysis

The standard deviation (SD) was the index of dispersion for all arithmetic means shown in this report, and n was the sample size. All statistical analyses were completed using Statistica version 8 (StatSoft Inc.,Tulsa OK, 2008), with significance levels set to α=0.05.

2.3.3.1 Fish Abundance

Relative fish abundance in the study area was determined using a catch per unit effort (CPUE) index, defined as the number of fish caught per 100 seconds of electrofishing effort. CPUE was calculated by species and site. For the two sites with three-pass electrofishing methods (MC3 and MC5), CPUE calculations were based on the effort and catch of pass 1 only to enable a better comparison with single-pass methods.

Fish population estimates were calculated using the Zippin three-pass exact methods approach, as described by Seber and Whale (1970) and Seber (1982). Areas were calculated by multiplying site sampling length (m) by the mean wetted width (m), and then population estimates were divided by area to obtain density estimates (No. Fish/100 m^2).

2.3.3.2 Length, Weight and Condition

Data from all sites were combined for length, weight and condition analyses to improve sample sizes and analytical inferences. Mean length and weight of each fish species were calculated; further analyses were only completed on rainbow trout and burbot, as they were the most dominant species in Mathews Creek, with sufficient sample sizes available for analyses.

Weight-length regressions were calculated as:

$$log_{10}(W) = a + b \times log_{10}(L) \quad (1)$$

where W = weight (g), L = length (mm), a = the intercept of the regression, and b = the slope of the regression.

One-sample t-tests were performed on estimated weight-length slope coefficients to determine if slopes significantly differed from the isometric growth value of three. Slope coefficients used in t-tests were estimated using species-specific linear regressions. Isometric growth is a requirement for calculating fish condition using the Fulton condition factor (*K*), as it assumes that fish shape does not change with increasing length. The Fulton condition factor was calculated for rainbow trout as:

$$K = \frac{W}{L^3} \times 100{,}000 \quad (2)$$

where K = Fulton condition factor, W= weight (g) and L= fork length (mm).

Burbot condition could not be assessed using the Fulton condition factor, due to allometric growth. Instead, the relative condition factor (K_n) was used to characterize fish condition:

$$K_n = \frac{W}{W'} \quad (3)$$

where W = fish actual weight (g) and W'= predicted length-specific weight using the length-weight regression outlined in Equation 1.

2.4 Fish Habitat Assessment

Two protocols were implemented on Mathews Creek in order to characterize and document available fish habitat. The *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory* ("1:20,000 survey") outlined by the Resource Inventory Committee (2001) was used to gain a general understanding of habitat characteristics at MC1, MC2 and MC6 (**Figure 1-2**). Using the standard site card provided in the manual, information was recorded on channel morphology, cover, substrate and disturbance indicators.

The more detailed FHAP survey, developed by Johnston and Slaney (1996), was followed at MC3, MC4 and MC5 (**Figure 1-2**). Individual habitat units were measured for length, mean wetted and bankfull width, mean depth, and maximum pool depth; observations of dominant and sub-dominant substrate, cover and functional woody debris were also recorded. Results of the field surveys were recorded on standardized FHAP survey field sheets.

2.5 Streamflow Monitoring

2.5.1 Hydrology

PECG installed a hydrometric station at MC1 on September 18, 2013, in order to initiate a hydrological monitoring program for Mathews Creek (**Figure 1-2**). The station consists of a Solinst Levelogger pressure transducer within a PVC tube, installed into the stream and anchored to the bank. The Levelogger provides continuous pressure measurements, as a basis for determining water levels at the site. The Levelogger was installed using a winterization procedure, so that it can remain in the creek throughout the winter and continue to record pressure measurements. Additionally, a Solinst Barologger was installed at the site in order to provide barometric compensation for the Levelogger.

Streamflow was determined based on velocity measurements made using a Marsh-McBirney Flomate 2000 series flow meter, and water depth measurements were made using a top-set wading rod. A fiberglass tape measure was suspended across the width of the stream, at a location adjacent to the hydrometric station where flow was least turbulent. Any large bed material (e.g., large cobbles) creating significant turbulence within the cross-section was removed. Depth and velocity measurements were recorded at a minimum of 15 locations across the width of the stream, while ensuring that no more than about 10% of the flow was represented by any one measurement.

2.5.2 Water Quality

In-situ water quality data was collected at each field site using a Hanna HI 9828 multi-parameter meter. Water temperature, pH, conductivity and specific conductance, dissolved oxygen (mg/L and percent saturation) and total dissolved solids were generally recorded.

Two water quality samples were collected based on standards outlined by the Resources Information Standards Committee (RISC) for "Designing and Implementing a Water Quality Monitoring Program in British Columbia" (Cavanagh et al., 1998) to provide an initial inventory of water quality for parameters such as total and dissolved metals, physical parameters, nutrients, pesticides, herbicides and coliform bacteria. This type of inventory-level monitoring was selected because water quality in Mathews Creek had not previously been evaluated. These results provide a first step toward establishing baseline water quality along Mathews Creek.

Samples were collected using precautions to avoid contamination (e.g., using nitrile gloves, minimizing sediment disturbance), preserved with the supplied preservative agents at the site, and promptly placed in a cooler with ice packs in order to maintain the viability of the samples until arrival at Maxxam Analytics in Burnaby, British Columbia, where laboratory analyses were completed.

2.5.3 Stream Temperature

Stream water temperatures were recorded during both the September and October field programs. In addition, Hobo Tidbit temperature loggers were installed at MC2, MC5 and MC6 in order to provide a continuous record of water temperatures at locations within, as well as upstream and downstream of, the former Mathews Creek Ranch. Tidbits were anchored using aircraft cable secured to rebar or a lag bolt. Tidbits were installed in locations unlikely to freeze during winter (e.g., deep pools) in order to maximize the likelihood of recording winter stream temperatures.

2.6 Geomorphic Channel Surveys

Geomorphic channel surveys were completed at MC4 and at nearby tributaries or ditches on October 1 and 2, 2013, using a survey level and hip-chain, where basic information on channel dimensions and slopes was required to support the development of conceptual design drawings. Representative, bankfull channel cross-sections and a full longitudinal profile of the channel bed and water surface were surveyed at MC4, in conjunction with the FHAP survey (**Figure 1-2**). Observations were made of bank erosion

patterns, channel roughness (Manning's n) and substrate variability. Cross-sectional dimensions were also measured within the sinuous, valley bottom tributary and along the slope-toe drainage ditch to the north. A longitudinal profile and two cross-sections were completed along the drainage ditch extending southward from the largest of the two ponds at the western limit of the main ranchland (**Figure 1-2**).

2.7 Georeferenced Aerial Videography

Continuous video coverage of Mathews Creek, from its mouth at Laidman Lake to its upper headwaters, was acquired during a low, slow helicopter fly-over using a standard, hand-held digital camera. The eight, sequential video clips were subsequently georeferenced, at key locations along the channel, based on simultaneous viewing of the video and high-resolution orthophotography (video clips and georeferencing table provided separately via FTP download, **Appendix A**). The video archive provided a valuable resource during post-field desktop analysis in this assignment, including in the identification of beaver dams, and for other project team members requiring an aerial perspective of the valley.

3 Existing Conditions

3.1 Watershed Overview

Mathews Creek watershed is approximately 180 km^2 and located in the Nechako Plateau of central British Columbia (**Figure 1-2**). Mathews Creek originates near treeline on the southwest flank of Mount Davidson (1,862 m) and flows generally west and northwestward through open and forested valleys to its mouth at Laidman Lake (~1,000 m), which defines its confluence with Fawnie Creek. Fawnie Creek flows northwestward through a series of narrow lakes before entering Entiako River, which flows northeastward to Natalkuz Lake, part of the Nechako Reservoir. Nechako River continues eastward to Prince George, where it joins Fraser River and flows southward to its mouth in Georgia Strait in Vancouver.

Mathews Creek watershed is situated within a region of gently rolling to hilly terrain, with more subdued topography than exists in the Coast Mountains about 100 km to the west. A clayey to sandy till dominates the surficial geology within the watershed (Plouffe et al., 2004). Glaciofluvial sand and gravel is widespread, however, along the lower valley sides adjacent to Mathews Creek and along the headwater tributary containing a small lake. Modern alluvial deposits fill most valley bottom areas, largely derived from upstream glaciofluvial deposits exposed in cut-banks. In the main ranchland area, the level floodplain is composed of fine sand, interbedded with silt and organic material.

Mathews Creek watershed is within the Sub-Boreal Spruce and Engelmann Spruce-Subalpine Fir biogeoclimatic zones of British Columbia. It is densely forested, except where the groundwater table is high in broad valley bottoms, where wet meadows and mixed shrub-herb fens are common, and in its subalpine to alpine headwaters, where subalpine firs, low shrubs and tundra vegetation predominate. The area receives 330 mm of annual precipitation, on average, and temperatures range from -40°C in winter to a maximum of 32°C in summer (GeoSim, 2012).

3.2 History of Anthropogenic Impacts

Mathews Creek was first visited by European settlers shortly after World War II (late 1940s), when a float plane pilot working in the area spotted and landed on Laidman Lake (Laidman Lake Lodge, 2013). Since then, human activity in the Mathews Creek watershed has altered its natural condition. Anthropogenic influences largely stem from agricultural activity, forest harvesting, mineral exploration and recreational fishing.

By far the most extensive impacts are the result of several decades of agricultural land use along Reach 5. Historical aerial photographs reveal that construction of the Mathews Creek Ranch and land clearing in support of cattle ranching began between 1964 and 1975 (**Figure 3-1**). Use of the floodplain for hay harvesting likely began within the same period during which drainage ditches were excavated along the valley bottom and in toe-slope positions: 1975 to 1991. The drainage ditches increased the efficiency of land drainage, particularly in the spring, maximizing accessibility for cattle grazing. The ditching has also lowered the groundwater table within the valley bottom alluvium, altering the natural soil moisture regimes and transforming areas of wet meadow and fens into drier meadow ecosystems.

Extensive cattle trampling of the floodplain and channel banks, where deterrent fences were absent or unmaintained, destabilized channel banks and has increased local and downstream in-stream sedimentation. Much of the channel has no overhanging vegetation for shading or cover. A sinuous tributary to Mathews Creek, which was regularly waded by cattle, has become so broad and shallow that emergent vegetation almost fully obstructs water flow. Several bridges constructed over Mathews Creek and its side channels are in states of disrepair or have completely collapsed into the channel, forming partial obstructions to flow.

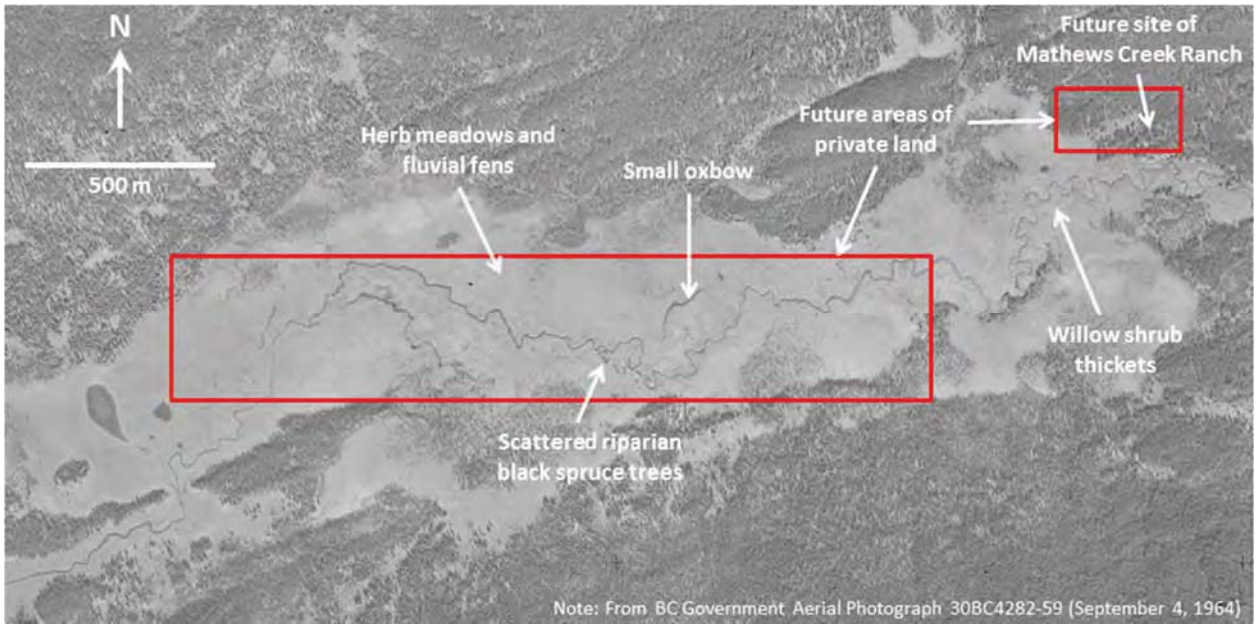


Figure 3-1. Mathews Creek Valley in 1964, Prior to Ranch Establishment

Non-agricultural anthropogenic disturbances have contributed less to impacts to the aquatic and riparian ecosystems of Mathews Creek and its tributaries. Extensive clear-cut forestry has occurred in the watershed, including on the lower valley sides adjacent to Mathews Creek between 1975 and 1991. This has mainly altered woody debris supply to intermittent headwater tributaries and has potentially increased stream temperatures and decreased hydrological response time slightly. Also, a number of bridges and culverts were constructed across Mathews Creek and its tributaries to provide forestry road access. Some mineral exploration has occurred intermittently in the recent past; a small exploration camp currently exists on the north side of Mathews Creek in Reach 4. Only limited recreational fishing occurs, mainly near the creek mouth at Laidman Lake Ecolodge (Reach 1).

3.3 Streamflow Conditions

3.3.1 Flow

Mathews Creek is understood to exhibit a typical hydrograph in which the greatest period of high flows occurs during the spring, in association with ice break-up and widespread snowmelt. Intense rainstorms that occur periodically throughout the year likely result in significant peaks in flow as well, especially downstream of widespread land clearing (e.g., clearcuts). During the summer and fall, baseflow in Mathews Creek is maintained by small contributions of groundwater that discharge in a number of valley side toe-slope positions. Locally extensive sand and gravel deposits on valley sides, which are highly permeable, promote infiltration of rainfall (and snowmelt) and help moderate the hydrological response in Mathews Creek.

Streamflow at MC1 was determined to be 0.08 m^3/s on September 18, 2013, and 0.09 m^3/s on October 2, 2013. Both monitoring events occurred during periods of relatively dry weather with little or no antecedent precipitation. Bankfull discharge at MC4 was estimated to be approximately 3.3 m^3/s, before flow spills overbank onto the level floodplain, based on field measurements made during the geomorphic channel survey.

3.3.2 Water Quality

Surface water quality was sampled at two locations in Mathews Creek, upstream (MC6, October 3, 2013) and downstream (MC2, September 21, 2013) of the ranchland area. Samples were analyzed for nutrients, anions, total and dissolved metals, organochlorinated and phenoxyalkyl acid pesticides, and coliform bacteria. The laboratory Certificate of Analysis (CofA) forms are provided in **Appendix B**.

Water quality results were compared to British Columbia and Canadian Council of Ministers of the Environment (CCME) guidelines for protection of aquatic life, to establish baseline conditions and assess the influence of the former ranching operation on downstream surface water chemistry (**Table 3-1**).

Table 3-1. Mathews Creek Surface Water Quality Data

CHEMICAL PARAMETERS	Units	RDL	Water Quality Guidelines CCME[1]	Water Quality Guidelines BC[2]	MC2 9/21/13	MC6 9/21/13
Misc. Inorganics						
Fluoride (F)	mg/L	0.010	-	-	0.062	0.054
Dissolved Hardness (CaCO3)	mg/L	0.50	-	-	53.1	47.8
Dissolved Organic Carbon (C)	mg/L	0.50	-	-	6.09	5.42
Alkalinity (Total as CaCO3)	mg/L	0.50	-	-	60.1	51.7
Total Organic Carbon (C)	mg/L	0.50	-	-	6.12	6.35
Bicarbonate (HCO3)	mg/L	0.50	-	-	73.3	63.1
Carbonate (CO3)	mg/L	0.50	-	-	<0.50	<0.50
Hydroxide (OH)	mg/L	0.50	-	-	<0.50	<0.50
Anions						
Dissolved Sulphate (SO4)	mg/L	0.50	-	100	<0.50	<0.50
Dissolved Chloride (Cl)	mg/L	0.50	-	150	0.79	0.73
Nutrients						
Ammonia (N)[a]	mg/L	0.0050	-	-	0.011	0.010
Nitrate plus Nitrite (N)	mg/L	0.020	-	-	<0.020	<0.020
Nitrite (N)	mg/L	0.0050	0.06	0.02	<0.0050	<0.0050
Physical Properties						
Conductivity	uS/cm	1.0	-	-	117	104
pH	pH Units	-	6.5-9.0	6.5-9.0	7.74	7.67
Physical Properties						
Total Suspended Solids	mg/L	4.0	-	-	<4.0	<4.0
Total Dissolved Solids	mg/L	10	-	-	78	58
Calculated Parameters						
Total Hardness (CaCO3)	mg/L	0.50	-	-	59.4	52.8
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	3.0	5.0 - 100.0[b]	-	***35.3***	***22.7***
Total Antimony (Sb)	ug/L	0.50	-	-	<0.50	<0.50
Total Arsenic (As)	ug/L	0.10	5	5	0.49	0.50
Total Barium (Ba)	ug/L	1.0	-	-	12.6	14.3
Total Beryllium (Be)	ug/L	0.10	-	-	<0.10	<0.10
Total Bismuth (Bi)	ug/L	1.0	-	-	<1.0	<1.0
Total Boron (B)	ug/L	50	1500	1200	<50	<50
Total Cadmium (Cd)	ug/L	0.010	0.017[c]	-	<0.010	0.010
Total Chromium (Cr)	ug/L	1.0	1.0	-	<1.0	<1.0
Total Cobalt (Co)	ug/L	0.50	-	4	<0.50	<0.50
Total Copper (Cu)	ug/L	0.20	2.0[d]	0.04 - 2.0[e]	***0.57***	***0.59***
Total Iron (Fe)	ug/L	5.0	300	100	***1060***	***1160***
Total Lead (Pb)	ug/L	0.20	1.0 - 7.0[f]	-	<0.20	<0.20
Total Lithium (Li)	ug/L	5.0	-	-	<5.0	<5.0
Total Manganese (Mn)	ug/L	1.0	-	700 - 1900[h]	10.6	52.0
Total Mercury (Hg)	ug/L	0.050	-	-	<0.050	<0.050
Total Molybdenum (Mo)	ug/L	1.0	73	1000	<1.0	<1.0
Total Nickel (Ni)	ug/L	1.0	25 - 150[i]	-	<1.0	<1.0
Total Selenium (Se)	ug/L	0.10	1.0	2.0	<0.10	<0.10
Total Silicon (Si)	ug/L	100	-	-	6140	6950
Total Silver (Ag)	ug/L	0.020	1.0	0.05 - 1.5[k]	0.033	<0.020
Total Strontium (Sr)	ug/L	1.0	-	-	88.5	79.9
Total Thallium (Tl)	ug/L	0.050	0.8	-	<0.050	<0.050
Total Tin (Sn)	ug/L	5.0	-	-	<5.0	<5.0
Total Titanium (Ti)	ug/L	5.0	-	-	<5.0	<5.0
Total Uranium (U)	ug/L	0.10	-	-	0.17	0.16
Total Vanadium (V)	ug/L	5.0	-	-	<5.0	<5.0
Total Zinc (Zn)	ug/L	5.0	30.0	7.5 - 240[l]	<5.0	<5.0
Total Zirconium (Zr)	ug/L	0.50	-	-	<0.50	<0.50
Total Calcium (Ca)	ug/L	0.050	-	-	16.6	15.2
Total Magnesium (Mg)	ug/L	0.050	-	-	4.33	3.62
Total Potassium (K)	ug/L	0.050	-	-	0.755	0.725
Total Sodium (Na)	ug/L	0.050	-	-	4.16	4.18
Total Sulphur (S)	ug/L	3.0	-	-	<3.0	<3.0

Table 3-1. Mathews Creek Surface Water Quality Data (continued)

CHEMICAL PARAMETERS	Units	RDL	Water Quality Guidelines CCME[1]	Water Quality Guidelines BC[2]	MC2 9/21/13	MC6 9/21/13
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	3.0	-	50[m]	14.4	14.0
Dissolved Antimony (Sb)	ug/L	0.50	-	-	<0.50	<0.50
Dissolved Arsenic (As)	ug/L	0.10	-	-	0.38	0.35
Dissolved Barium (Ba)	ug/L	1.0	-	-	12.0	13.5
Dissolved Beryllium (Be)	ug/L	0.10	-	-	<0.10	<0.10
Dissolved Bismuth (Bi)	ug/L	1.0	-	-	<1.0	<1.0
Dissolved Boron (B)	ug/L	50	-	-	<50	<50
Dissolved Cadmium (Cd)	ug/L	0.010	-	-	<0.010	<0.010
Dissolved Chromium (Cr)	ug/L	1.0	-	-	<1.0	<1.0
Dissolved Cobalt (Co)	ug/L	0.50	-	-	<0.50	<0.50
Dissolved Copper (Cu)	ug/L	0.20	-	-	0.82	0.58
Dissolved Iron (Fe)	ug/L	5.0	-	350	***725***	***710***
Dissolved Lead (Pb)	ug/L	0.20	-	-	<0.20	<0.20
Dissolved Lithium (Li)	ug/L	5.0	-	-	<5.0	<5.0
Dissolved Manganese (Mn)	ug/L	1.0	-	-	8.6	46.7
Dissolved Mercury (Hg)	ug/L	0.050	-	-	<0.050	<0.050
Dissolved Molybdenum (Mo)	ug/L	1.0	-	-	<1.0	<1.0
Dissolved Nickel (Ni)	ug/L	1.0	-	-	<1.0	<1.0
Dissolved Selenium (Se)	ug/L	0.10	-	-	<0.10	<0.10
Dissolved Silicon (Si)	ug/L	100	-	-	5560	6760
Dissolved Silver (Ag)	ug/L	0.020	-	-	<0.020	<0.020
Dissolved Strontium (Sr)	ug/L	1.0	-	-	76.2	71.4
Dissolved Thallium (Tl)	ug/L	0.050	-	-	<0.050	<0.050
Dissolved Tin (Sn)	ug/L	5.0	-	-	<5.0	<5.0
Dissolved Titanium (Ti)	ug/L	5.0	-	-	<5.0	<5.0
Dissolved Uranium (U)	ug/L	0.10	-	-	0.16	0.16
Dissolved Vanadium (V)	ug/L	5.0	-	-	<5.0	<5.0
Dissolved Zinc (Zn)	ug/L	5.0	-	-	<5.0	<5.0
Dissolved Zirconium (Zr)	ug/L	0.50	-	-	<0.50	<0.50
Dissolved Calcium (Ca)	ug/L	0.050	-	-	14.5	13.6
Dissolved Magnesium (Mg)	ug/L	0.050	-	-	4.11	3.38
Dissolved Potassium (K)	ug/L	0.050	-	-	0.669	0.551
Dissolved Sodium (Na)	ug/L	0.050	-	-	3.79	3.26
Dissolved Sulphur (S)	ug/L	3.0	-	-	<3.0	<3.0
Microbiological Param.						
E. coli	CFU/100mL	1	-	-	9	82
Fecal Coliforms	CFU/100mL	1	-	-	9	91
Total Coliforms	CFU/100mL	1	-	-	460	110
Phenoxyalkyl Acid Pesticides						
3,5-dichlorobenzoic acid	ug/L	0.080	-	-	<0.080	<0.080
Dicamba	ug/L	0.0050	10	-	<0.0050	<0.0050
MCPP	ug/L	0.080	-	-	<0.080	<0.080
MCPA	ug/L	0.020	2.6	-	<0.020	<0.020
Dichlorprop	ug/L	0.080	-	-	<0.080	<0.080
Bromoxynil	ug/L	0.020	5	-	<0.020	<0.020
2,4-D	ug/L	0.050	4	-	<0.050	<0.050
Pentachlorophenol	ug/L	0.080	0.5	-	<0.080	<0.080
2,4,5-TP	ug/L	0.080	-	-	<0.080	<0.080
2,4,5-T	ug/L	0.080	-	-	<0.080	<0.080
Chloramben	ug/L	0.080	-	-	<0.080	<0.080
Dinoseb (DNBP)	ug/L	0.020	0.05	-	<0.020	<0.020
Bentazon	ug/L	0.080	-	-	<0.080	<0.080
2,4-DB	ug/L	0.080	-	-	<0.080	<0.080
Picloram	ug/L	0.080	29	-	<0.080	<0.080
Diclofop-methyl	ug/L	0.080	6.1	-	<0.080	<0.080

Table 3-1. Mathews Creek Surface Water Quality Data (continued)

CHEMICAL PARAMETERS	Units	RDL	Water Quality Guidelines CCME[1]	Water Quality Guidelines BC[2]	MC2 9/21/13	MC6 9/21/13
Organochlorinated Pesticides						
Aldirin+Dieldrin	ug/L	0.005	-	-	<0.005	<0.005
Chlordane (Total)	ug/L	0.005	-	-	<0.005	<0.005
DDT+Metabolites	ug/L	0.005	-	-	<0.005	<0.005
Heptachlor+Heptachlor epoxide	ug/L	0.005	-	-	<0.005	<0.005
o,p-DDD+p,p-DDD	ug/L	0.005	-	-	<0.005	<0.005
o,p-DDE+p,p-DDE	ug/L	0.005	-	-	<0.005	<0.005
o,p-DDT+p,p-DDT	ug/L	0.005	-	-	<0.005	<0.005
Total Endosulfan	ug/L	0.005	-	-	<0.005	<0.005
Total PCB	ug/L	0.05	-	-	<0.05	<0.05
Aldrin	ug/L	0.005	-	-	<0.005	<0.005
Dieldrin	ug/L	0.005	-	-	<0.005	<0.005
a-Chlordane	ug/L	0.005	-	-	<0.005	<0.005
g-Chlordane	ug/L	0.005	-	-	<0.005	<0.005
o,p-DDD	ug/L	0.005	-	-	<0.005	<0.005
p,p-DDD	ug/L	0.005	-	-	<0.005	<0.005
o,p-DDE	ug/L	0.005	-	-	<0.005	<0.005
p,p-DDE	ug/L	0.005	-	-	<0.005	<0.005
o,p-DDT	ug/L	0.005	-	-	<0.005	<0.005
p,p-DDT	ug/L	0.005	-	-	<0.005	<0.005
Lindane	ug/L	0.003	-	-	<0.003	<0.003
Endosulfan 1 (alpha)	ug/L	0.005	0.003	-	<0.005	<0.005
Endosulfan II	ug/L	0.005	-	-	<0.005	<0.005
Endrin	ug/L	0.005	-	-	<0.005	<0.005
Heptachlor	ug/L	0.005	-	-	<0.005	<0.005
Heptachlor epoxide	ug/L	0.005	-	-	<0.005	<0.005
Hexachlorobenzene	ug/L	0.005	-	-	<0.005	<0.005
Methoxychlor	ug/L	0.01	7.8	-	<0.01	<0.01
Aroclor 1016	ug/L	0.05	-	-	<0.05	<0.05
Aroclor 1221	ug/L	0.05	-	-	<0.05	<0.05
Aroclor 1232	ug/L	0.05	-	-	<0.05	<0.05
Aroclor 1248	ug/L	0.05	-	-	<0.05	<0.05
Aroclor 1254	ug/L	0.05	-	-	<0.05	<0.05
Aroclor 1260	ug/L	0.05	-	-	<0.05	<0.05
alpha-BHC	ug/L	0.005	-	-	<0.005	<0.005
beta-BHC	ug/L	0.005	-	-	<0.005	<0.005
delta-BHC	ug/L	0.005	-	-	<0.005	<0.005
Endosulfan sulfate	ug/L	0.005	-	-	<0.005	<0.005
Endrin aldehyde	ug/L	0.005	-	-	<0.005	<0.005
Endrin ketone	ug/L	0.005	-	-	<0.005	<0.005
Mirex	ug/L	0.005	-	-	<0.005	<0.005
Octachlorostyrene	ug/L	0.005	-	-	<0.005	<0.005
Oxychlordane	ug/L	0.005	-	-	<0.005	<0.005
Toxaphene	ug/L	0.2	-	-	<0.2	<0.2

(6) Duplicate RPD above control limit - (10% of analytes failure allowed).

(7) Dissolved greater than total. Reanalysis yields similar results

British Columbia water quality guideline (BC-WQG) exceedances
CCME exceedances
Both BC-WQG and CCME exceedances

Notes:

All units mg/L unless otherwise noted

1) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007

2) British Columbia water quality guidelines for the protection of aquatic life, BC Environmental Protection Division, 2010

a) Guideline based on pH=8.5 and temperature=20ºC for total ammonia-N

b) 0.005 mg/L at pH < 6.5, $[Ca^{2+}]$ < 4 mg/L, DOC < 2 mg/L: 0.1 mg/L at pH ≥ 6.5, $[Ca^{2+}]$ ≥ 4 mg/L, DOC ≥ 2 mg/L

c) $10^{\{0.86[\log(\text{hardness})]-3.2\}}$

d) Cu water quality guideline is a minimum of 0.002 mg/L regardless of hardness

e) 0.00004mg/L at [CaCO3]>50 mg/L; 0.002mg/L at [CaCO3] ≤ 50 mg/L

f) 0.001 mg/L at $[CaCO_3]$ = 0 - 60 mg/L; 0.002 mg/L at $[CaCO_3]$ = 60 - 120 mg/L; 0.004 mg/L at $[CaCO_3]$ = 120 - 180 mg/L; 0.007 mg/L at $[CaCO_3]$ > 180 mg/L

g) only applies when [CaCO3]>8 mg/L

h) 0.7mg/L at [CaCO3]=25mg/L; 0.8mg/L at [CaCO3]=50mg/L; 1.0mg/L at [CaCO3]=100mg/L; 1.3mg/L at [CaCO3]=150mg/L; 1.9mg/L at [CaCO3]=300mg/L

i) 0.025 mg/L at $[CaCO_3]$ = 0 - 60 mg/L; 0.065 mg/L at $[CaCO_3]$ = 60 - 120 mg/L; 0.110 mg/L at $[CaCO_3]$ = 120 - 180 mg/L; 0.150 mg/L at $[CaCO_3]$ > 180 mg/L

j) Lakes only, no value proposed for streams

k) 0.00005 mg/L at [CaCO3]≤100 mg/L; 0.0015 mg/L at [CaCO3]>100 mg/L

l) Total zinc guideline is 0.0075mg/L at [CaCO3]≤90mg/L; For [CaCO3]>90mg/L use equation: total zinc (micrograms/L)=-7.5+0.75([CaCO3]-90)

m) When pH ≥ 6.5, otherwise use calculation in note m)

n) When pH < 6.5

There was little difference between surface water chemistry upstream and downstream of the ranchland in Reach 5. Total iron concentration exceeded the provincial and CCME guidelines at both sites, and dissolved iron exceeded British Columbia guidelines (**Table 3-1**). Total copper concentrations at both MC2 and MC6 exceeded the provincial 30-day average criteria of 0.04 µg/L, but met the maximum allowable concentration for the protection of aquatic life of 2.0 µg/L.

Nutrient concentrations both upstream and downstream of the ranchlands were low, indicating that current agricultural land use in the middle and upper reaches of the watershed are not contributing to increased nitrogen levels in Mathews Creek.

No pesticides or herbicides were detected in the water quality samples taken at either site. *E. coli* and fecal coliform counts were higher upstream of the ranchlands at MC6 than at the downstream location (MC2), which was not expected. A source of bacteria may be present in the upper reaches of Mathews Creek, although this interpretation from a single sample would be strengthened by additional sampling.

In situ water quality data collected as part of the September 2013 field investigations are provided in **Table 3-2**. These data were collected at MC1, MC2, MC5 and MC6. Conductivity, pH and total dissolved solids were relatively consistent at each sampling location. Dissolved oxygen (DO) was highest at the farthest downstream site (MC1) and is related to the moderate gradient, pool-riffle sequence at this location. MC5 was largely backwatered with slow-moving water, which likely explains the low DO.

Table 3-2. Summary of* In Situ *Water Quality Data for Mathews Creek

Site	Date (2013)	pH	Conductivity (uS/cm)	Specific Conductance (uS/cm^2)	Dissolved Oxygen (mg/L)	D.O. % Saturation	Total Dissolved Solids (ppm)	Water Temperature (ºC)
MC1	Sep. 18	6.49	65	46	10.24	98.6	33	8.8
MC2	Sep. 21	7.01	89	62	NA	NA	45	9.2
MC4	Oct. 1	6.80	114	NA	NA	NA	NA	5.2
MC5	Sep. 20	6.86	85	NA	6.95	68.9	NA	9.3
MC6	Sep. 21	6.88	58	41	NA	NA	30	8.8

3.3.3 Water Temperature

Stream water temperature was recorded at several locations along Mathews Creek as part of the fish sampling and *in situ* water quality testing (**Table 3-2**). Temperatures were generally about 0.5ºC warmer along the open, meadow-lined middle reaches of Mathews Creek (MC2 and MC5) than in the more forested reaches upstream (MC6) and downstream (MC1). Summertime water temperatures, however, would be more informative.

3.4 Fish Community

Reconnaissance-level fish sampling was conducted during early fall 2013, in order to gain an initial understanding of the fish community within Mathews Creek. Its results are representative of only one sampling event and additional sampling will be required to more accurately characterize the fish community. Data associated with the fish community assessment are provided in **Appendix C**, including electrofishing effort (C1), minnow trapping effort (C2) and fish biological characteristics (C3).

3.4.1 Species Composition, Relative Abundance and Distribution

Rainbow trout (RB) and burbot (BB) were the most dominant species captured in Mathews Creek, with low abundances of white sucker (WSU), longnose dace (LNC), brassy minnow (BMC), and slimy sculpin (CCG) also present throughout the watershed (**Tables 3-3** and **3-4**; **Figure 3-2**). CPUE was highest at MC1 in Reach 2 (3.42 individuals/100s electrofishing), lowest in Reach 5 (0.49 individuals/100s electrofishing), and intermediate in reaches 4 and 7 (1.30 and 0.83 individuals/100s electrofishing, respectively).

Table 3-3. Fish Community Composition by Reach, Mathews Creek, September-October 2013

Reach	BB	BMC	CCG	LNC	RB	WSU
2	7%	0%	9%	14%	70%	0%
4	74%	8%	0%	0%	2%	16%
5	59%	29%	0%	0%	6%	6%
7	75%	0%	0%	0%	25%	0%
Species Total:	**47%**	**7%**	**3%**	**5%**	**30%**	**7%**

Notes: BB=burbot, BMC=brassy minnow, CCG=slimy sculpin, LNC=longnose dace, RB=rainbow trout and WSU=white sucker
Fish catch includes all fish sampling methods (one- and three-pass electrofishing and minnow trapping)

Table 3-4. Electrofishing CPUE by Site, Mathews Creek, September 2013

Site	Reach	Effort (s)	BB	BMC	CCG	LNC	RB	WSU	Site Total
MC1	2	1638	0.24	0.00	0.31	0.49	2.38	0.00	**3.42**
MC2	4	956	0.84	0.10	0.00	0.00	0.00	0.10	**1.05**
MC3	4	1100	0.82	0.18	0.00	0.00	0.00	0.55	**1.55**
MC5	5	1233	0.32	0.00	0.00	0.00	0.08	0.08	**0.49**
MC6	7	965	0.52	0.00	0.00	0.00	0.31	0.00	**0.83**
Species Total:		**5892**	**0.51**	**0.05**	**0.08**	**0.14**	**0.73**	**0.14**	**1.65**

Notes: BB=burbot, BMC=brassy minnow, CCG=slimy sculpin, LNC=longnose dace, RB=rainbow trout and WSU=white sucker
All CPUE values are number of fish caught per 100s of electrofishing
Where 3-pass electrofishing was conducted (MC3 and MC5), only data from pass 1 were included

Three-pass electrofishing methods were employed at MC3 and MC5 to estimate population densities; however, catch size did not decrease with progressive passes at MC3 and thus population density could not be estimated for this site. At MC5 in Reach 5, the population size estimate was 0.03 fish/m^2 ± 0.02 (90% confidence intervals).

The majority of rainbow trout were captured at the most downstream sampling site, MC1, located in Reach 2 of Mathews Creek. At MC1, rainbow trout comprised 70% of the community, followed by longnose dace (14%), slimy sculpin (9%), and burbot (7%). No brassy minnow or white sucker was captured at this site. Slimy sculpin and longnose dace were not found at any other sampling sites, suggesting that Reach 2 is the upstream extent of their distribution.

The community composition shifted farther upstream in Reach 4. Burbot was most dense in this reach, representing 70% of the community and demonstrating CPUEs of 0.82-0.84 individuals caught per 100s of electrofishing effort (**Table 3-4**; **Figure 3-2**). Also captured were white sucker (16%), brassy minnow (8%), and a single rainbow trout at MC3 (2%).

In the anthropogenically impacted section of Reach 5, the community consisted of mostly burbot (59%), followed by brassy minnow (29%), rainbow trout (6%) and white sucker (6%). No sampling was conducted in Reach 6 where habitat quality notably increased; however, sampling conducted farther upstream in Reach 7 demonstrated a minor increase in CPUE for both burbot and rainbow trout (**Table 3-4**; **Figure 3-2**). In contrast, white suckers and brassy minnow were not present.

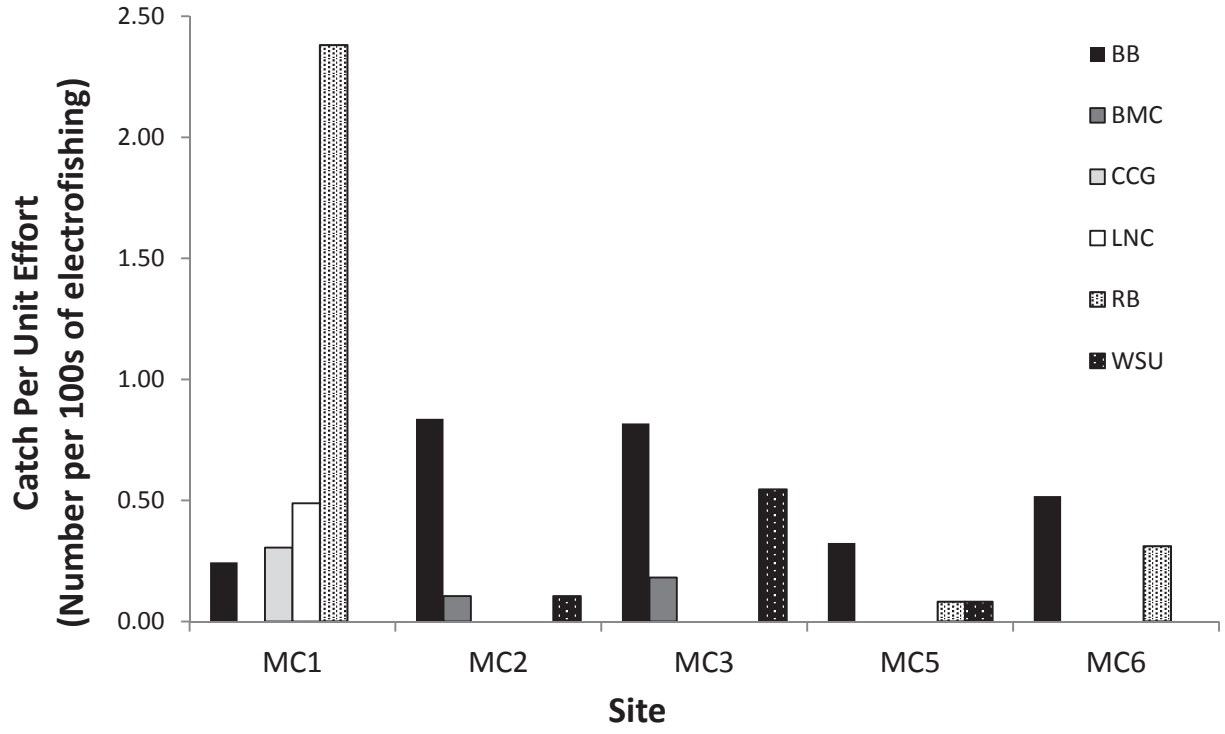


Figure 3-2. Electrofishing CPUE by Site, Mathews Creek, Sept. 2013

3.4.2 Length, Weight and Condition

Mean length and weight of each fish species are reported in **Table 3-5**. Further analyses were completed on rainbow trout and burbot, as they were the most dominant species in Mathews Creek, with sufficient sample sizes.

Table 3-5. Mean Length and Weight of Fish Species in Mathews Creek, September-October 2013

Species	n	Length (mm)				Weight (g)			
		Min	Mean	Max	SD	Min	Mean	Max	SD
BB	69	55	101	230	43	0.9	9.3	68.6	11.8
BMC	10	67	100	123	20	2.0	8.2	17.1	4.8
CCG	5	70	77	89	7	3.4	5.3	8.5	1.9
LNC	8	51	96	138	31	1.4	10.6	27.8	9.6
RB	44	58	117	199	32	2.2	16.4	80.6	14.4
WSU	11	96	135	209	37	7.1	26.9	84.8	25.8

Notes: BB=burbot, BMC=brassy minnow, CCG=slimy sculpin, LNC=longnose dace, RB=rainbow trout and WSU=white sucker
n=sample size, Min=minimum value, Max=maximum value, SD=Standard deviation

Rainbow Trout

Rainbow trout lengths ranged from 58 to 199 mm, with an average length of 117 mm (**Table 3-5**). The majority of rainbow trout were between 50 and 150 mm (**Figure 3-3**), demonstrating the usage of Mathews Creek by both juvenile and adult trout. Further, the smallest individuals are likely young-of-the-year, as rainbow trout fry reach sizes ranging from 35 to 120 mm by the end of their first season, depending on latitude and altitude (McPhail, 2007). Rainbow trout in Mathews Creek may be stream-resident or lake-stream migratory, given the close proximity of Laidman Lake (Behnke, 2002; Meka et al., 2003).

The rainbow trout length-weight regression was significant (**Figure 3-4**, Linear regression, R^2=0.98, df=1,42, P<0.01), and growth was isometric (t-test, t=1.79, df=43, P=0.08), facilitating the calculation of Fulton's condition factor (*K*). Mean condition (*K*) was 0.85 ± 0.10 (standard deviation).

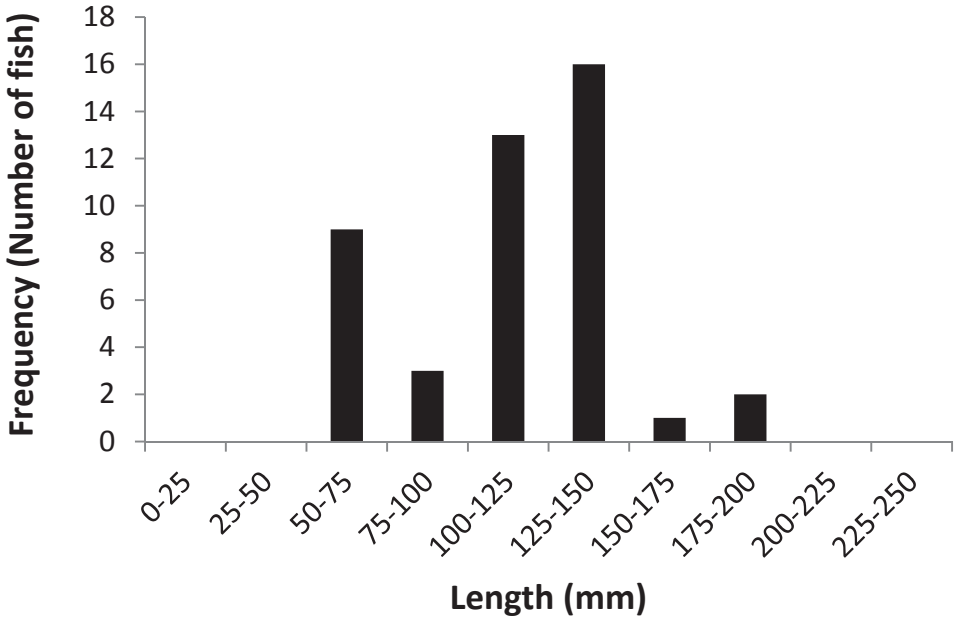


Figure 3-3. Rainbow Trout Lengths in Mathews Creek, September-October 2013

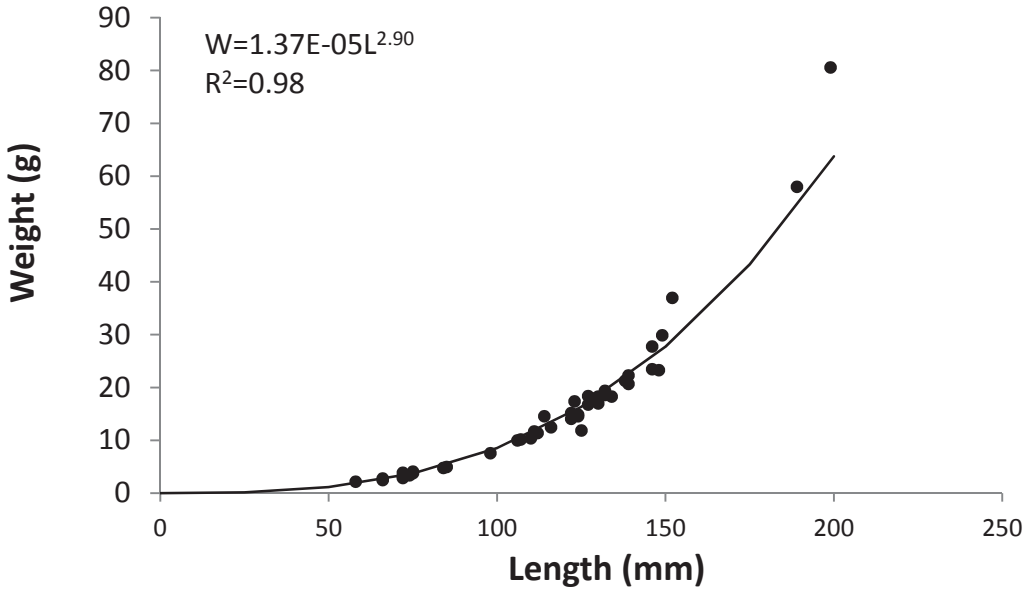


Figure 3-4. Rainbow Trout Weight-Length Relationship in Mathews Creek, September-October 2013

Burbot

Burbot lengths ranged from 55 to 230 mm, with an average length of 101 mm (**Table 3-5**). The majority of burbot were between 50 and 150 mm (**Figure 3-5**), demonstrating that Mathews Creek primarily supports young-of-the-year and juvenile rearing activities, as burbot can reach sizes of 110 to 120 mm by the end of their first growing season (McPhail, 1997).

Based on the sizes caught, most of the burbot in Mathews Creek likely feed primarily on benthic invertebrates and insects. The shift to piscivory in burbot is size-related and progressive, with individuals under 200 mm generally feeding on invertebrates (Beeton, 1956; Nagy, 1985). However, burbot less than 200 mm will still consume fish opportunistically, with evidence of piscivory observed for burbot as small as 40 mm (Beeton, 1956; Bishop, 1975).

The burbot length-weight regression was significant (**Figure 3-6**, Linear regression, R^2=0.98, df=1,66, P<0.01), and growth was allometric (t-test, t=2.10, df=67, P=0.04), with fish becoming relatively lighter as length increased. Mean relative condition (K_n) was 1.01 ± 0.17 (standard deviation).

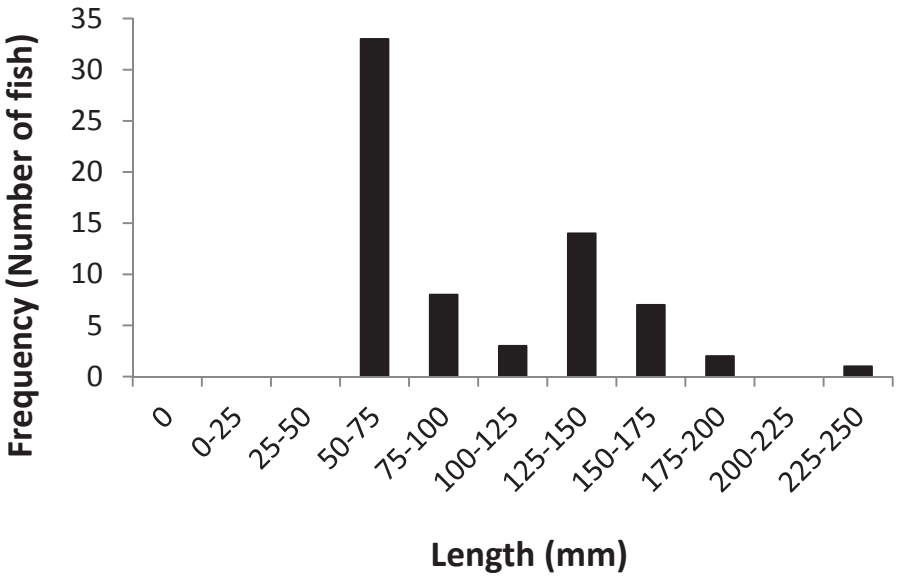


Figure 3-5. Burbot Lengths in Mathews Creek, September-October 2013

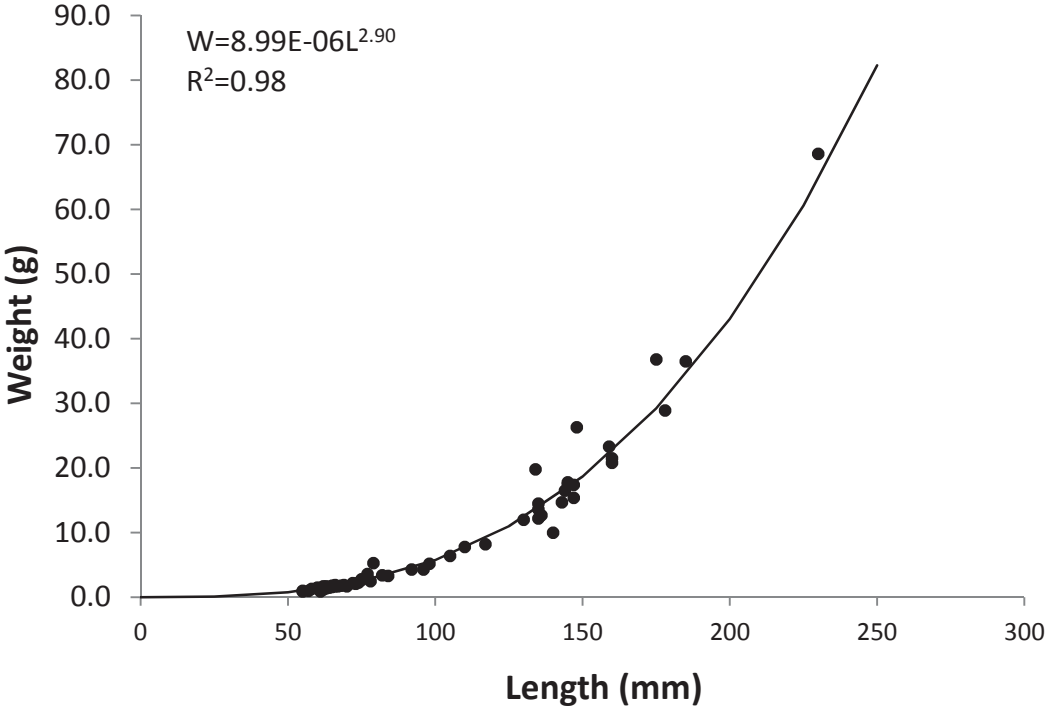


Figure 3-6. Burbot Weight-Length Relationship in Mathews Creek, September-October 2013

3.5 Fish Habitat

3.5.1 Mathews Creek

Mathews Creek exhibits nine distinct reaches (**Figure 1-2**). After its steep, headwater reaches, Mathews Creek exhibits a gentle gradient along its middle reaches before dropping more steeply toward its mouth at Laidman Lake (**Figure 3-7**). Typical photographs of each reach, taken from a low-flying helicopter, are provided in **Appendix D**.

Existing channel morphology and fish habitat along each reach are described below based on observations from low, slow helicopter fly-overs and interpretations from high-resolution aerial photography, with reference to detailed fish habitat assessments (FHAP and 1:20,000 surveys), where available. The greatest detail is provided for Reach 5, along which fish habitat offsetting measures are proposed (as described below in Section 4.2). The results of the site-specific fish habitat assessments are provided in **Appendix E**.

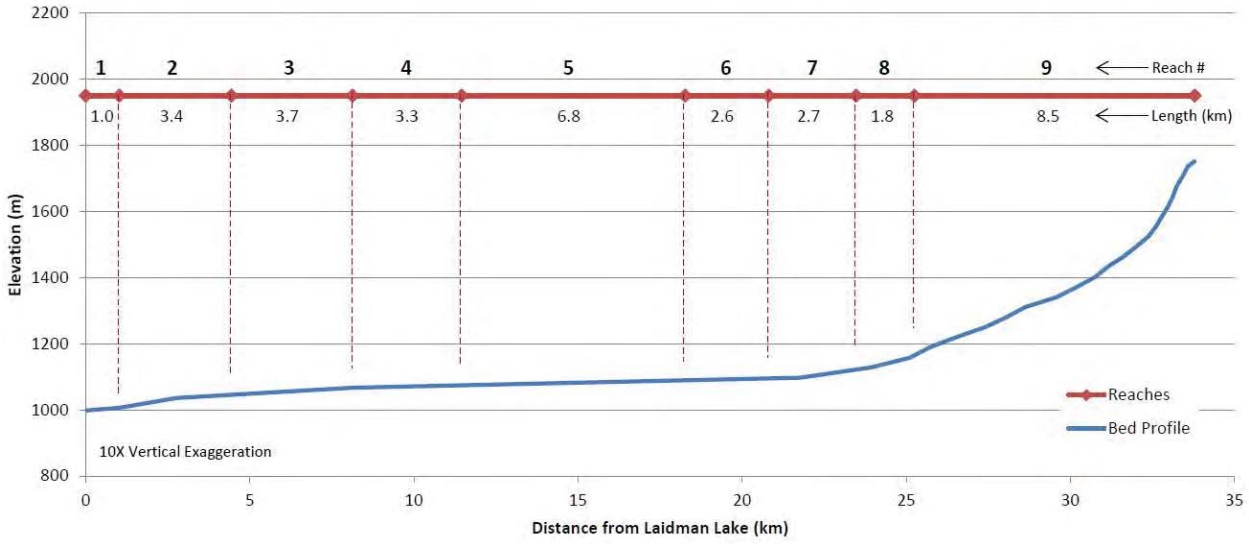


Figure 3-7. Longitudinal Profile of Mathews Creek

Reach 1 – Alluvial Fan-Delta

The channel exhibits an unconfined, sinuous pattern as it flows across the gentle alluvial fan-delta to its mouth at Laidman Lake. It is relatively wide and shallow, with well-defined pool-riffle morphology and a gravel bed. Only a small deposit of sediment extends into Laidman Lake at its mouth, indicating that sediment transport rates are modest. Riparian vegetation is mixed coniferous and deciduous forest, except where anthropogenic grassy areas exist in association the Laidman Lake Ecolodge, situated on the shore of Laidman Lake. In-stream large woody debris is rare.

Reach 2 – Bouldery Canyon (including MC1)

The channel exhibits a confined, sinuous to regular meander pattern as it flows through a moderately sloping (2% average gradient), relatively narrow and deep valley incised into adjacent glaciofluvial and till deposits. It is relatively wide and shallow, with a complex of pool-riffle-run habitat. Cobbles and boulders, derived mainly from several high, unstable cut-banks along the reach, dominate the bed and protrude above the water surface during low to moderate flows. Large woody debris extends into the channel along some portions of the banks, derived from fallen coniferous trees that line both sides of the channel. A small cascade, formed at a prominent bedrock outcrop on the creek bed, defines the upstream limit of the reach.

At MC1, total forested canopy cover is low (1-20%), but provides some in-stream large woody debris habitat from fallen coniferous trees (**Appendix E**). Overhanging riparian vegetation from coniferous trees and herbaceous vegetation provides minimal fish protective cover and shade. In-stream cover for fish consists of boulders (>20% of total area), followed by in-stream vegetation and deep pools (5-20% of total area) suitable for providing overwintering habitat. However, there was no gravel substrate observed to support rainbow trout spawning.

Reach 3 – Irregularly Meandering Meadow

The channel exhibits a partly confined, irregular meander pattern as it flows along a broad, level valley bottom. The low gradient and local abundance of beaver dams (approximately 12 along its upstream end, **Figure 1-2**) minimize flow velocities and maintain a deep channel dominated by run and pool habitats. Channel substrates are mostly sand with minor amounts of gravel. In-stream large woody debris is uncommon, as the channel is bound by mostly open herb meadows, some of which continue to be cleared for hay harvesting.

Reach 4 – Sinuous Meadow (including MC2 and MC3)

The channel exhibits a sinuous to straight pattern as it flows along a slightly steeper and narrower valley bottom to that of Reach 3. Several oxbows alongside the active channel represent sites of past changes in channel pattern. Channel morphology is still dominated by run and pool habitats, although a few small riffles composed of gravel and small cobble were observed. About seven beaver dams contribute to deep, slow flows and mostly submerged riffles (**Figure 1-2**). As in Reach 3, in-stream large woody debris is rare due to the predominance of herbaceous riparian vegetation.

At MC3, in-stream cover for fish was provided mainly by deep pools and abundant in-stream vegetation (**Appendix E**). In-stream vegetation was the only significant form of cover habitat at MC2. As in Reach 3, in-stream large woody debris and overhanging vegetation were rare due to the absence of any forested canopy cover. The prevalence of deep water (100% of 248 m-long surveyed section of channel was pool habitat) suggests that Reach 4 may provide overwintering habitat depending on local groundwater inputs and winter temperatures. However, the lack of gravel substrate indicates that rainbow trout likely do not spawn in this reach.

Reach 5 – Tortuous Meandering Meadow (including MC4 and MC5)

The channel exhibits an unconfined, tortuous meander pattern as it flows across a very broad, level valley bottom, within which past agricultural activity has been most intense of all reaches. Its gradient is the lowest of all reaches (~0.1%), and riffles are rare to non-existent. In-stream habitats are dominated by long runs (approx. 58% of channel, on average, at MC4 and MC5), with small pools situated at the apices of sharp meanders (approx. 42% of channel, on average, at MC4 and MC5). Most drops in water elevation along the reach occur in association with the 20 observed beaver dams (**Figure 1-2**). Bed material is dominantly sand, with fine gravels exposed along local flow constrictions formed by collapsed banks, where velocities are higher. Little in-stream large woody debris exists in the downstream two-thirds of the reach (e.g., MC4 and MC5), where agricultural land use predominates and natural, shrubby riparian vegetation has been removed or trampled by cattle (**Photo 3-1**). Moderate to abundant fish cover is provided by deep pools and in-stream vegetation, with isolated accumulations of small woody debris and collapsing, undercut banks also noted (**Appendix E**, **Photo 3-2**).

Upstream of the former Mathews Creek Ranch, the same broad, gentle valley bottom is a mosaic of shrubs and herb fens, with black spruce scattered along the tops of banks providing some forested canopy cover (10%) (**Photo 3-3**). Functional large woody debris is common. Overhanging vegetation is abundant, with boulders, in-stream vegetation and woody debris providing additional cover.



Photo 3-1. Representative Section of Reach 5 Impacted by Cattle Grazing and Trampling



Photo 3-2. Trampled and Collapsing Banks with In-stream Flow Obstructions in Areas of Reach 5 Accessed by Cattle



Photo 3-3. Representative Undisturbed Section of Reach 5 Upstream of Former Mathews Creek Ranch Site

As in Reach 4, deep pools may provide overwintering habitat depending on local groundwater inputs and winter temperatures. However, the lack of gravel substrate indicates that rainbow trout spawning is unlikely supported along this reach.

Reach 6 – Moderate Gradient Forested Meanders

The channel exhibits a partly confined, sinuous pattern as it flows through a densely forested valley with a slightly higher gradient than that in Reach 5. In-stream habitats comprise a complex assemblage of riffles, runs and pools, with overhanging vegetation and locally undercut banks. The channel has a notably higher width-to-depth ratio than upstream and downstream reaches, due to the absence of deeply and densely rooted herbaceous and shrubby vegetation along the banks. Bed material is dominated by gravel, with patches of sand and cobbles in areas of slower and higher velocity, respectively. In-stream large woody debris is abundant and strongly controls local channel morphology.

Reach 7 – Unstable Aggrading Channel (including MC6)

The channel exhibits an unconfined, irregular meander pattern with locally braided sections. Channel gradient and confinement are insufficient to transport the gravel bedload that enters the reach from the much steeper Reach 7, upstream. As a result, the channel has aggraded, forming anomalously large mid- and side-channel bars and promoting channel widening and overbank flooding. Past beaver dam activity appears to have further exacerbated natural instability along the reach, based on the extent of by-pass channels around breached dams.

At MC6, the valley bottom is a mixture of open, shrubby meadows and patches of coniferous forest providing low canopy cover (1-20%) (**Appendix E**). Fish cover, overall abundant, is provided mainly by large woody debris, with trace amounts of overhanging and in-stream vegetation, and undercut banks also noted. Most in-stream large woody debris has been recruited from the adjacent floodplain during flood events and lateral channel adjustment.

Reach 8 – Moderately Steep, Sinuous Canyon

The channel exhibits a partly confined, sinuous pattern as it flows along the bottom of a comparatively steep, narrow valley incised into the surrounding glaciofluvial and till deposits. Its downstream limit is defined by a large alluvial fan into which the channel has incised. Pool-riffle-run morphology is well developed in gravel to small cobble bed material. Large woody debris is present along the banks at and downstream of cut-banks, where riparian coniferous trees have fallen into the channel.

Reach 9 – Headwater Straight Canyon

The channel exhibits a mostly straight pattern confined within a V-shaped valley. The downstream limit of the reach is defined by a bedrock gorge, with a free-falling waterfall more than 5 m high (photograph of Reach 9 in **Appendix D**). Upstream of this waterfall, which represents a permanent barrier to upstream fish passage, the channel is relatively narrow and dominated by cobbles and boulders on its steep bed. Mature coniferous forest lines both banks and provides sources of in-stream large woody debris, which is common.

3.5.2 Drainage Ditches

Approximately 4.5 km of drainage ditches have been excavated alongside Reach 5 of Mathews Creek during the past several decades (**Figure 1-2**). All ditches appear to have been excavated with the sole purpose of increasing the efficiency of land drainage and lowering the groundwater table. While most have remained stable and generally retained their initial “bank” definition, some have experienced local collapses and have filled in with fine sediments, especially where trampled by cattle. Former connections with Mathews Creek itself have been lost in some areas. Most exhibit a U-shaped cross-section, with steep banks and a relatively deep centre.

Most ditches were partly filled with water during the field reconnaissance in September and October 2013, indicating that they have been excavated beneath the groundwater table. Although flow is visually imperceptible along most of the ditches, a minor difference in water surface elevation (a few centimetres) observed across a small beaver dam in one of the slope-toe ditches indicates that there is some flow. Natural vegetation has successfully colonized the banks of the ditches, since they were constructed, to such an extent that some likely provide reasonable habitat for forage species and amphibians. Some ditches that follow the treeline at the edge of the valley are even spanned by large woody debris, which has fallen across them and now provides cover habitat (**Photo 3-4**).



Photo 3-4. Portion of Slope-toe Drainage Ditch with Vegetated Banks and Woody Debris

3.5.3 Off-line Ponds

Several small ponds exist in the valley bottom alongside Reach 5 of Mathews Creek. All are natural, not excavated, given their presence in the 1964 aerial photography, which predates at least obvious agricultural land uses. The two largest ponds, separated by only about 90 m, are located on the north side of Mathews Creek, near the downstream limit of Reach 5 (**Figure 1-2**; **Photo 3-5**). Both ponds are estimated to be a few metres deep, based on the absence of emergent vegetation and the inability to see the bottom even though the water is not turbid. Some floating vegetation was observed on the surface of both ponds. The two ponds have a direct hydraulic connection, due to the excavation of a straight drainage ditch between them. A 220 m-long continuation of this drainage ditch extends southwestward toward Mathews Creek, but it currently does not connect due to a short section through a low, forested ridge that has collapsed or been filled (**Photo 3-5**). A narrow (<0.2 m), grass-lined swale appears to connect the two ponds to Mathews Creek, at least seasonally, indicating that they may provide rearing and potentially overwintering habitat for forage species.



Photo 3-5. Two Natural, Valley Bottom Ponds near the Downstream Limit of Reach 5

3.5.4 Limitations to Habitat Productive Capacity

There are several important natural and anthropogenic limitations on the productive capacity of fish habitat along Mathews Creek and its minor tributaries. Perhaps of greatest importance is the naturally low average gradient of about 0.2% along reaches 3, 4 and 5. Such a low gradient limits stream flow velocity along the sinuous to tortuously meandering channel, limiting its capacity to entrain and transport all but the finest sediments. Channel bed material is dominated by sand, with only localized accumulations of alluvial gravel (mostly <20 mm) and isolated patches of cobble lag deposits derived from glaciofluvial terraces. Regular stream flows cannot transport material larger than a few centimetres in diameter (based on an erosion threshold analysis), except over short distances in association with sudden discharges from breached beaver dams or other temporary obstructions. A low channel gradient also limits riffle habitat formation and attracts beaver activity.

Beavers are an important, natural part of the aquatic and riparian ecosystems along the low-gradient middle reaches of Mathews Creek. Approximately 39 beaver dams were identified along reaches 3, 4 and 5 during field reconnaissance conducted in early October 2013 (**Figure 1-2**). The distribution and clustering of these dams (i.e., approximately three dams per kilometre of channel, on average) indicates that there are likely multiple families of beavers taking advantage of the low gradient, slow-flowing channel. One of the principal benefits of beaver dams to aquatic species is the maintenance of pools that provide overwintering habitat in reaches that may otherwise freeze to their beds. Widespread beaver activity also results in natural disturbances to aquatic habitat along Mathews Creek. Beaver dams alter local channel (energy) gradients, flood upstream areas, temporarily trap bed material, and can obstruct

fish passage during certain flow conditions (**Photo 3-6**). Their breaches can cause sudden and locally severe erosion downstream, and lead to extended periods of sedimentation as their head-pond deposits are gradually flushed downstream. Beaver activity also affects channel bank stability through the widespread and recurrent removal of riparian shrubs and deciduous trees. While willows typically grow back quickly, following pruning by beavers, other species take longer to grow and may not be able to contribute to bank stability for years to decades (Groupe Hémisphères, 2013).



Photo 3-6. Beaver Dam at MC4 Forming ~0.6 m-high Impoundment

Anthropogenic changes along Reach 5 of Mathews Creek, in particular, may have affected local, upstream and downstream habitat productive capacities. Fish utilization along Reach 5 itself is likely reduced from its natural condition due to a lack of habitat structural complexity (e.g., riparian vegetation, large woody debris and stable, undercut banks) that provides fish cover and substrate for periphyton and benthic invertebrates, and from locally high suspended sediment concentrations from the erosion of trampled and collapsed banks. Fine substrates have been associated with reductions in benthic invertebrate and periphyton abundance and diversity (Wood and Armitage, 1997), and lower salmonid growth and survival rates (Suttle et al., 2004).

The current sparse riparian canopy also increases predation from birds and mammals and raises water temperatures through reduced shading. Allocthonous inputs including nutrients and food from riparian vegetation have been reduced along and thus downstream of the reach. Large woody debris disbursement, which provides organic carbon, fish protective cover, benthic invertebrate habitat and the facilitation and maintenance of complex stream features (e.g., scour pools, undercut banks), is largely absent.

Downstream aquatic habitat may also have been adversely affected by the limited downstream transport of nutrients, food and woody debris, as well as by unnaturally high suspended sediment concentrations. The potential impacts to productive capacity upstream of Reach 5 may be indirect. Because of the limitations outlined above, fish may be deterred from migrating through the long, exposed section of Reach 5 to access higher quality habitats immediately upstream (e.g., Reach 6). As a result, Reach 6 likely has a far greater productive capacity than has been realized since the downstream two-thirds of Reach 5 were so severely altered. Similarly, resident fish upstream of Reach 5 may have limited migrations, and thus reduced access to potential food, spawning areas or predator refuges farther downstream.

4 Fish Habitat Offsetting Measures

4.1 Objectives and Rationale

The main objective of the proposed habitat offsetting measures in the Mathews Creek watershed is to increase the productive capacity of fish habitat along the section of Mathews Creek most impacted by past agricultural activity. Proposed habitat offsetting efforts target the specific preferences of rainbow trout, although benefits are also expected to other species that use, or previously used, the impacted section of Reach 5. Key elements of the proposed watershed-based, offsetting strategy include exclusion or responsible management of cattle, restoration of riparian vegetation, and restoration and enhancement of in-stream habitat along Mathews Creek and its tributaries. All proposed works are designed to be permanent or self-sustaining, requiring little to no maintenance in the long-term, and build on the successes of habitat restoration projects in other ranchland settings.

There are many successful accounts of increased habitat quality, and resultant fish usage, following cattle exclusion, riparian vegetation restoration and the enhancement of in-stream habitat (Roni et al., 2008). Restored riparian areas following cattle exclusion have been associated with numerous enhancements to aquatic habitat, including increased food production (Laffaille et al., 2000), cooler stream temperatures (e.g., Platts, 1991; Li et al., 1994; Wu et al., 2000), higher availability of protective fish cover (Myers and Swanson, 1995), better water quality (Sovell et al., 2000; Meals and Hopkins, 2002) and increased bank stability (Connin, 1991; Myers and Swanson, 1995). Further, the installation of in-stream habitat features such as woody debris structures has been linked to increased channel stability, higher availability of pool habitat and increased fish abundances (White et al., 2011; Pierce et al., 2013). Ultimately, higher aquatic habitat quality and quantity have been related to increased aquatic biota health, fish densities and overall ecosystem functioning (Hunt, 1976; Platts, 1991; Li et al., 1994; Kauffman et al., 2002; O'Grady et al., 2002; Binns, 2004; Pierce et al., 2013). The proposed habitat offsetting measures along Mathews Creek and its tributaries are aimed at restoring and diversifying in-stream and riparian habitats for ultimate gains in ecosystem function.

Habitat enhancements in a given reach can have farther-reaching effects on adjacent reaches by increasing the overall habitat productive capacity of the watershed, and thus increasing overall population abundances (Behnke, 1992; Baldigo et al., 2008; White et al., 2011; Pierce et al., 2013). Several studies have reported fish community shifts toward more specialized dominant species such as trout, following habitat riparian restoration efforts (Behnke, 1992; Baldigo et al., 2008). As dominant fish move into newly improved areas, sub-dominant fish with a broader range of environmental tolerances will move into abandoned habitats, resulting in an overall increase in population abundance (Baldigo et al., 2008). Community shifts and changes in overall watershed population abundances can occur over relatively short timelines (<3 years), with observed changes maintained over long-term periods (5-20 years; Hunt, 1976; Pierce et al., 2013). The anticipated response of fish populations within Mathews Creek to habitat restoration and enhancement is increased utilization of Reach 5 by rainbow trout, to take advantage of installed complex habitat structures (e.g., root wad-boulder complexes) and to access higher quality habitats upstream (e.g., Reach 6).

Habitat enhancement may also yield indirect effects on habitat quality in downstream reaches following riparian vegetation restoration and bank stabilization efforts. Naturally low-gradient habitats in reaches 3 and 4, which have deep, slow-flowing water, are likely impacted by sediment loading from Reach 5 (upstream) and the incapacity to efficiently convey fine sediments farther downstream. Restoration of Reach 5 is expected to reduce sediment loading to downstream habitat, thereby lowering stream turbidity and substrate embededdness, and increasing habitat complexity for fish and aquatic organisms. Thus, overall benefits to fish and fish habitat along Mathews Creek are expected not only along Reach 5, where restoration and enhancement efforts are focused, but also along downstream reaches currently impacted by the unnatural instability along Reach 5.

4.1.1 Natural Limitations

The restoration of impacted habitats along Reach 5 will address key factors that currently limit the productive capacity of local and downstream habitats, including high sediment loading from unstable banks; a lack of riparian vegetation for protective cover, shading and allocthonous inputs; and an absence of in-stream habitat features formed by large woody debris. However, an important *natural* limitation on the productive capacity of habitat along Reach 5 warrants acknowledgment. The reach's naturally low gradient minimizes flow velocity, diversity and its capacity to transport bed material downstream. Slow-flowing water also tends to have warmer temperatures and possibly poorer water quality (e.g., lower DO) in comparison to fast-flowing water. While restoration efforts cannot increase reach-scale gradients and average velocities without detrimental effects on channel morphology, in-stream habitat structures (e.g., root wads, boulder clusters) are designed to locally accelerate and diversify flow, creating micro-habitats and opportunities for aeration that may not otherwise exist.

The naturally low gradient also predisposes the reach to widespread beaver activity. Regardless of the effectiveness of offsetting efforts to restore and enhance in-stream and riparian habitat, the temporary and localized impoundments formed behind beaver dams will affect flow velocities, water depths and patterns in sediment transport. This being said, local experience and studies indicate that beavers and rainbow trout healthily co-exist in natural, functional stream ecosystems (pers. comm., Scott McIntosh, Site Manager, Saik'uz First Nation, October 2013).

4.2 Description of Proposed Habitat Offsetting Measures

Four potential opportunities for fish habitat offsetting within the Mathews Creek watershed were initially identified based on the field investigations and subsequent desktop analysis completed by PECG in September and October 2013. One of the opportunities considered the enhancement of existing off-channel pond habitat, near the downstream limit of Reach 5 (**Photo 3-5**), by deepening and enlarging the two existing ponds and establishing a permanent, naturalized connection to Mathews Creek. Although this option would greatly expand off-channel overwintering and rearing habitat for some local fish species, it may yield little benefit to rainbow trout, the main target species for habitat offsetting work. Therefore, this habitat offset is no longer under consideration at this time.

The remaining three opportunities were selected for more detailed planning and design, as they meet the key objectives outlined above (**Table 4-1**). The estimated maximum gain in spatial habitat area (m^2) associated with each of the three opportunities is based on the product of the channel lengths (m) and widths (m) along which habitat offsetting works are proposed. Where only one side of the channel warrants restoration and enhancement, the potential gain in habitat is proportionally only one half of the channel. Each opportunity is described below, with reference to conceptual design drawings and a map showing the locations and extents of proposed fish habitat offsetting measures (**Figure 4-1**).

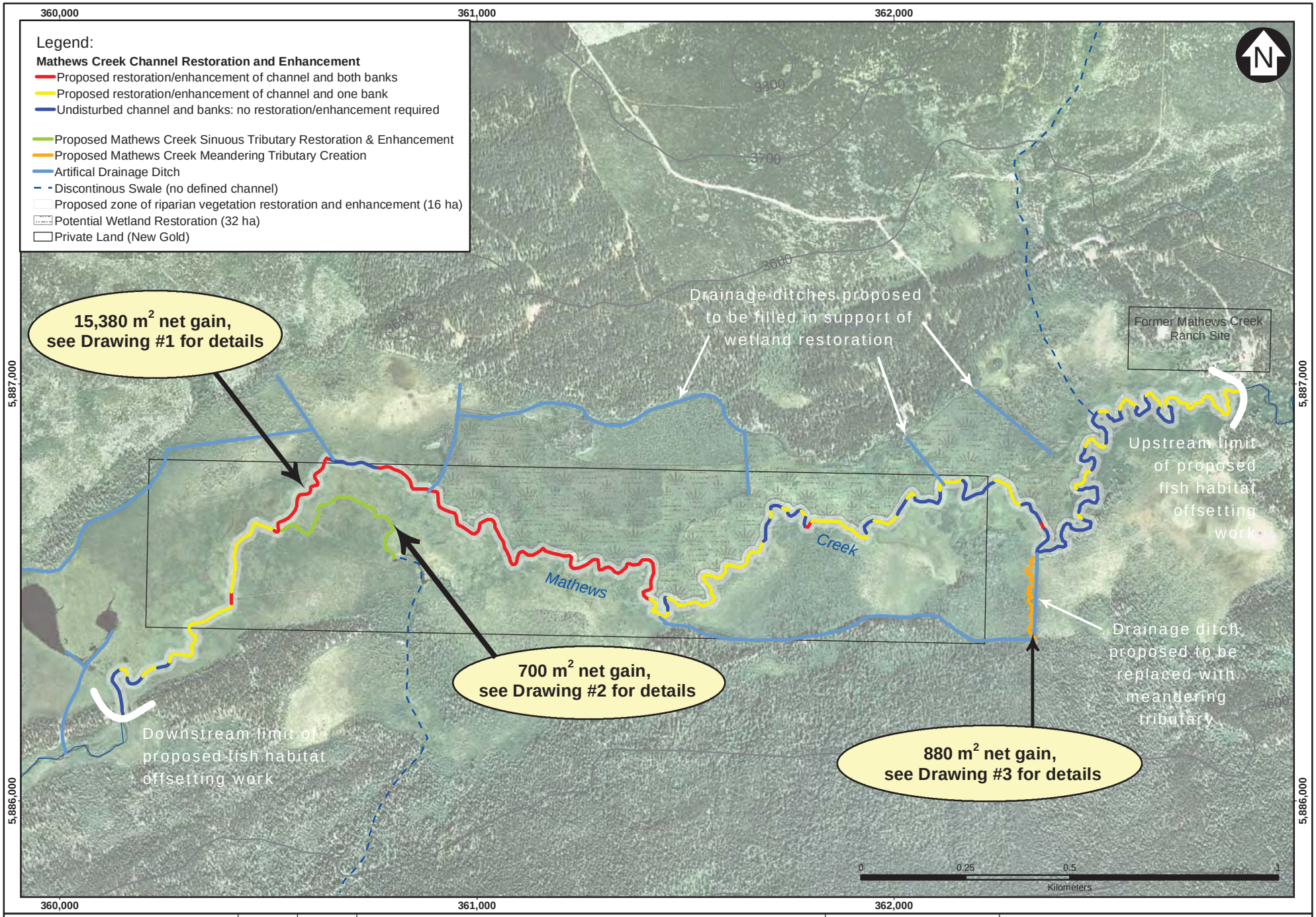
Table 4-1. Areas of Proposed In-stream Habitat Offsetting Measures

Habitat Offsetting Opportunity	Length (m)	Width (m)	Area (m^2)[a]
Mathews Creek Channel Restoration and Enhancement	1,393 (channel bed & both banks)	6[b]	8,360
	2,341 (channel bed & one bank only)	3[c]	7,020
Mathews Creek Sinuous Tributary Restoration and Enhancement	468	1.5	700
Mathews Creek Meandering Tributary Creation	294	3	880
Total:			**16,960**

[a] *Areas rounded to the nearest 10 m^2.*

[b] *Average channel width along section of Reach 5 where channel bed and both banks warrant restoration and enhancement.*

[c] *Half of average channel width along section of Reach 5 where channel bed and one bank warrant restoration and enhancement.*



PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

DESIGNED	RM
DRAWN	KP
CHK'D	RM
APP'D	-
REV	-
DATE	31'10'13

NOTES:
1. BASE MAP: CanVec 92F03
2. PROJECTION: NAD 1983 UTM Zone 10N
3. COORDINATE GRID: Metres

newgold

Blackwater Project

Locations and Extents of Proposed Fish Habitat Offsetting Measures

FIGURE 4-1

4.2.1 Mathews Creek Channel Restoration and Enhancement

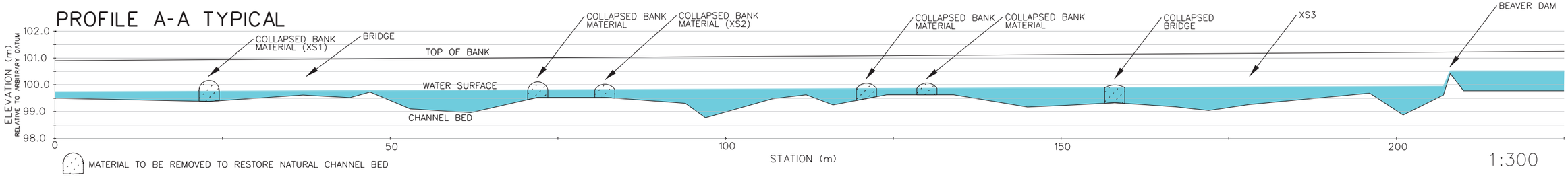
The primary limitations to the productive capacity of fish habitat in the Mathews Creek watershed occur along the 5.4 km-long section of Reach 5 that has supported agricultural land use for the past several decades (**Figure 4-1**). The restoration of degraded in-stream and riparian habitats along the reach is principally important in efforts to reduce local and downstream sediment loading and accommodate rainbow trout migration through the low-gradient reach to access high quality, upstream habitat. Additional measures to enhance in-stream cover, a key requirement for rainbow trout, are also incorporated into overall channel restoration and enhancement works. They include installing in-stream habitat features including root wads and boulder clusters, and more widespread riparian planting of black spruce on low mounds or in areas naturally elevated slightly above the surrounding floodplain, where a high groundwater table may otherwise inhibit their growth.

Restoration efforts are proposed to be focused along segments of Mathews Creek where either one or both banks have been impacted by cattle trampling (yellow and red segments on plan overview in **Drawing 1**, respectively). The proposed restoration first involves the removal of unnatural, in-stream obstructions to flow, including collapsed and unmaintained bridges, haphazard blocks of collapsed, sandy banks, and isolated metal debris from agricultural vehicles, in order to restore natural pool-run bed morphology (**Photo 4-1**). Some of these obstructions exacerbate bank erosion, while others at least partially impede fish passage during periods of low flow. Any anthropogenic materials (metal debris, treated wood, etc.) will be disposed of off-site at an appropriate facility. The collapsed bank material can be used in the re-sculpting of banks or in low mounds on which black spruce saplings will be planted in the riparian zone.



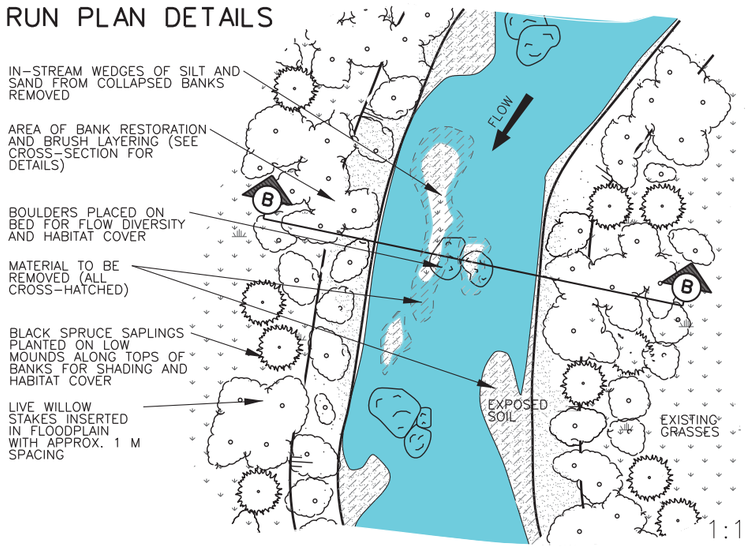
Photo 4-1. Material from Collapsed Bridge and Banks to be Removed During Restoration

PROFILE A-A TYPICAL



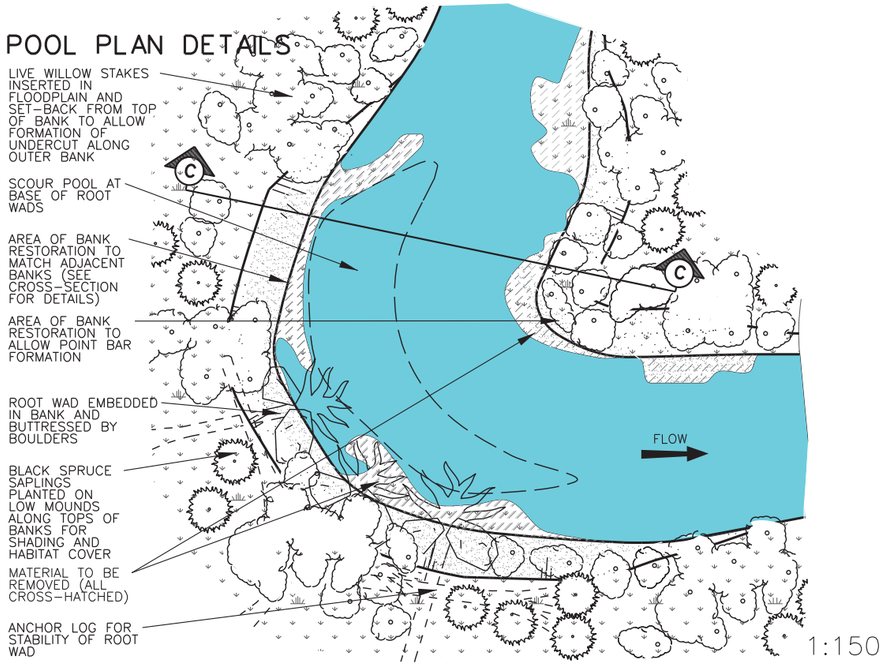
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RUN PLAN DETAILS



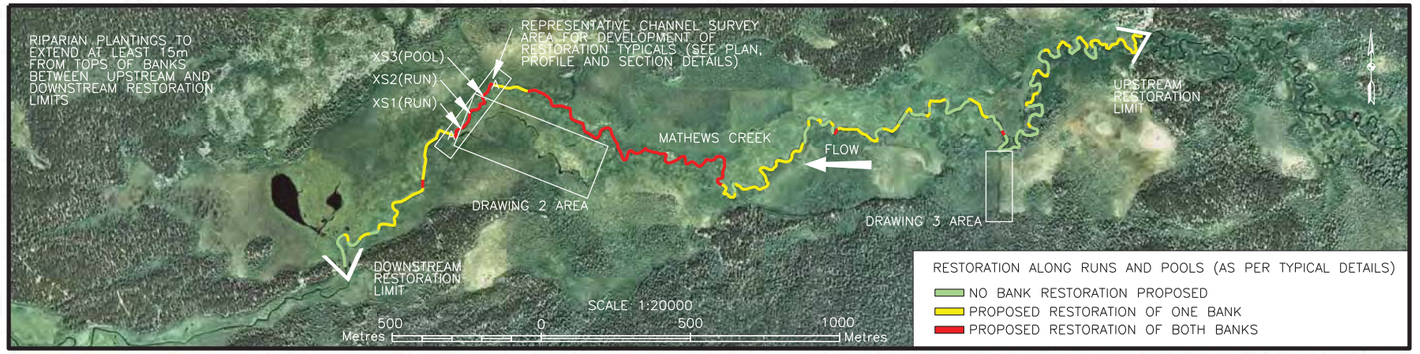
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POOL PLAN DETAILS



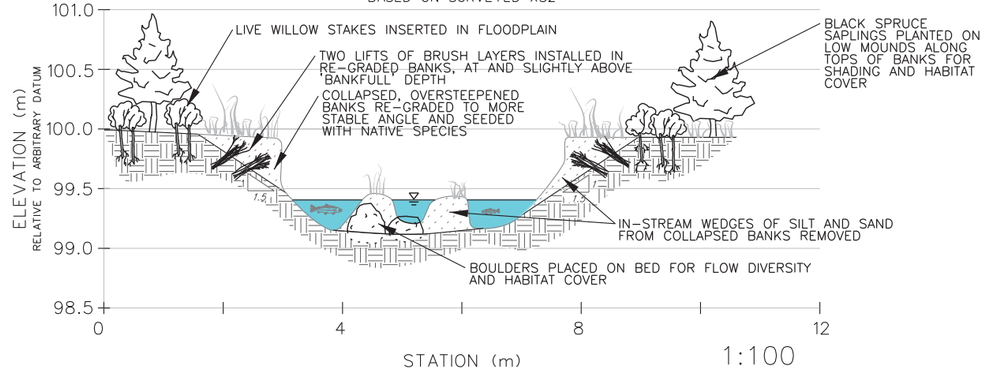
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MATHEWS CREEK PLAN OVERVIEW



RUN SECTION B-B TYPICAL

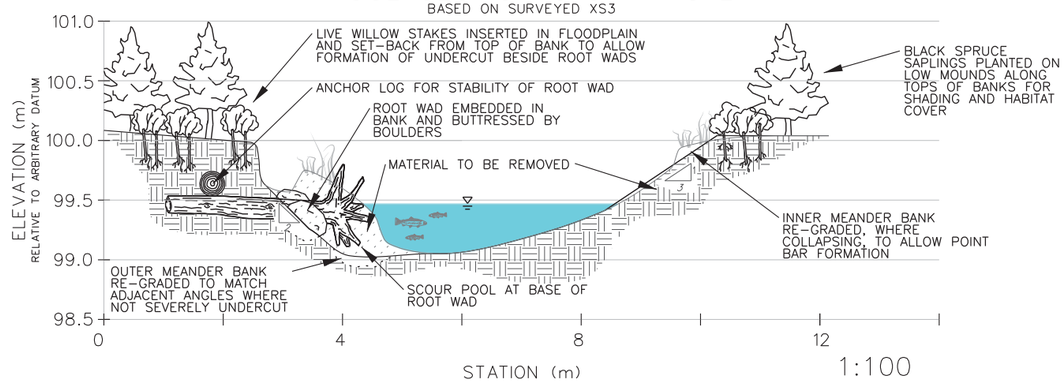
BASED ON SURVEYED XS2



1:100

POOL SECTION C-C TYPICAL

BASED ON SURVEYED XS3



1:100

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WATER RESOURCES AND ENVIRONMENTAL ENGINEERING
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MATHEWS CREEK CHANNEL RESTORATION AND ENHANCEMENT

BLACKWATER PROJECT

CONCEPTUAL DESIGN

DATE:	DESIGN BY	CHKD. BY	APPD. BY
OCTOBER 22, 2013	E.G.	B.G.	R.M.

SCALE	AS SHOWN	DRAWING NO. 1
		SHEET NO. 1

As shown in the representative channel survey area of Reach 5, cattle trampling has resulted in an irregular planform configuration of channel banks (**Drawing 1**); areas of alternating erosion and collapse have formed mounds that project into the active channel, exposing them to rapid erosion. The banks will be re-graded and initially restored to more stable angles, giving riparian plantings the opportunity to grow and naturally stabilize the banks. Bioengineering techniques will be incorporated in order to accelerate natural stabilization of banks and allow for the natural formation of undercut banks, an optimal attractant for rainbow trout among other species. Along runs, two lifts of brush layers will be installed in the upper portions of the restored banks, at and just above the bankfull depth (Section B-B, **Drawing 1**). Along pools, which most commonly exist near the apices of sharp meanders, root wads will be installed along the outer bank (Section C-C, **Drawing 1**). The root wads will be embedded in the banks, beneath an anchor log, and buttressed by boulders. The clustering of root wad structures along the downstream arms of meanders is designed to promote the formation of a deep scour pool along their bases.

Live willow stakes will be inserted along the tops of banks and into the adjacent floodplain to promote rapid establishment of deeply rooted riparian vegetation. The stakes will be set-back slightly from the tops of the outer banks above pools, in order to allow channel migration to set up the formation of an undercut bank, naturally stabilized by a dense root network. Small, isolated clusters of boulders will be placed on the channel bed in order to provide in-stream cover and create micro-habitats with widely varying, local flow velocities.

In addition to focusing efforts along the channel banks, shrubby vegetation with scattered black spruce will be re-established within a minimum 15 m-wide buffer along each channel bank, representing approximately 16 ha of restored and enhanced riparian vegetation (**Figure 4-1**). Willow thickets will be created to replicate natural conditions prior to agricultural activity. Black spruce saplings will be planted on existing micro-topographic highs, slightly elevated relative to the average floodplain elevation, or on constructed low mounds. This measure is necessary to ensure their roots are sufficiently elevated above the groundwater table that their growth is uninhibited by high soil moisture below.

4.2.2 Mathews Creek Sinuous Tributary Restoration and Enhancement

The only natural, valley bottom tributary that enters the former ranchland along Reach 5 of Mathews Creek has been severely impacted along its downstream two-thirds by cattle trampling its banks and bed. Its cross-section is unnaturally wide and shallow, and in-stream vegetation nearly obstructs flow (**Photo 4-2**). Although the sinuous tributary does not contribute large amounts of flow to Mathews Creek, its slope-toe spring maintains some flow throughout the drier months.



Photo 4-2. Unnaturally Wide and Shallow Tributary from Cattle Trampling

A more natural morphology is proposed to be restored along the impacted sections of the sinuous tributary in order to provide opportunities for off-line rearing in a groundwater-fed channel and to help maintain the important baseflow contributions provided to Mathews Creek. (Cattle were unable to access the upstream one-third of the tributary, so its morphology is natural and does not require restoration.) The downstream two-thirds of the channel will be deepened and narrowed slightly from its over-widened condition, to inhibit the growth of dense, emergent vegetation (**Drawing 2**). The banks will be re-sculpted using clean, native fill.

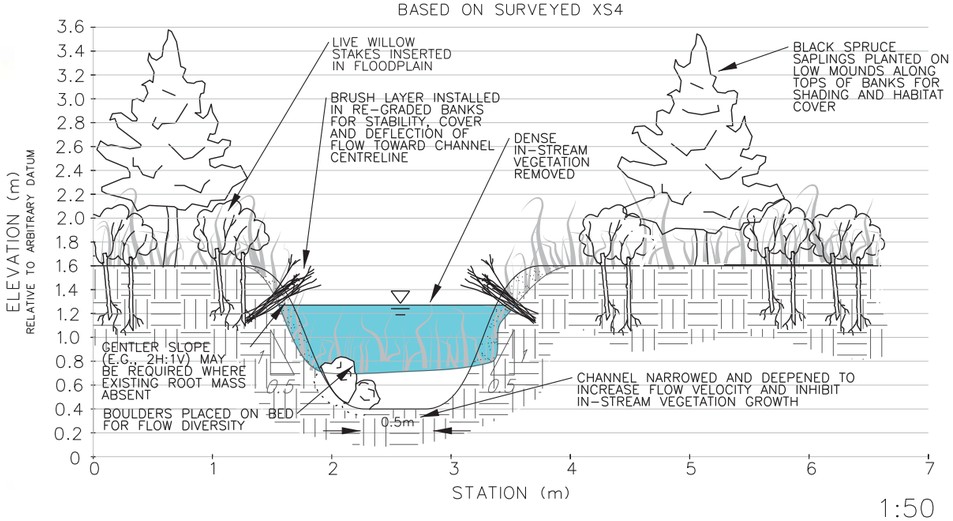
A single brush layer installed just below the tops of banks will help maintain a narrow, concentrated thalweg along the channel centreline, and will provide important cover for fish. Live willow stakes planted along the banks and in the adjacent floodplain will ultimately help shade the channel and provide important allocthonous inputs. A few black spruce saplings will be planted on low mounds adjacent to the channel to provide cover.

PLAN OVERVIEW



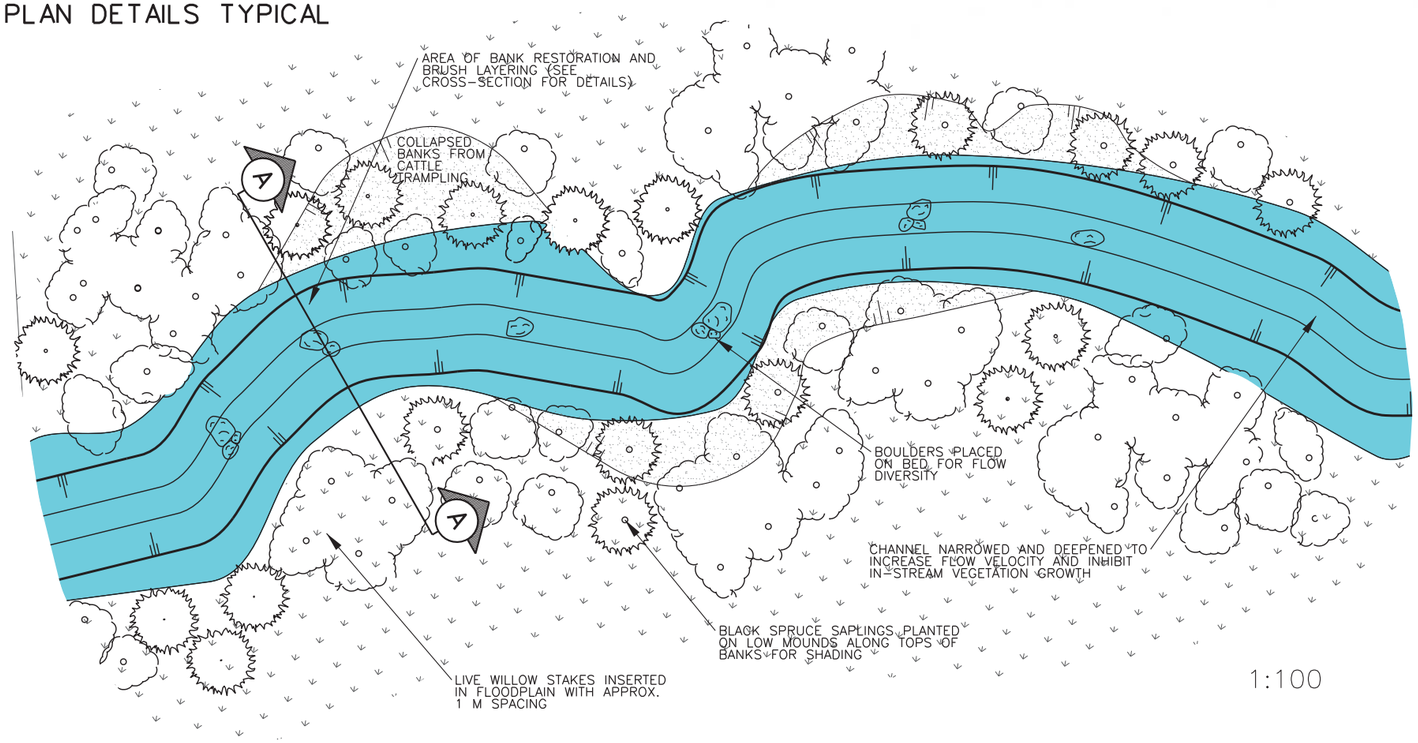
SECTION A-A TYPICAL

BASED ON SURVEYED XS4



1:50

PLAN DETAILS TYPICAL



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MATHEWS CREEK SINUOUS TRIBUTARY RESTORATION AND ENHANCEMENT

BLACKWATER PROJECT

CONCEPTUAL DESIGN

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		SHEET NO. 1

4.2.3 Mathews Creek Meandering Tributary Creation

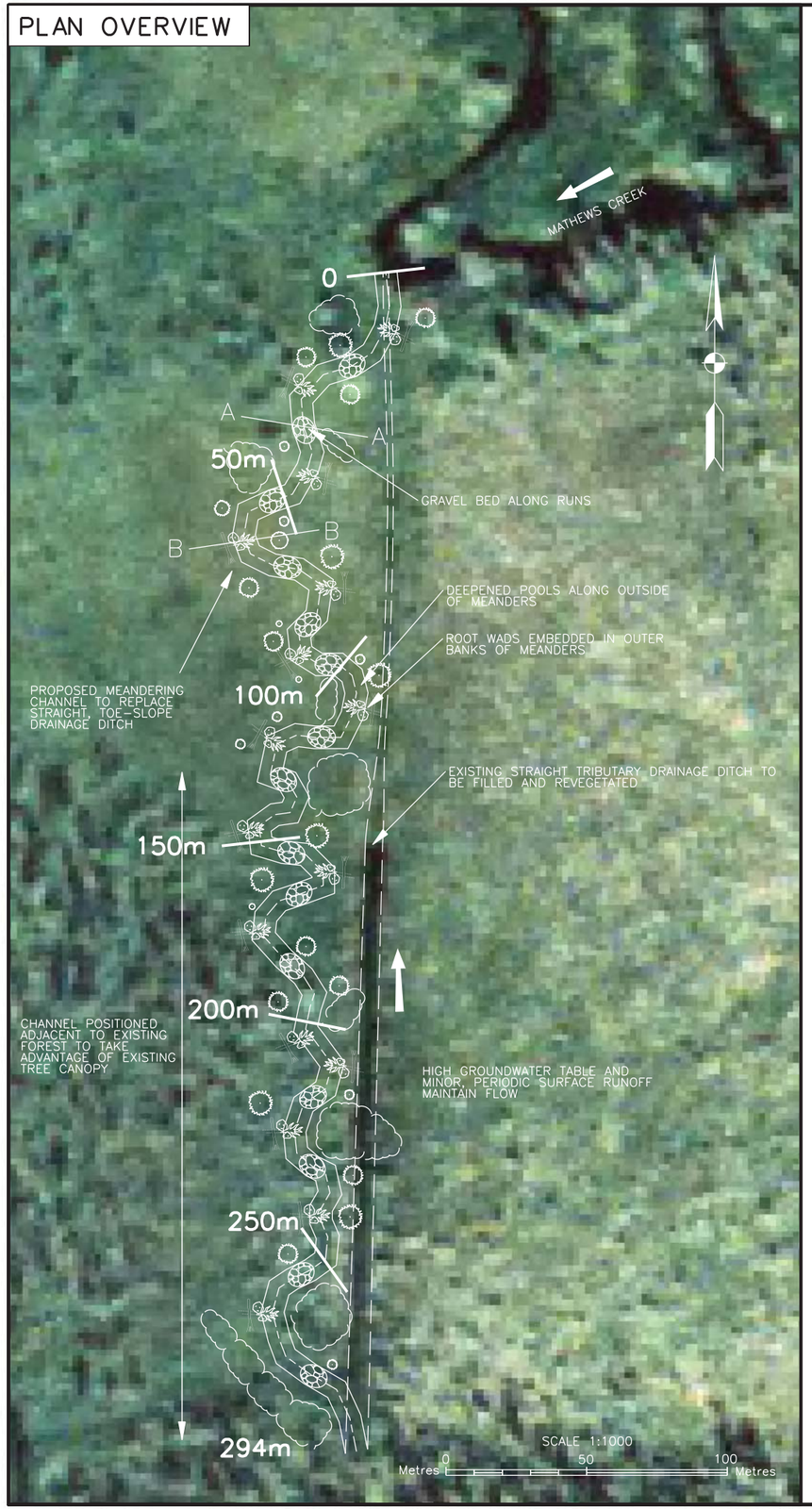
Of the numerous drainage ditches excavated within the valley encompassing Reach 5 of Mathews Creek, one descends a gentle slope-toe apron with upslope-downslope (fall-line) orientation (**Photo 4-3**). It is widest along its upper half (~3 m) and then narrows to less than 0.5 m along its lower half, before draining over a grassy, natural embankment into a deep pool at the apex of a sharp meander in Mathews Creek (lower-left corner of **Photo 4-3**). A naturally high groundwater table in the slope-toe apron maintains flow, albeit at a low rate, through the drier months.



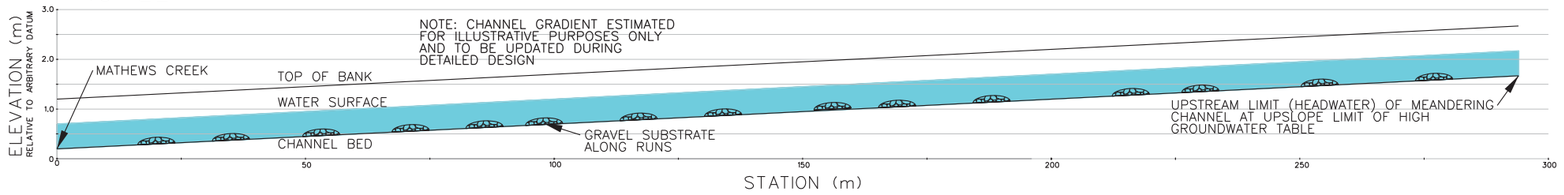
Photo 4-3. Slope-toe Drainage Ditch Proposed to be Replaced with Small, Meandering Tributary

The existing, straight drainage ditch is proposed to be replaced with a meandering channel to create new, fish-accessible, meandering tributary habitat (**Drawing 3**). The proposed configuration of the new channel is based on the meander pattern of a natural tributary that descends a similarly gentle slope-toe apron just 1 km to the east (**Photo 4-4**). A symmetric cross-section and relatively shallow depth is proposed at runs, located along the straight sections between meanders. A brush layer is proposed along both banks, at the bankfull level, for habitat cover and bank stability. Gravel is proposed to be placed along the bed at runs, in order to provide substrate diversity and inhibit potential scour during the spring snowmelt, when surface contributions to flow will be at a maximum. An asymmetric cross-section is proposed within pools along each meander, with a steeper outer bank and a gentler inner bank. A root wad, stabilized with an anchor log, will be embedded into the outer bank of the meanders. Boulder stabilization is unnecessary, given the modest flow expected in the channel. A small scour pool may form at the base of the root wad, with sedimentation occurring along the inner bank. Live willow stakes immediately adjacent to the channel will help maintain bank stability and provide important habitat cover, although they are unnecessary and inappropriate in areas of existing forest cover (e.g., upper-right corner of **Photo 4-3**). Where the height of ground above the groundwater table is sufficient, black spruce saplings will be planted on low mounds for additional cover, shading and allocthonous inputs.

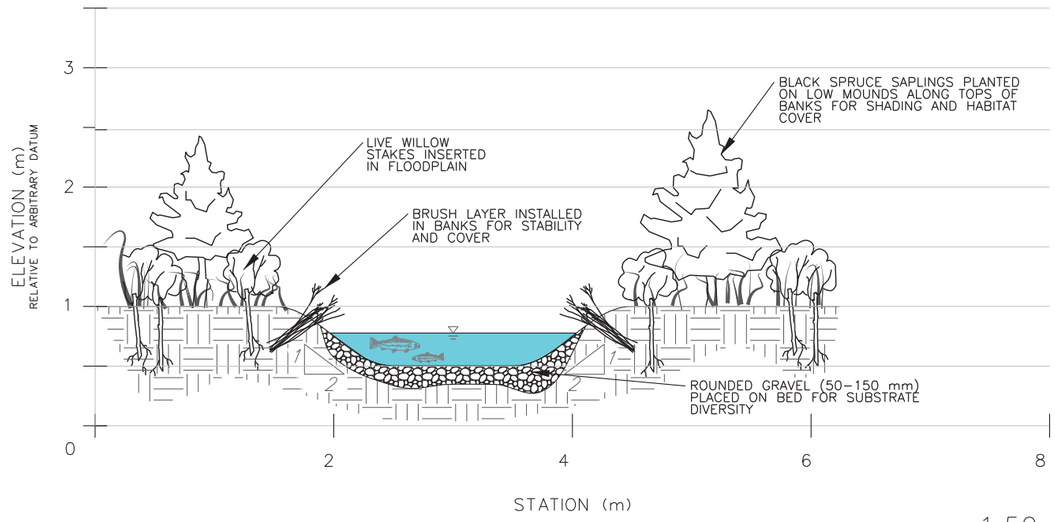
PLAN OVERVIEW



PROFILE

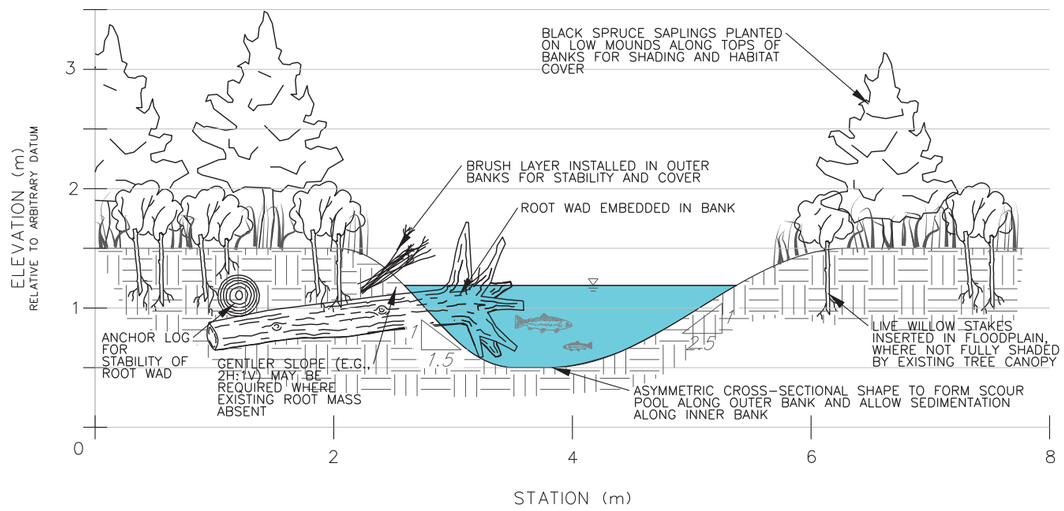


RUN SECTION A-A TYPICAL



1:50

POOL SECTION B-B TYPICAL



1:50

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MATHEWS CREEK MEANDERING TRIBUTARY CREATION

BLACKWATER PROJECT

CONCEPTUAL DESIGN

DATE:	DESIGN BY	CHK'D. BY	APP'D. BY
OCTOBER 22, 2013	E.G.	B.G.	R.M.

SCALE		DRAWING NO. 3
AS SHOWN		SHEET NO. 1



Photo 4-4. Nearby Reference Reach of Meandering Tributary to Mathews Creek (Upper Right)

4.3 Integration with Wetland Restoration

Wetland restoration is proposed to be integrated with the fish habitat offsetting measures described above, in order to maximize the long-term benefits to both aquatic and terrestrial ecosystems along Mathews Creek. Following from the objectives identified by AMEC's wetland ecologists in Section 1.2.2, several drainage ditches on the north side Mathews Creek are proposed to be filled (**Figure 4-1**). Each of the affected ditches is either disconnected from Mathews Creek or only seasonally connected via a cattle-trampled, vegetated swale. Filling the ditches will return the groundwater table to its slightly higher, natural level within the valley bottom alluvium, which in turn will restore the wetter soil moisture regime necessary to promote and sustain the growth of natural wetland vegetation communities (Groupe Hémisphères, 2013). A mosaic of habitat types will be created within a 32 ha area on the north side of Mathews Creek, as shown in **Figure 4-1**, by planting willows, with patches of black spruce on slightly elevated ground and herbaceous species on slightly depressed ground. The re-establishment of natural, historical vegetation patterns is also anticipated to attract birds and small mammals that would have been displaced from the area by land clearing and cattle ranching activity.

Wetland restoration is also expected to yield important benefits for Mathews Creek itself. The exclusion of cattle from the area of wetland restoration will eliminate unnaturally high nutrient loading from animal waste, moderate surface runoff and flooding, reduce erosion and sedimentation, and improve thermal regulation. In combination, these changes should result in marked improvements in the quality of local and downstream fish habitat.

5 Implementation Strategy

5.1 Timing

The proposed habitat offsetting measures will be completed in accordance with the applicable "reduced risk timing window" for in-water work in areas of rainbow trout habitat, as established by BC Ministry of Environment and supported by DFO. This will minimize risk to rainbow trout and other local fish species during activities within the channel and adjacent riparian zones.

Because all work within the Mathews Creek watershed is outside the limits of the Blackwater Project, it can be completed in advance of any impacts that are authorized by DFO in association with the project. Completing the work as far in advance as possible will avoid impacts to the productivity of fisheries by providing the opportunity for new, restored and enhanced habitats to become functional prior to impact.

All channel works will be completed "in the dry", either by conducting work along sections of channel that are dry or completely frozen (preferred) or by isolating the work area from flowing water. A number of measures can be used alone or in combination to isolate a dry work area, including properly configured coffer dams, with flow by-pass flumes or pipes with pumps, where required. Once the work area has been isolated and allowed to drain (dewater), a qualified fisheries biologist or technician with a fish collection license will capture, identify and release upstream any fish that become trapped within the work area. The channel restoration and enhancement works will be completed as efficiently as possible, thereby minimizing the period during which a portion of habitat is isolated from the adjacent channel.

5.2 Environmental Management Plan

An Environmental Management Plan (EMP) will be developed prior to initiation of restoration activities as a basis for protecting aquatic and riparian ecosystems during construction of restoration and enhancement measures. It will outline key roles and responsibilities, including those of the proponent, consultant and contractor, and will detail the different phases of monitoring to be conducted (Section 5.3). A project-specific 'trigger-response action plan' will be included in the EMP as a framework for promptly identifying and addressing any potential issues of concern that arise during implementation of the habitat offsetting works.

A principal component of the EMP will be an erosion and sediment control (ESC) plan. The ESC plan will focus on controlling surface run-off and minimizing the extent and duration of soil exposure, in order to inhibit erosion and sedimentation along Mathews Creek or its tributaries. The plan will reflect best management practices to satisfy the *Water Act* regulation's Protection of Habitat Section 42(1) and Protection of Water Quality (Section 41) Standards, as well as Section 35 of the *Fisheries Act*. In addition to detailing all physical ESC measures, it will specify the necessary frequency of inspection, relative to key construction activities, weather conditions and site-specific environmental conditions. Inspection should be completed regularly during the construction process to ensure that ESC measures are functioning as intended and to provide for the timely maintenance of ESC measures.

The appropriate combination and distribution of ESC measures will be finalized during detailed design and specified on the ESC plan. All measures will be in place and operational prior to construction commencement. Key details of the plan may include, but not be limited to, the following:

- Strategies for preventing off-site water from entering the work area, and for managing on-site water;
- Erosion control strategies, including techniques, materials and installation methods;
- Sediment control strategies, including techniques, materials and installation methods;
- Delineation of areas of greatest ecological risk;
- Site restoration and re-vegetation prescriptions;
- Locations for storing and refueling all equipment (>30 m from any water feature);
- Contingency plans for unforeseen high flow events; and
- Monitoring program details

5.3 Monitoring

To ensure that the benefits of the proposed restoration and enhancement of the Mathews Creek watershed are realized, several recommendations regarding implementation and monitoring of the proposed works are provided below:

- **Construction Supervision** – An environmental monitoring technician will be on-site throughout the period of in-water work to document compliance with all environmental protection measures and inspect and report on all ESC measures. A qualified professional with experience in the supervision of channel restoration projects (e.g., fluvial geomorphologist, habitat restoration specialist) will visit the site at critical times during construction to ensure all elements of channel works are completed according to design specifications, and to assist with field-fit modifications, where required. Key elements of construction to supervise include, but are not limited to, the following:
    - Implementation of functional erosion and sediment control measures, including flow by-pass measures;
    - Removal of existing vegetation within, and protection of vegetation in close proximity to, the work areas and access route;
    - Establishment of key profile (elevation) points and channel dimensions;
    - Installation of habitat cover features (e.g., root wads, boulder clusters, brush layers, live stakes); and
    - Construction of transitions to the upstream and downstream tie-in points.

- **Vegetation Planting Success** – Regular monitoring and maintenance of vegetation plantings should be conducted within the first year of plant growth to improve the chances of survival, and may include the following:

    - Selective irrigation;
    - Removal of invasive species;
    - Documentation and replacement of unsuccessful plantings;
    - Protection of erosion areas; and
    - Identification and mitigation of animal intrusion or damage.

- **Baseline and Construction Monitoring –** It is recommended that field inspections be conducted periodically before and during construction to document and photograph site conditions associated with channel and bank restoration activities. The field inspections should be conducted at least once prior to construction and weekly during the construction period. Photographs should be collected from the same vantage point and with the same field of view to allow for time series comparison.

- **Post-Construction Monitoring** – For stream restoration projects, DFO typically includes as a condition in its permit a requirement for post-construction monitoring. Detailed as-built surveys and drawings should also be completed immediately following construction by the contractor in consultation with the channel design consultant. The specific details and periods of monitoring required for each restoration and enhancement site will be developed in consultation with approval agencies during the permitting process.

- **Ecological Effectiveness Monitoring** – Although improvements to aquatic and riparian ecology from restoration projects are difficult to quantify, it is recommended that an ecological post-construction monitoring plan be implemented to provide data on the effectiveness of the habitat offsetting measures. Post-restoration fish and fish habitat assessments should be carried out by qualified personnel and should include the following elements:

    - FHAP surveys;
    - Fish community sampling, to determine relative abundance and the distribution of target species;
    - Flow condition monitoring; and
    - Stream temperature and potentially water quality monitoring within and downstream of the restored and enhanced reaches.

    The results of the post-restoration assessments will be compared to existing conditions within the Mathews Creek watershed to evaluate the effectiveness of habitat offsetting measures, identify deficiencies, and recommend additional works for consideration.

5.4 Cattle Management Plan

The impact of cattle grazing, trampling and wading on Mathews Creek has been emphasized already (e.g., Section 3.2). The remarkable contrast in vegetation communities and channel morphology between areas accessible to cattle and areas where cattle were prohibited elucidates the importance of excluding cattle or at least managing cattle access along Mathews Creek and its tributaries as much as reasonably possible.

New Gold's purchase of Mathews Creek Ranch is the greatest mitigation measure for avoiding the destruction of restored sections of channel or further impacts to undisturbed portions of channel. New Gold commits to working with MFLNRO on how the range tenure it now holds gets reassigned. If cattle grazing within its private lands continues in the future, it will be conducted responsibly and in a manner that protects the fish habitat offsetting measures described in this report. Regardless, consideration will need to be given to incorporating cattle exclusion measures in the immediate vicinity of restored sections of Mathews Creek that are within surrounding Crown land. Several ideas worth considering are identified below:

- Fencing set-back from the tops of banks to prevent cattle access to the banks;
- Riparian "pavement" formed with angular or rounded stone alongside critical sections of the channel, as a deterrent to cattle;
- Limited access points to the creek, with short, rock-lined patches of channel immediately upstream and downstream to deter cattle wading; and/or
- Creation of off-line cattle watering ponds.

6 References

Baldigo, B.P., Warren, D.R., Ernst A.G. and Mulvihill, C.I., 2008. Response of fish populations to natural channel design restoration in streams of the Catskill Mountains, New York. North American Journal of Fisheries Management 28:954–969.

Beeton, A.M., 1956. Food habits of the burbot (*Lota lota* lacustris) in the White River, a Michigan trout stream. Copeia 1:58-60.

Behnke, R.J., 1992. Native trout of western North America. American Fisheries Society, Monograph 6, Bethesda, Maryland.

Behnke, R.J., 2002. Trout and salmon of North America. Free Press, New York.

Binns, N.A., 2004. Effectiveness of habitat manipulation for wild salmonids in Wyoming streams. North American Journal of Fisheries Management 24:911–921.

Bishop, F.G., 1975. Observations on the fish fauna of the Peace River in Alberta. Can. Field-Nat. 89: 423430.

Cavanagh, N., Nordin, R.N., Pommen, L.W. and Swain, L.G., 1998. Guidelines for Designing and Implementing a Water Quality Monitoring Program in British Columbia. Ministry of Environment, Lands, and Parks, Aquatic Inventory Task Force of the Resource Inventory Standards Committee (RISC). Accessed on-line at: http://www.ilmb.gov.bc.ca/risc/pubs/aquatic/design/index.htm.

Connin, S., 1991. Characteristics of successful riparian restoration projects in the Pacific Northwest. Environmental Protection Agency, Report EPA/910/9–91/033, Seattle.

GeoSim Services Inc., 2012. Technical Report Blackwater Gold Project, Omineca Mining Division, British Columbia, Canada. Prepared for New Gold Inc. March 23, 2012.

Groupe Hémisphères, 2013. Interpretation of Natural and Anthropogenic Vegetation Communities and Beaver Control Strategies, Mathews Creek Area, B.C. Letter prepared for Palmer Environmental Consulting Group Inc., October 25, 2013.

Hunt, R.L., 1976. A long-term evaluation of trout habitat development and its relation to improving management-related research. Transactions of the American Fisheries Society 105:361–364.

Kauffman, J.B., Bayley, P., Li, H., McDowell, P. and Beschta, R.L., 2002. Research/Evaluate restoration of NE Oregon streams: effects of livestock exclosures (corridor fencing) on riparian vegetation, stream geomorphic features, and fish populations. Oregon State University, Report BPA Report DOE/BP-00006210-1, Corvallis.

Laffaille, P., Lefeuvre, J.C. and Feunteun, E., 2000. Impact of sheep grazing on juvenile sea bass, *Dicentrarchus labrax* L., in tidal salt marshes. Biological Conservation 96(3):271–277.

Laidman Lake Lodge, 2013. About Laidman Lake Ecolodge: Extended information on our our [sic] history. Last accessed online on October 30, 2013 at: http://www.laidmanlakelodge.com/history.php.

Li, H.W., Lamberti, G.A., Pearsons, T.N., Tait, C.K., Li, J.L. and Buckhouse, J.C., 1994. Cumulative effects of riparian disturbances along high desert trout streams of the John Day Basin, Oregon. Transactions of the American Fisheries Society 123:627–640.

McPhail, D.L., 2007. The Freshwater Fishes of British Columbia. University of Alberta Press, Edmonton, Alberta.

Meals, D.W. and Hopkins, R.B., 2002. Phosphorus reductions following riparian restoration in two agricultural watersheds in Vermont, USA. Water Science and Technology 45(9):51–60.

Meka, J.M., Knudsen, E.E., Douglas, D.C. and Benter, R.B., 2003. Variable Migratory Patterns of Different Adult Rainbow Trout Life History Types in a Southwest Alaska Watershed, Transactions of the American Fisheries Society, 132:4, 717-732.

Myers, T.J., and Swanson, S., 1995. Impact of deferred rotation grazing on stream characteristics in central Nevada: a case study. North American Journal of Fisheries Management 15:428–439.

Nagy, S., 1985. The food of burbot (*Lota lota,* L.) in the Turiec River. Zivocisna-vyroba 30: 943-952 (in Czech with an English summary).

O'Grady, M., Gargan, P., Delanty, K., Igoe, F. and Byrne, C., editors, 2002. Observations in relation to changes in some physical and biological features of the Glenglosh River following bank stabilisation. Central Fisheries Board, Westport, Ireland.

Pierce, R., Podner, C. and Carim, K., 2013. Response of Wild Trout to Stream Restoration over Two Decades in the Blackfoot River Basin, Montana, Transactions of the American Fisheries Society, 142:1, 68-81, DOI: 10.1080/00028487.2012.720626

Platts, W. S., 1991. Livestock grazing. Pages 389–423 in W. R. Meehan, editor. Influences of forest and rangeland management on salmonid fishes and their habitats. American Fisheries Society, Special Publication 19, Bethesda, Maryland.

Plouffe, A., Levson, V.M. and Mate, D.J., 2004. Surficial geology, Nechako River, British Columbia. Geological Survey of Canada, Map 2067A, scale 1:250,000.

Resource Inventory Committee, 2001. Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Standards and Procedures (Version 2.0). Prepared by BC Fisheries Information Services Branch, April 2001, 170 p.

Roni, P., Hanson, K. and Beechie, T., 2008. Global review of the physical and biological effectiveness of stream habitat rehabilitation techniques. North American Journal of Fisheries Management 28:856–890.

Seber, G.A.F., 1982. The estimation of animal abundance and related parameters, Griffin, London. 654 p.

Seber, G.A.F. and Whale, J.F., 1970. The removal method for two and three Samples. Biometrics 26:393-400.

Sovell, L.A., Vondracek, B., Frost, J.A. and Mumford, K.G., 2000. Impacts of rotational grazing and riparian buffers on physicochemical and biological characteristics of southeastern Minnesota, USA, streams. Environmental Management 26:629–641.

Suttle, K.B., Power, M.E., Levine, J.M. and NcNeely C., 2004. How fine sediment in riverbeds impairs growth and survival of juvenile salmonids. Ecological applications 14(4): 969:974.

White, S.L., Gowan, C., Fausch, K.D., Harris, J.G., and Saunders, W.C., 2011. Response of trout populations in five Colorado streams two decades after habitat manipulation. Canadian Journal of Fisheries and Aquatic Sciences 68:2057–2063.

Wood, P.J. and Armitage, P.D., 1997. Biological effects of fine sediment in the lotic environment. Environmental Management 21(2): 203-217.

Wu, J., Adams, R. M. and Boggess, W.G., 2000. Cumulative effects and optimal targeting of conservation efforts: Steelhead trout habitat enhancement in Oregon. American Journal of Agricultural Economics 82:400–413.

Appendix A

Georeferenced Aerial Videography (via FTP download)

Appendix A - Georeferenced Aerial Videography

Video fly-over, upstream from mouth to headwaters (video clips available via FTP download)

Video	Reach Start	Time	Easting/Northing	Comment
PA010900	1	0:00	354,329.402 5,889,551.472	Mouth (Laidman Lake)
		0:20	354,289.638 5,889,223.417	Edge trees on fan-delta
		0:42	354,447.590 5,888,862.225	Bridge, near apex fan
	2	0:54	354,520.492 5,888,662.299	Reach 1/2 break, fan apex
		1:22	354,683.967 5,888,275.702	NE cut-bank
		1:49	354,820.933 5,887,974.156	NE riparian wetland
		1:56	354,857.383 5,887,778.649	W cut-bank
		2:06	355,025.277 5,887,799.635	NE cut-bank
		2:28	354,911.507 5,887,516.867	E riparian wetland
		2:47	355,060.094 5,886,988.607	**MC1**
		2:50	355,062.832 5,886,950.226	Bridge, d/s trib
	3	3:15	355,563.199 5,886,775.705	In-stream bedrock outcrop (Reach 2/3 break)
PA010901		0:02	355,587.499 5,886,801.110	Ford
		0:10	355,724.465 5,886,857.443	d/s end large, harvested meadow
		0:24	356,265.701 5,886,537.120	S tributary confluence (harvested floodplain)
		0:42	356,877.629 5,886,520.551	S tributary confluence (draining lake)
		1:05	357,647.509 5,887,081.669	Flooded area u/s large beaver dam
PA010902	4	0:00	357,802.148 5,887,016.500	Reach 3/4 break
		0:22	358,274.901 5,886,485.205	**MC2** (hydrometric station), bridge
		0:40	358,774.164 5,886,239.992	Water access from 3T's exploration camp (Independence Gold)
		0:52	359,052.513 5,885,917.460	Most d/s drainage ditches, long oxbow
		1:13	355,060.094 5,886,988.607	**MC3**
		1:18	360,019.006 5,886,129.536	Confluence with disconnected drainage ditch from large pond
PA010903	5	0:00	360,155.972 5,886,209.065	Reach 4/5 break, d/s edge large ranchland meadow
		0:04	360,132.776 5,886,288.593	Two ponds in N floodplain
		0:16	360,523.791 5,886,643.158	**MC4**, confluence with side sinuous side channel
		0:29	360,977.767 5,886,488.519	Appearance/disappearance of sinous side channel
		0:40	361,456.043 5,886,435.500	Confluence with long slope-toe drainage ditch
		1:04	362,371.725 5,886,607.812	**MC5**, confluence with sloping drainage ditch
		1:18	362,794.773 5,886,934.763	Mathews Creek Ranch, u/s limit of anthropogenic disturbance
		1:31	363,345.950 5,886,888.371	Potential natural analogue for ranchland restoration
		1:36	363,451.988 5,886,687.340	S tributary confluence
	6	1:45	363,687.260 5,886,614.439	Reach 5/6 break, d/s edge dense coniferous forest
		1:55	363,868.408 5,886,449.859	Large N slope-toe wetland
PA010904		0:11	364,136.817 5,886,214.587	Forested heli stop where photos taken
		0:40	364,705.667 5,886,118.490	Oxbow lake
	7	1:07	365,402.646 5,886,083.144	Reach 6/7 break, u/s edge dense coniferous forest
		1:13	365,621.174 5,886,156.921	**MC6**
PA010905		0:00	365,916.268 5,885,957.224	Dry and flooded oxbows
		0:24	366,643.070 5,885,478.949	Backflooded, aggraded area
	8	0:36	366,943.512 5,885,185.135	Reach 7/8 break, confluence with valley head tributary with lake
PA010906		0:26	367,784.421 5,885,555.141	Bridge
		0:45	367,932.588 5,885,920.267	Small N valley wall slope failure
PA010907	9	0:00	368,093.984 5,886,018.163	Reach 8/9 break, waterfall and bedrock gorge
		0:35	368,432.651 5,886,978.602	NW cut-bank
		0:56	369,091.465 5,887,663.874	Gravel bars in opening in forest
		1:08	369,451.299 5,887,849.083	Small wetland SE of creek
		1:19	369,509.507 5,888,354.438	Bend in valley, u/s limit of video fly-over

VIDEO TERMINATED PRIOR TO ABSOLUTE HEADWATERS OF MATHEWS CREEK

Appendix B

Water Quality Laboratory Analysis Results

Maxxam

Success Through Science®

Your Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Your C.O.C. #: G082328

Attention: Jason Cole
Palmer Environmental Consulting Group (PECG)
475 Howe Street
Suite 1030
Vancouver, BC
CANADA V6C 2B3

Report Date: 2013/10/02

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B386289
Received: 2013/09/23, 08:25

Sample Matrix: Water
Samples Received: 2

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	2	2013/09/23	2013/09/23	BBY6SOP-00026	SM2320B
Chloride by Automated Colourimetry	2	N/A	2013/09/24	BBY6SOP-00011	SM-4500-Cl-
Coliform by membrane filtration	2	N/A	2013/09/23	BBY4SOP-00001	Based on SM-9222
Carbon (DOC) - field filtered/preserved	2	N/A	2013/09/23	BBY6SOP-00003	SM-5310C
E.coli by membrane filtration in Water	2	N/A	2013/09/23	BBY4SOP-00001	Based on SM-9222
Conductance - water	2	N/A	2013/09/23	BBY6SOP-00026	SM-2510B
Fluoride	2	N/A	2013/09/24	BBY6SOP-00012	SM - 4500 F C
Fecal Coliform by membrane filtration	2	N/A	2013/09/23	BRN SOP 00363 R2.0	Based on SM-9222
Hardness Total (calculated as CaCO3)	1	N/A	2013/09/27	BBY7SOP-00002	EPA 6020A
Hardness Total (calculated as CaCO3)	1	N/A	2013/09/30	BBY7SOP-00002	EPA 6020A
Hardness (calculated as CaCO3)	2	N/A	2013/09/25	BBY7SOP-00002	EPA 6020A
Ion Balance	2	N/A	2013/09/25	Calc	
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	2	N/A	2013/09/25	BBY7SOP-00002	EPA 6020A
Elements by CRC ICPMS (dissolved)	2	N/A	2013/09/25	BBY7SOP-00002	EPA 6020A
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	2013/09/23	2013/09/27	BBY7SOP-00002	EPA 6020A
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	2013/09/23	2013/09/30	BBY7SOP-00002	EPA 6020A
Elements by CRC ICPMS (total)	2	2013/09/27	2013/09/27	BBY7SOP-00002	EPA 6020A
Ammonia-N (Preserved)	2	N/A	2013/09/24	BBY6SOP-00009	SM-4500NH3G
Nitrate + Nitrite (N)	2	N/A	2013/09/24	BBY6SOP-00010	SM 4500NO3-I
Nitrite (N) by CFA	2	N/A	2013/09/24	BBY6SOP-00010	EPA 353.2
Nitrogen - Nitrate (as N)	2	N/A	2013/09/24	BBY6SOP-00010	SM 4500NO3-I
Filter and HNO3 Preserve for Metals	2	N/A	2013/09/23	BBY6WI-00001	EPA 200.2
pH Water	2	N/A	2013/09/23	BBY6SOP-00026	SM-4500H+B
Phenoxyalkyl acid Pesticides (1)	2	2013/09/27	2013/10/02	CAL SOP-00094	EPA 8151 A
Sulphate by Automated Colourimetry	2	N/A	2013/09/24	BBY6SOP-00017	SM4500-SO42- E
Total Dissolved Solids (Filt. Residue)	2	2013/09/25	2013/09/26	BBY6SOP-00033	SM 2540C
Carbon (Total Organic)	2	N/A	2013/09/23	BBY6SOP-00003	SM-5310C
Total Suspended Solids	2	N/A	2013/09/26	BBY6SOP-00034	SM - 2540 D
Pesticides, OC Water Subcontract (2)	1	2013/10/01	2013/10/02	CAM SOP-00307	EPA 8081A(1)

* Results relate only to the items tested.

(1) This test was performed by Maxxam Calgary Environmental
(2) This test was performed by Maxxam Ontario (From Burnaby)

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Tabitha Rudkin, Burnaby Project Manager
Email: TRudkin@maxxam.ca
Phone# (604) 638-2639

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Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HP1841	HP1842		
Sampling Date		2013/09/21 11:30	2013/09/21 09:30		
	UNITS	**MC2**	**MC7**	**RDL**	**QC Batch**
Parameter					
Subcontract Parameter	N/A	ATTACHED		N/A	7201900
ANIONS					
Nitrite (N)	mg/L	<0.0050	<0.0050	0.0050	7189082
Calculated Parameters					
Filter and HNO3 Preservation	N/A	FIELD	FIELD	N/A	ONSITE
Ion Balance	N/A	1.0	1.1	0.010	7185981
Nitrate (N)	mg/L	<0.020	<0.020	0.020	7185985
Misc. Inorganics					
Fluoride (F)	mg/L	0.062	0.054	0.010	7188655
Dissolved Organic Carbon (C)	mg/L	6.09	5.42	0.50	7185617
Alkalinity (Total as CaCO3)	mg/L	60.1	51.7	0.50	7187265
Total Organic Carbon (C)	mg/L	6.12	6.35	0.50	7185623
Alkalinity (PP as CaCO3)	mg/L	<0.50	<0.50	0.50	7187265
Bicarbonate (HCO3)	mg/L	73.3	63.1	0.50	7187265
Carbonate (CO3)	mg/L	<0.50	<0.50	0.50	7187265
Hydroxide (OH)	mg/L	<0.50	<0.50	0.50	7187265
Anions					
Dissolved Sulphate (SO4)	mg/L	<0.50	<0.50	0.50	7189256
Dissolved Chloride (Cl)	mg/L	0.79	0.73	0.50	7189230
Nutrients					
Ammonia (N)	mg/L	0.011	0.010	0.0050	7188142
Nitrate plus Nitrite (N)	mg/L	<0.020	<0.020	0.020	7189032
Physical Properties					
Conductivity	uS/cm	117	104	1.0	7187268
pH	pH Units	7.74	7.67		7187267
Physical Properties					
Total Suspended Solids	mg/L	<4.0	<4.0	4.0	7190431
Total Dissolved Solids	mg/L	78	58	10	7190437

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

PHENOXYALKYL ACID PESTICIDES/HERBICIDES (WATER)

Maxxam ID		HP1841	HP1842		
Sampling Date		2013/09/21 11:30	2013/09/21 09:30		
	UNITS	**MC2**	**MC7**	**RDL**	**QC Batch**
Phenoxyalkyl acid Pest.					
3,5-dichlorobenzoic acid	ug/L	<0.080	<0.080	0.080	7195158
Dicamba	ug/L	<0.0050	<0.0050	0.0050	7195158
MCPP	ug/L	<0.080	<0.080	0.080	7195158
MCPA	ug/L	<0.020	<0.020	0.020	7195158
Dichlorprop	ug/L	<0.080	<0.080	0.080	7195158
Bromoxynil	ug/L	<0.020	<0.020	0.020	7195158
2,4-D	ug/L	<0.050	<0.050	0.050	7195158
Pentachlorophenol	ug/L	<0.080	<0.080	0.080	7195158
2,4,5-TP	ug/L	<0.080	<0.080	0.080	7195158
2,4,5-T	ug/L	<0.080	<0.080	0.080	7195158
Chloramben	ug/L	<0.080	<0.080	0.080	7195158
Dinoseb (DNBP)	ug/L	<0.020	<0.020	0.020	7195158
Bentazon	ug/L	<0.080	<0.080	0.080	7195158
2,4-DB	ug/L	<0.080	<0.080	0.080	7195158
Picloram	ug/L	<0.080	<0.080	0.080	7195158
Diclofop-methyl	ug/L	<0.080	<0.080	0.080	7195158
Surrogate Recovery (%)					
2,4,6-TRIBROMOPHENOL (sur.)	%	114	105		7195158

MICROBIOLOGY (WATER)

Maxxam ID		HP1841	HP1842		
Sampling Date		2013/09/21 11:30	2013/09/21 09:30		
	UNITS	**MC2**	**MC7**	**RDL**	**QC Batch**
Microbiological Param.					
E. coli	CFU/100mL	9	82	1	7186096
Fecal Coliforms	CFU/100mL	9	91	1	7186098
Total Coliforms	CFU/100mL	460	110	1	7186094

RDL = Reportable Detection Limit

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

CSR DISSOLVED METALS IN WATER (WATER)

Maxxam ID		HP1841		HP1842		
Sampling Date		2013/09/21 11:30		2013/09/21 09:30		
	UNITS	**MC2**	**QC Batch**	**MC7**	**RDL**	**QC Batch**
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	53.1	7185036	47.8	0.50	7185036
Dissolved Metals by ICPMS						
Dissolved Aluminum (Al)	ug/L	14.4	7188442	14.0	3.0	7188442
Dissolved Antimony (Sb)	ug/L	<0.50	7188442	<0.50	0.50	7188442
Dissolved Arsenic (As)	ug/L	0.38	7188442	0.35	0.10	7188442
Dissolved Barium (Ba)	ug/L	12.0	7188442	13.5	1.0	7188442
Dissolved Beryllium (Be)	ug/L	<0.10	7188442	<0.10	0.10	7188442
Dissolved Bismuth (Bi)	ug/L	<1.0	7188442	<1.0	1.0	7188442
Dissolved Boron (B)	ug/L	<50	7188442	<50	50	7188442
Dissolved Cadmium (Cd)	ug/L	<0.010	7188442	<0.010	0.010	7188442
Dissolved Chromium (Cr)	ug/L	<1.0	7188442	<1.0	1.0	7188442
Dissolved Cobalt (Co)	ug/L	<0.50	7188442	<0.50	0.50	7188442
Dissolved Copper (Cu)	ug/L	0.82	7188442	0.58	0.20	7202045
Dissolved Iron (Fe)	ug/L	725	7188442	710	5.0	7188442
Dissolved Lead (Pb)	ug/L	<0.20	7188442	<0.20	0.20	7188442
Dissolved Lithium (Li)	ug/L	<5.0	7188442	<5.0	5.0	7188442
Dissolved Manganese (Mn)	ug/L	8.6	7188442	46.7	1.0	7188442
Dissolved Mercury (Hg)	ug/L	<0.050	7188442	<0.050	0.050	7188442
Dissolved Molybdenum (Mo)	ug/L	<1.0	7188442	<1.0	1.0	7188442
Dissolved Nickel (Ni)	ug/L	<1.0	7188442	<1.0	1.0	7188442
Dissolved Selenium (Se)	ug/L	<0.10	7188442	<0.10	0.10	7188442
Dissolved Silicon (Si)	ug/L	5560	7188442	6760	100	7188442
Dissolved Silver (Ag)	ug/L	<0.020	7188442	<0.020	0.020	7188442
Dissolved Strontium (Sr)	ug/L	76.2	7188442	71.4	1.0	7188442
Dissolved Thallium (Tl)	ug/L	<0.050	7188442	<0.050	0.050	7188442
Dissolved Tin (Sn)	ug/L	<5.0	7188442	<5.0	5.0	7188442
Dissolved Titanium (Ti)	ug/L	<5.0	7188442	<5.0	5.0	7188442
Dissolved Uranium (U)	ug/L	0.16	7188442	0.16	0.10	7188442
Dissolved Vanadium (V)	ug/L	<5.0	7188442	<5.0	5.0	7188442
Dissolved Zinc (Zn)	ug/L	<5.0	7188442	<5.0	5.0	7188442
Dissolved Zirconium (Zr)	ug/L	<0.50	7188442	<0.50	0.50	7188442
Dissolved Calcium (Ca)	mg/L	14.5	7185037	13.6	0.050	7185037
Dissolved Magnesium (Mg)	mg/L	4.11	7185037	3.38	0.050	7185037
Dissolved Potassium (K)	mg/L	0.669	7185037	0.551	0.050	7185037
Dissolved Sodium (Na)	mg/L	3.79	7185037	3.26	0.050	7185037
Dissolved Sulphur (S)	mg/L	<3.0	7185037	<3.0	3.0	7185037

RDL = Reportable Detection Limit

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

CSR TOTAL METALS IN WATER (WATER)

Maxxam ID		HP1841	HP1842		
Sampling Date		2013/09/21 11:30	2013/09/21 09:30		
	UNITS	**MC2**	**MC7**	**RDL**	**QC Batch**
Calculated Parameters					
Total Hardness (CaCO3)	mg/L	59.4	52.8	0.50	7185160
Total Metals by ICPMS					
Total Aluminum (Al)	ug/L	35.3	22.7	3.0	7195195
Total Antimony (Sb)	ug/L	<0.50	<0.50	0.50	7195195
Total Arsenic (As)	ug/L	0.49	0.50	0.10	7195195
Total Barium (Ba)	ug/L	12.6	14.3	1.0	7195195
Total Beryllium (Be)	ug/L	<0.10	<0.10	0.10	7195195
Total Bismuth (Bi)	ug/L	<1.0	<1.0	1.0	7195195
Total Boron (B)	ug/L	<50	<50	50	7195195
Total Cadmium (Cd)	ug/L	<0.010	0.010	0.010	7195195
Total Chromium (Cr)	ug/L	<1.0	<1.0	1.0	7195195
Total Cobalt (Co)	ug/L	<0.50	<0.50	0.50	7195195
Total Copper (Cu)	ug/L	0.57	0.59	0.20	7195195
Total Iron (Fe)	ug/L	1060	1160	5.0	7195195
Total Lead (Pb)	ug/L	<0.20	<0.20	0.20	7195195
Total Lithium (Li)	ug/L	<5.0	<5.0	5.0	7195195
Total Manganese (Mn)	ug/L	10.6	52.0	1.0	7195195
Total Mercury (Hg)	ug/L	<0.050	<0.050	0.050	7195195
Total Molybdenum (Mo)	ug/L	<1.0	<1.0	1.0	7195195
Total Nickel (Ni)	ug/L	<1.0	<1.0	1.0	7195195
Total Selenium (Se)	ug/L	<0.10	<0.10	0.10	7195195
Total Silicon (Si)	ug/L	6140	6950	100	7195195
Total Silver (Ag)	ug/L	0.033	<0.020	0.020	7195195
Total Strontium (Sr)	ug/L	88.5	79.9	1.0	7195195
Total Thallium (Tl)	ug/L	<0.050	<0.050	0.050	7195195
Total Tin (Sn)	ug/L	<5.0	<5.0	5.0	7195195
Total Titanium (Ti)	ug/L	<5.0	<5.0	5.0	7195195
Total Uranium (U)	ug/L	0.17	0.16	0.10	7195195
Total Vanadium (V)	ug/L	<5.0	<5.0	5.0	7195195
Total Zinc (Zn)	ug/L	<5.0	<5.0	5.0	7195195
Total Zirconium (Zr)	ug/L	<0.50	<0.50	0.50	7195195
Total Calcium (Ca)	mg/L	16.6	15.2	0.050	7185984
Total Magnesium (Mg)	mg/L	4.33	3.62	0.050	7185984
Total Potassium (K)	mg/L	0.755	0.725	0.050	7185984
Total Sodium (Na)	mg/L	4.16	4.18	0.050	7185984
Total Sulphur (S)	mg/L	<3.0	<3.0	3.0	7185984

RDL = Reportable Detection Limit

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

General Comments

Sample HP1841-01: The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Sample HP1842-01: The BC-MOE and APHA Standard Method require pH to be analysed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the BC-MOE/APHA Standard Method holding time.

Sample HP1842, Elements by CRC ICPMS (dissolved): Test repeated.

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7185617	Dissolved Organic Carbon (C)	2013/09/23	NC	80 - 120	105	80 - 120	<0.50	mg/L	1.2	20
7185623	Total Organic Carbon (C)	2013/09/23	NC	80 - 120	104	80 - 120	<0.50	mg/L	3.9	20
7187265	Alkalinity (Total as CaCO3)	2013/09/23	109	80 - 120	95	80 - 120	<0.50	mg/L	3.9	20
7187265	Alkalinity (PP as CaCO3)	2013/09/23					<0.50	mg/L	NC	20
7187265	Bicarbonate (HCO3)	2013/09/23					<0.50	mg/L	3.9	20
7187265	Carbonate (CO3)	2013/09/23					<0.50	mg/L	NC	20
7187265	Hydroxide (OH)	2013/09/23					<0.50	mg/L	NC	20
7187268	Conductivity	2013/09/23			100	80 - 120	1.2, RDL=1.0	uS/cm		
7188142	Ammonia (N)	2013/09/24	99	80 - 120	99	80 - 120	<0.0050	mg/L	NC	20
7188442	Dissolved Aluminum (Al)	2013/09/25	102	80 - 120	101	80 - 120	<3.0	ug/L	NC	20
7188442	Dissolved Antimony (Sb)	2013/09/25	100	80 - 120	101	80 - 120	<0.50	ug/L	NC	20
7188442	Dissolved Arsenic (As)	2013/09/25	101	80 - 120	103	80 - 120	<0.10	ug/L	4.2	20
7188442	Dissolved Barium (Ba)	2013/09/25	NC	80 - 120	103	80 - 120	<1.0	ug/L	1.5	20
7188442	Dissolved Beryllium (Be)	2013/09/25	103	80 - 120	98	80 - 120	<0.10	ug/L	NC	20
7188442	Dissolved Bismuth (Bi)	2013/09/25	87	80 - 120	99	80 - 120	<1.0	ug/L	NC	20
7188442	Dissolved Cadmium (Cd)	2013/09/25	98	80 - 120	103	80 - 120	<0.010	ug/L	NC	20
7188442	Dissolved Chromium (Cr)	2013/09/25	96	80 - 120	105	80 - 120	<1.0	ug/L	NC	20
7188442	Dissolved Cobalt (Co)	2013/09/25	95	80 - 120	104	80 - 120	<0.50	ug/L	NC	20
7188442	Dissolved Copper (Cu)	2013/09/25	94	80 - 120	104	80 - 120	<0.20	ug/L	NC	20
7188442	Dissolved Iron (Fe)	2013/09/25	NC	80 - 120	109	80 - 120	<5.0	ug/L	1.2	20
7188442	Dissolved Lead (Pb)	2013/09/25	96	80 - 120	102	80 - 120	<0.20	ug/L	NC	20
7188442	Dissolved Lithium (Li)	2013/09/25	95	80 - 120	93	80 - 120	<5.0	ug/L	NC	20
7188442	Dissolved Manganese (Mn)	2013/09/25	NC	80 - 120	100	80 - 120	<1.0	ug/L	7.0	20
7188442	Dissolved Mercury (Hg)	2013/09/24	96	80 - 120	98	80 - 120	<0.050	ug/L		
7188442	Dissolved Molybdenum (Mo)	2013/09/25	NC	80 - 120	101	80 - 120	<1.0	ug/L	NC	20
7188442	Dissolved Nickel (Ni)	2013/09/25	95	80 - 120	105	80 - 120	<1.0	ug/L	NC	20
7188442	Dissolved Selenium (Se)	2013/09/25	104	80 - 120	106	80 - 120	<0.10	ug/L	NC	20
7188442	Dissolved Silver (Ag)	2013/09/25	87	80 - 120	102	80 - 120	<0.020	ug/L	NC	20
7188442	Dissolved Strontium (Sr)	2013/09/25	NC	80 - 120	97	80 - 120	<1.0	ug/L	3.9	20
7188442	Dissolved Thallium (Tl)	2013/09/25	101	80 - 120	103	80 - 120	<0.050	ug/L	NC	20
7188442	Dissolved Tin (Sn)	2013/09/25	97	80 - 120	103	80 - 120	<5.0	ug/L	NC	20
7188442	Dissolved Titanium (Ti)	2013/09/25	100	80 - 120	98	80 - 120	<5.0	ug/L	NC	20
7188442	Dissolved Uranium (U)	2013/09/25	96	80 - 120	100	80 - 120	<0.10	ug/L	NC	20
7188442	Dissolved Vanadium (V)	2013/09/25	98	80 - 120	101	80 - 120	<5.0	ug/L	NC	20
7188442	Dissolved Zinc (Zn)	2013/09/25	NC	80 - 120	105	80 - 120	<5.0	ug/L	NC	20
7188442	Dissolved Boron (B)	2013/09/25					<50	ug/L	NC	20
7188442	Dissolved Silicon (Si)	2013/09/25					<100	ug/L	1.0	20
7188442	Dissolved Zirconium (Zr)	2013/09/25					<0.50	ug/L	NC	20
7188655	Fluoride (F)	2013/09/24	98	80 - 120	100	80 - 120	<0.010	mg/L	5.7	20
7189032	Nitrate plus Nitrite (N)	2013/09/24	98	80 - 120	106	80 - 120	<0.020	mg/L		

Maxxam Job #: B386289
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Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7189082	Nitrite (N)	2013/09/24	102	80 - 120	101	80 - 120	<0.0050	mg/L	NC	20
7189230	Dissolved Chloride (Cl)	2013/09/24	NC	80 - 120	101	80 - 120	0.78, RDL=0.50	mg/L	NC	20
7189256	Dissolved Sulphate (SO4)	2013/09/24	NC	80 - 120	100	80 - 120	<0.50	mg/L	NC	20
7190431	Total Suspended Solids	2013/09/26	NC	80 - 120	96	80 - 120	<4.0	mg/L	NC	20
7190437	Total Dissolved Solids	2013/09/26	NC	80 - 120	94	80 - 120	<10	mg/L	6.2	20
7195158	2,4,6-TRIBROMOPHENOL (sur.)	2013/10/02			87	30 - 130	98	%		
7195158	3,5-dichlorobenzoic acid	2013/10/02			114	10 - 130	<0.080	ug/L		
7195158	Dicamba	2013/10/02			104	10 - 130	<0.0050	ug/L		
7195158	MCPP	2013/10/02			113	10 - 130	<0.080	ug/L		
7195158	MCPA	2013/10/02			110	10 - 130	<0.020	ug/L		
7195158	Dichlorprop	2013/10/02			112	10 - 130	<0.080	ug/L		
7195158	Bromoxynil	2013/10/02			124	10 - 130	<0.020	ug/L		
7195158	2,4-D	2013/10/02			99	10 - 130	<0.050	ug/L		
7195158	Pentachlorophenol	2013/10/02			122	10 - 130	<0.080	ug/L		
7195158	2,4,5-TP	2013/10/02			112	10 - 130	<0.080	ug/L		
7195158	2,4,5-T	2013/10/02			106	10 - 130	<0.080	ug/L		
7195158	Chloramben	2013/10/02			68	10 - 130	<0.080	ug/L		
7195158	Dinoseb (DNBP)	2013/10/02			8.5(1)	10 - 130	<0.020	ug/L		
7195158	Bentazon	2013/10/02			122	10 - 130	<0.080	ug/L		
7195158	2,4-DB	2013/10/02			116	10 - 130	<0.080	ug/L		
7195158	Picloram	2013/10/02			27	10 - 130	<0.080	ug/L		
7195158	Diclofop-methyl	2013/10/02			114	10 - 130	<0.080	ug/L		
7195195	Total Aluminum (Al)	2013/09/27	117	80 - 120	112	80 - 120	<3.0	ug/L	1.8	20
7195195	Total Antimony (Sb)	2013/09/27	112	80 - 120	114	80 - 120	<0.50	ug/L	NC	20
7195195	Total Arsenic (As)	2013/09/27	105	80 - 120	101	80 - 120	<0.10	ug/L	NC	20
7195195	Total Barium (Ba)	2013/09/27	NC	80 - 120	102	80 - 120	<1.0	ug/L	3.7	20
7195195	Total Beryllium (Be)	2013/09/27	104	80 - 120	101	80 - 120	<0.10	ug/L	NC	20
7195195	Total Bismuth (Bi)	2013/09/27	98	80 - 120	100	80 - 120	<1.0	ug/L	NC	20
7195195	Total Cadmium (Cd)	2013/09/27	103	80 - 120	102	80 - 120	<0.010	ug/L	NC	20
7195195	Total Chromium (Cr)	2013/09/27	100	80 - 120	104	80 - 120	<1.0	ug/L	NC	20
7195195	Total Cobalt (Co)	2013/09/27	105	80 - 120	104	80 - 120	<0.50	ug/L	NC	20
7195195	Total Copper (Cu)	2013/09/27	106	80 - 120	107	80 - 120	<0.20	ug/L	NC	20
7195195	Total Iron (Fe)	2013/09/27	NC	80 - 120	111	80 - 120	6.5, RDL=5.0	ug/L	2.2	20
7195195	Total Lead (Pb)	2013/09/27	100	80 - 120	99	80 - 120	<0.20	ug/L	NC	20
7195195	Total Lithium (Li)	2013/09/27	102	80 - 120	101	80 - 120	<5.0	ug/L	NC	20
7195195	Total Manganese (Mn)	2013/09/27	NC	80 - 120	109	80 - 120	<1.0	ug/L	4.0	20
7195195	Total Mercury (Hg)	2013/09/27	107	80 - 120	107	80 - 120	<0.050	ug/L	NC	20
7195195	Total Molybdenum (Mo)	2013/09/27	NC	80 - 120	114	80 - 120	<1.0	ug/L	NC	20
7195195	Total Nickel (Ni)	2013/09/27	102	80 - 120	105	80 - 120	<1.0	ug/L	NC	20
7195195	Total Selenium (Se)	2013/09/27	107	80 - 120	103	80 - 120	<0.10	ug/L	NC	20

Maxxam Job #: B386289
Report Date: 2013/10/02

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172-BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: JC

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	UNITS	Value (%)	QC Limits
7195195	Total Silver (Ag)	2013/09/27	99	80 - 120	102	80 - 120	0.035, RDL=0.020	ug/L	NC	20
7195195	Total Strontium (Sr)	2013/09/27	NC	80 - 120	103	80 - 120	<1.0	ug/L	2.6	20
7195195	Total Thallium (Tl)	2013/09/27	109	80 - 120	100	80 - 120	<0.050	ug/L	NC	20
7195195	Total Tin (Sn)	2013/09/27	103	80 - 120	106	80 - 120	<5.0	ug/L	NC	20
7195195	Total Titanium (Ti)	2013/09/27	104	80 - 120	95	80 - 120	<5.0	ug/L	NC	20
7195195	Total Uranium (U)	2013/09/27	98	80 - 120	97	80 - 120	<0.10	ug/L	NC	20
7195195	Total Vanadium (V)	2013/09/27	111	80 - 120	107	80 - 120	<5.0	ug/L	NC	20
7195195	Total Zinc (Zn)	2013/09/27	87	80 - 120	104	80 - 120	<5.0	ug/L	NC	20
7195195	Total Boron (B)	2013/09/27					<50	ug/L	NC	20
7195195	Total Silicon (Si)	2013/09/27					<100	ug/L	0.09	20
7195195	Total Zirconium (Zr)	2013/09/27					<0.50	ug/L	NC	20
7202045	Dissolved Copper (Cu)	2013/10/02			99	80 - 120	<0.20	ug/L		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

Maxxam

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Maxxam Job#: B386289

CHAIN OF CUSTODY RECORD

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G 082328

Invoice To: Require Report? Yes ☐ No ☐

Company Name: Dillon Environmental
Contact Name: Jason Cole
Address: 475 Howe St, Suite 1030
Vancouver, BC PC: 2B3
Phone / Fax#: Ph: 416-605-5797 Fax:
E-mail: jasonc@peeg.ca

Report To:

Company Name: Dillon Environmental
Contact Name: Jason Cole
Address: 357 Bay Street Suite 800
Toronto, ON PC: M5H 2T7
Phone / Fax#: Ph: 416-605-5797 Fax:
E-mail: jasonc@peeg.ca

PO #: 613-072.2 - FC
Quotation #:
Project # : 13172 - Blackwater
Proj. Name:
Location: Blackwater Gold Mine
Sampled By: J.Cole / E.Cleveland

REGULATORY REQUIREMENTS SERVICE REQUESTED:

☐ CSR
☐ CCME
☐ BC Water Quality
☐ Other
☐ DRINKING WATER

☒ Regular Turn Around Time (TAT) (5 days for most tests)
☐ RUSH (Please contact the lab)
☐ 1 Day ☐ 2 Day ☐ 3 Day
Date Required:

Special Instructions:

Return Cooler ☐ Ship Sample Bottles (please specify) ☐

Microbiology Samples are Rush. Must hold HT.

ANALYSIS REQUESTED

	Sample Identification	Lab Identification	Sample Type	Date/Time Sampled
1	MC2	HP1841	SW	Sept 21/2013 11:30
2	MC7	HP1842	SW	Sept 21/2013 9:30
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

BTEX/VPH ☐ MTBE ☐
VOC/VPH ☐
EPH ☐ TEH ☐
PAH ☐ LEPH/HEPH ☐
CCME-PHC (Fractions 1-4 Plus BTEX) ☐
CCME-PHC (Fractions 2-4) ☐
CCME BTEX (Fraction 1 Plus BTEX) ☐
PCB ☐
Phenols by 4AAP ☐ Phenols by GCMS ☐
TOG ☐ SWOG ☐ MOG ☐
Dissolved Metals: N ☒ Y ☒ Field Filtered? Y ☒
Totals Metals Field Acidified?: N ☒ Y ☒ Field Acidified? Y ☒
Nitrate ☒ Nitrite ☒ Ammonia ☒
Chloride ☒ Fluoride ☒ Sulphate ☒
Total Suspended Solids-TSS ☒ TDS ☒
pH ☒ Conductivity ☒ Alkalinity ☒
BOD ☐
COD ☐
Coliform, Total & E.coli ☒ Fecal ☒
Asbestos ☐
DOC (Filtered & Acidified) ☒
Organochlorine Pesticides ☒
Phenoxy Acid Herbicides ☒
TOC ☒
HOLD ☐

*MC7 only has one (1) bottle for Herbicides and Pesticides

Samples are from a Drinking Water Source? YES ☐ NO ☒
Does source supply multiple households? YES ☐ NO ☒

B386289

Laboratory Use Only

*Relinquished by:	Date (YY/MM/DD):	Time:	Received by:	Date (YY/MM/DD):	Time:	Time Sensitive	Temperature on Receipt (°C)	Custody Seal Intact on Cooler?
Jason Cole	Sept 23/2013	8:25	[illegible]	2013/09/23	08:25	☒	7.5,6.	Yes ☐ No ☐ NA

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

Maxxam International Corporation o/a Maxxam Analytics

1X9-996

Maxxam Analytics
4606 Canada Way
Burnaby, British Columbia, V5G 1K5
Phone: (604) 734 7276
Fax: (604) 731 2386

Maxxam

SUBCONTRACTING REQUEST FORM

Palmer Environmental Consulting Group (PECG)
Maxxam PM Tabitha Rudkin

To: Maxxam Calgary Environmental

Job# B386289

☐ Yes ☑ No International Sample/BioHazard (if yes, add copy of Movement Cert., heat treat is required prior to disposal)
☐ Yes ☑ No Special Protocol (if yes, Protocol _____)

Sample ID	Matrix	Test(s) Required	Container	Date Sampled	Date Required
HP1841-02R \ MC2	WATER	Phenoxyalkyl acid ~~Pesticides~~ Herbicides	1(1LAG)	2013/09/21 11:30	2013/10/03
HP1842-01R \ MC7	WATER	Phenoxyalkyl acid ~~Pesticides~~ Herbicides	1(1LAG)	2013/09/21 09:30	2013/10/03

JF 2013/09/23

	Temp. 1	Temp. 2	Temp. 3			
Cooler #1	-0	2	3	Custody Seal Present	YES	NO
				Custody Seal Intact	YES	NO
				Ice Present Upon Receipt	YES	NO
Cooler #2				Custody Seal Present	YES	NO
				Custody Seal Intact	YES	NO
				Ice Present Upon Receipt	YES	NO
Cooler #3				Custody Seal Present	YES	NO
				Custody Seal Intact	YES	NO
				Ice Present Upon Receipt	YES	NO

Receiving Maxxam Location: Maxxam Calgary Environmental JOB # _____

Relinquished by (Sign) _____ (Print) Ken Robins Date and Time Sept 24/13 16:05

Received by (Sign) _____ (Print) Jane Musanda Date and Time 2013/09/25 0906

NOTES:
1) Please call us if due date cannot be met. Please reference Sample ID on your report.
2) Include copy of this completed form, Client COC & signed final report to TRudkin@maxxam.ca, and to **customerservicebc@maxxamanalytics.com**

Reporting Requirements:
National:
Regional:

Rec 2x 1L Amber SDG 2013/09/25

SHIPPING INSTRUCTIONS

☐ Ship Immediately (highlight Yellow)
☐ Requires 9am
☐ Requires Sat. Delivery
☑ Regular Ship next available day
☑ Ship Cold
☐ Ship Room Temp
☐ Ship Frozen
☐ COC Must be Attached
Sender (Print) Jennifer V. Initial JV

SHIPPING DEPARTMENT CHECKLIST

☑ Correct Shipping location
☑ Correct Sample Ids (Paperwork vs Bottles)
☑ Yes ☐ No Special-Cooler, Ice, Tape-custody seal, Date&Sign
Date Shipped Sept 24/13 Number of coolers 1
Shipper (Print) Ken Robins Initial KR

Your Project #: B386289
Your C.O.C. #: na

Attention: Tabitha Rudkin
Maxxam Analytics
4606 Canada Way
Burnaby, BC
V5G 1K5

Report Date: 2013/10/01

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B3G2211
Received: 2013/09/25, 10:24

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
OC Pesticides (Selected) & PCB (1)	1	2013/09/26	2013/09/30	CAM SOP-00307	SW846 8081,8082
OC Pesticides Summed Parameters	1	N/A	2013/10/01	CAM SOP-00307	SW846 8081, 8082

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) Chlordane (Total) = Alpha Chlordane + Gamma Chlordane

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Shaun Nowickyj,
Email: SNowickyj@maxxam.ca
Phone# (905) 817-5700

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam Job #: B3G2211
Report Date: 2013/10/01

Maxxam Analytics
Client Project #: B386289

ORGANOCHLORINATED PESTICIDES BY GC-ECD (WATER)

Maxxam ID		TF0674		
Sampling Date		2013/09/21 11:30		
COC Number		na		
	Units	**HP1841-01\MC2**	**RDL**	**QC Batch**
Aldrin + Dieldrin	ug/L	<0.005	0.005	3362241
Chlordane (Total)	ug/L	<0.005	0.005	3362241
DDT+ Metabolites	ug/L	<0.005	0.005	3362241
Heptachlor + Heptachlor epoxide	ug/L	<0.005	0.005	3362241
o,p-DDD + p,p-DDD	ug/L	<0.005	0.005	3362241
o,p-DDE + p,p-DDE	ug/L	<0.005	0.005	3362241
o,p-DDT + p,p-DDT	ug/L	<0.005	0.005	3362241
Total Endosulfan	ug/L	<0.005	0.005	3362241
Total PCB	ug/L	<0.05	0.05	3362241
Aldrin	ug/L	<0.005	0.005	3363772
Dieldrin	ug/L	<0.005	0.005	3363772
a-Chlordane	ug/L	<0.005	0.005	3363772
g-Chlordane	ug/L	<0.005	0.005	3363772
o,p-DDD	ug/L	<0.005	0.005	3363772
p,p-DDD	ug/L	<0.005	0.005	3363772
o,p-DDE	ug/L	<0.005	0.005	3363772
p,p-DDE	ug/L	<0.005	0.005	3363772
o,p-DDT	ug/L	<0.005	0.005	3363772
p,p-DDT	ug/L	<0.005	0.005	3363772
Lindane	ug/L	<0.003	0.003	3363772
Endosulfan I (alpha)	ug/L	<0.005	0.005	3363772
Endosulfan II	ug/L	<0.005	0.005	3363772
Endrin	ug/L	<0.005	0.005	3363772
Heptachlor	ug/L	<0.005	0.005	3363772
Heptachlor epoxide	ug/L	<0.005	0.005	3363772
Hexachlorobenzene	ug/L	<0.005	0.005	3363772
Methoxychlor	ug/L	<0.01	0.01	3363772
Aroclor 1016	ug/L	<0.05	0.05	3363772
Aroclor 1221	ug/L	<0.05	0.05	3363772
Aroclor 1232	ug/L	<0.05	0.05	3363772
Aroclor 1242	ug/L	<0.05	0.05	3363772
Aroclor 1248	ug/L	<0.05	0.05	3363772
Aroclor 1254	ug/L	<0.05	0.05	3363772

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Job #: B3G2211
Report Date: 2013/10/01

Maxxam Analytics
Client Project #: B386289

ORGANOCHLORINATED PESTICIDES BY GC-ECD (WATER)

Maxxam ID		TF0674		
Sampling Date		2013/09/21 11:30		
COC Number		na		
	Units	**HP1841-01\MC2**	**RDL**	**QC Batch**
Aroclor 1260	ug/L	<0.05	0.05	3363772
alpha-BHC	ug/L	<0.005	0.005	3363772
beta-BHC	ug/L	<0.005	0.005	3363772
delta-BHC	ug/L	<0.005	0.005	3363772
Endosulfan sulfate	ug/L	<0.005	0.005	3363772
Endrin aldehyde	ug/L	<0.005	0.005	3363772
Endrin ketone	ug/L	<0.005	0.005	3363772
Mirex	ug/L	<0.005	0.005	3363772
Octachlorostyrene	ug/L	<0.005	0.005	3363772
Oxychlordane	ug/L	<0.005	0.005	3363772
Toxaphene	ug/L	<0.2	0.2	3363772
Surrogate Recovery (%)				
2,4,5,6-Tetrachloro-m-xylene	%	71	N/A	3363772
Decachlorobiphenyl	%	79	N/A	3363772

N/A = Not Applicable
RDL = Reportable Detection Limit
QC Batch = Quality Control Batch

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B3G2211
Report Date: 2013/10/01

Maxxam Analytics
Client Project #: B386289

Test Summary

Maxxam ID TF0674
Sample ID HP1841-01\MC2
Matrix Water

Collected 2013/09/21
Shipped
Received 2013/09/25

Test Description	Instrumentation	Batch	Extracted	Analyzed	Analyst
OC Pesticides (Selected) & PCB	GC/ECD	3363772	2013/09/26	2013/09/30	Farahnaz Somwaru
OC Pesticides Summed Parameters	CALC	3362241	N/A	2013/10/01	Automated Statchk

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Job #: B3G2211
Report Date: 2013/10/01

Maxxam Analytics
Client Project #: B386289

Package 1	4.7°C

Each temperature is the average of up to three cooler temperatures taken at receipt

GENERAL COMMENTS

Results relate only to the items tested.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Maxxam Analytics
Attention: Tabitha Rudkin
Client Project #: B386289
P.O. #:
Site Location:

Quality Assurance Report

Maxxam Job Number: MB3G2211

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
3363772	FSO	Matrix Spike	2,4,5,6-Tetrachloro-m-xylene	2013/09/30		73	%	50 - 130
			Decachlorobiphenyl	2013/09/30		101	%	50 - 130
			Aldrin	2013/09/30		73	%	50 - 130
			Dieldrin	2013/09/30		95	%	50 - 130
			a-Chlordane	2013/09/30		86	%	50 - 130
			g-Chlordane	2013/09/30		84	%	50 - 130
			o,p-DDD	2013/09/30		95	%	50 - 130
			p,p-DDD	2013/09/30		110	%	50 - 130
			o,p-DDE	2013/09/30		86	%	50 - 130
			p,p-DDE	2013/09/30		84	%	50 - 130
			o,p-DDT	2013/09/30		76	%	50 - 130
			p,p-DDT	2013/09/30		81	%	50 - 130
			Lindane	2013/09/30		82	%	50 - 130
			Endosulfan I (alpha)	2013/09/30		80	%	50 - 130
			Endosulfan II	2013/09/30		85	%	50 - 130
			Endrin	2013/09/30		82	%	50 - 130
			Heptachlor	2013/09/30		78	%	50 - 130
			Heptachlor epoxide	2013/09/30		88	%	50 - 130
			Hexachlorobenzene	2013/09/30		78	%	50 - 130
			Methoxychlor	2013/09/30		91	%	50 - 130
			alpha-BHC	2013/09/30		78	%	30 - 130
			beta-BHC	2013/09/30		79	%	30 - 130
			delta-BHC	2013/09/30		76	%	30 - 130
			Endosulfan sulfate	2013/09/30		98	%	30 - 130
			Endrin aldehyde	2013/09/30		86	%	30 - 130
			Endrin ketone	2013/09/30		86	%	30 - 130
			Mirex	2013/09/30		83	%	30 - 130
			Octachlorostyrene	2013/09/30		78	%	30 - 130
			Oxychlordane	2013/09/30		76	%	30 - 130
		Spiked Blank	2,4,5,6-Tetrachloro-m-xylene	2013/09/30		68	%	50 - 130
		Spiked Blank DUP	2,4,5,6-Tetrachloro-m-xylene	2013/09/30		71	%	50 - 130
		Spiked Blank	Decachlorobiphenyl	2013/09/30		116	%	50 - 130
		Spiked Blank DUP	Decachlorobiphenyl	2013/09/30		89	%	50 - 130
		Spiked Blank	Aldrin	2013/09/30		73	%	50 - 130
			Dieldrin	2013/09/30		108	%	50 - 130
			a-Chlordane	2013/09/30		92	%	50 - 130
			g-Chlordane	2013/09/30		90	%	50 - 130
			o,p-DDD	2013/09/30		101	%	50 - 130
			p,p-DDD	2013/09/30		121	%	50 - 130
			o,p-DDE	2013/09/30		91	%	50 - 130
			p,p-DDE	2013/09/30		95	%	50 - 130
			o,p-DDT	2013/09/30		81	%	50 - 130
			p,p-DDT	2013/09/30		76	%	50 - 130
			Lindane	2013/09/30		87	%	50 - 130
			Endosulfan I (alpha)	2013/09/30		91	%	50 - 130
			Endosulfan II	2013/09/30		92	%	50 - 130
			Endrin	2013/09/30		93	%	50 - 130
			Heptachlor	2013/09/30		76	%	50 - 130
			Heptachlor epoxide	2013/09/30		96	%	50 - 130
			Hexachlorobenzene	2013/09/30		82	%	50 - 130
			Methoxychlor	2013/09/30		87	%	50 - 130
		Spiked Blank DUP	Aroclor 1242	2013/09/30		116	%	60 - 130
		RPD	Aroclor 1242	2013/09/30	NC		%	30
		Spiked Blank	alpha-BHC	2013/09/30		83	%	30 - 130
			beta-BHC	2013/09/30		88	%	30 - 130

Maxxam Analytics
Attention: Tabitha Rudkin
Client Project #: B386289
P.O. #:
Site Location:

Quality Assurance Report (Continued)

Maxxam Job Number: MB3G2211

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
3363772	FSO	Spiked Blank	delta-BHC	2013/09/30		83	%	30 - 130
			Endosulfan sulfate	2013/09/30		128	%	30 - 130
			Endrin aldehyde	2013/09/30		97	%	30 - 130
			Endrin ketone	2013/09/30		98	%	30 - 130
			Mirex	2013/09/30		91	%	30 - 130
			Octachlorostyrene	2013/09/30		79	%	30 - 130
			Oxychlordane	2013/09/30		81	%	30 - 130
		Spiked Blank DUP	Toxaphene	2013/09/30		117	%	30 - 130
		RPD	Toxaphene	2013/09/30	NC		%	40
		Method Blank	2,4,5,6-Tetrachloro-m-xylene	2013/09/30		69	%	50 - 130
			Decachlorobiphenyl	2013/09/30		94	%	50 - 130
			Aldrin	2013/09/30	<0.005		ug/L	
			Dieldrin	2013/09/30	<0.005		ug/L	
			a-Chlordane	2013/09/30	<0.005		ug/L	
			g-Chlordane	2013/09/30	<0.005		ug/L	
			o,p-DDD	2013/09/30	<0.005		ug/L	
			p,p-DDD	2013/09/30	<0.005		ug/L	
			o,p-DDE	2013/09/30	<0.005		ug/L	
			p,p-DDE	2013/09/30	<0.005		ug/L	
			o,p-DDT	2013/09/30	<0.005		ug/L	
			p,p-DDT	2013/09/30	<0.005		ug/L	
			Lindane	2013/09/30	<0.003		ug/L	
			Endosulfan I (alpha)	2013/09/30	<0.005		ug/L	
			Endosulfan II	2013/09/30	<0.005		ug/L	
			Endrin	2013/09/30	<0.005		ug/L	
			Heptachlor	2013/09/30	<0.005		ug/L	
			Heptachlor epoxide	2013/09/30	<0.005		ug/L	
			Hexachlorobenzene	2013/09/30	<0.005		ug/L	
			Methoxychlor	2013/09/30	<0.01		ug/L	
			Aroclor 1016	2013/09/30	<0.05		ug/L	
			Aroclor 1221	2013/09/30	<0.05		ug/L	
			Aroclor 1232	2013/09/30	<0.05		ug/L	
			Aroclor 1242	2013/09/30	<0.05		ug/L	
			Aroclor 1248	2013/09/30	<0.05		ug/L	
			Aroclor 1254	2013/09/30	<0.05		ug/L	
			Aroclor 1260	2013/09/30	<0.05		ug/L	
			alpha-BHC	2013/09/30	<0.005		ug/L	
			beta-BHC	2013/09/30	<0.005		ug/L	
			delta-BHC	2013/09/30	<0.005		ug/L	
			Endosulfan sulfate	2013/09/30	<0.005		ug/L	
			Endrin aldehyde	2013/09/30	<0.005		ug/L	
			Endrin ketone	2013/09/30	<0.005		ug/L	
			Mirex	2013/09/30	<0.005		ug/L	
			Octachlorostyrene	2013/09/30	<0.005		ug/L	
			Oxychlordane	2013/09/30	<0.005		ug/L	
			Toxaphene	2013/09/30	<0.2		ug/L	
		RPD - Sample/Sample Dup	Aldrin	2013/09/30	NC		%	30
			Dieldrin	2013/09/30	NC		%	30
			a-Chlordane	2013/09/30	NC		%	30
			g-Chlordane	2013/09/30	NC		%	30
			o,p-DDD	2013/09/30	NC		%	30
			p,p-DDD	2013/09/30	NC		%	30
			o,p-DDE	2013/09/30	NC		%	30

Maxxam Analytics
Attention: Tabitha Rudkin
Client Project #: B386289
P.O. #:
Site Location:

Quality Assurance Report (Continued)

Maxxam Job Number: MB3G2211

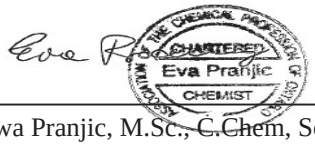
QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	%Recovery	Units	QC Limits
3363772	FSO	RPD - Sample/Sample Dup	p,p-DDE	2013/09/30	NC		%	30
			o,p-DDT	2013/09/30	NC		%	30
			p,p-DDT	2013/09/30	NC		%	30
			Lindane	2013/09/30	NC		%	30
			Endosulfan I (alpha)	2013/09/30	NC		%	30
			Endosulfan II	2013/09/30	NC		%	30
			Endrin	2013/09/30	NC		%	30
			Heptachlor	2013/09/30	NC		%	30
			Heptachlor epoxide	2013/09/30	NC		%	30
			Hexachlorobenzene	2013/09/30	NC		%	30
			Methoxychlor	2013/09/30	NC		%	30
			Aroclor 1016	2013/09/30	NC		%	30
			Aroclor 1221	2013/09/30	NC		%	30
			Aroclor 1232	2013/09/30	NC		%	30
			Aroclor 1248	2013/09/30	NC		%	30
			Aroclor 1254	2013/09/30	NC		%	30
			Aroclor 1260	2013/09/30	NC		%	30
			alpha-BHC	2013/09/30	NC		%	40
			beta-BHC	2013/09/30	NC		%	40
			delta-BHC	2013/09/30	NC		%	40
			Endosulfan sulfate	2013/09/30	NC		%	40
			Endrin aldehyde	2013/09/30	NC		%	40
			Endrin ketone	2013/09/30	NC		%	40
			Mirex	2013/09/30	NC		%	40
			Octachlorostyrene	2013/09/30	NC		%	40
			Oxychlordane	2013/09/30	NC		%	30

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
Surrogate: A pure or isotopically labeled compound whose behavior mirrors the analytes of interest. Used to evaluate extraction efficiency.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

Validation Signature Page

Maxxam Job #: B3G2211

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Ewa Pranjic, M.Sc., C.Chem, Scientific Specialist



Mahmudul Khan, GC Analysts

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Analytics International Corporation o/a Maxxam Analytics 6740 Campobello Road, Mississauga, Ontario, L5N 2L8 Tel: (905) 817-5700 Toll-Free: 800-563-6266 Fax: (905) 817-5777 www.maxxam.ca

Success Through Science®

Your Project #: 13172 BLACKWATER
Site Location: BLACKWATER MINE
Your C.O.C. #: 08379863

Attention: Jason Cole
Palmer Environmental Consulting Group (PECG)
475 Howe Street
Suite 1030
Vancouver, BC
CANADA V6C 2B3

Report Date: 2013/10/16

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B391062
Received: 2013/10/04, 09:00

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Pesticides, OC Water Subcontract (1)	1	2013/10/16	2013/10/16	CAM SOP-00307	EPA 8081A(1)

* Results relate only to the items tested.

(1) This test was performed by Maxxam Ontario (From Burnaby)

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

Tabitha Rudkin, Burnaby Project Manager
Email: TRudkin@maxxam.ca
Phone# (604) 638-2639

==========

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

Maxxam Job #: B391062
Report Date: 2013/10/16

Palmer Environmental Consulting Group (PECG)
Client Project #: 13172 BLACKWATER
Site Location: BLACKWATER MINE
Sampler Initials: RM

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		HS3502		
Sampling Date		2013/10/03 09:00		
	UNITS	**MC7**	**RDL**	**QC Batch**
Parameter				
Subcontract Parameter	N/A	ATTACHED	N/A	7231987

N/A = Not Applicable
RDL = Reportable Detection Limit

Maxxam

Burnaby: 4606 Canada Way, Burnaby, BC V5G 1K5 Ph: (604) 734-7276 Fax: (604) 731-2386, Toll Free: (800) 685-6566

CHAIN OF CUSTODY RECORD

Maxxam Job #: B391062 **COC #:** 08379863 **Page:** 1 of 1

Invoice To: Require Report? Yes ☑ No ☐

Company Name:	Palmer Enviromental Consulting Group
Contact Name:	Jason Cole
Address:	1030-475 Howe St
	Vancouver PC: V6C 2B3
Phone / Fax#:	Ph: 604-629-9075 Fax:
E-mail	jason@pecg.ca

Report To:

Company Name:	Palmer Enviromental Consulting Group
Contact Name:	Jason Cole
Address:	800-357 Bay St
	Toronto PC: M5H 2T7
Phone / Fax#:	Ph: 604-629-9075 Fax:
E-mail	jason@pecg.ca

PO #:	
Quotation #:	
Project # :	13172 Blackwater
Proj. Name:	
Location:	Blackwater mine
Sampled by:	RM, RP

REGULATORY REQUIREMENTS:

- ☐ CSR
- ☐ CCME
- ☐ BC Water Quality
- ☐ Other
- ☐ DRINKING WATER

SERVICE REQUESTED:

- ◉ Regular Turn Around Time (TAT) (5 days for most tests)
- **RUSH** (Please contact the lab) ○ 1 Day ○ 2 Day ○ 3 Day
- Date Required:

SPECIAL INSTRUCTIONS:

Return Cooler ☐ Ship Sample Bottles (please specify) ☐

ANALYSIS REQUESTED

	Sample Identification	Lab Identification (Lab Use Only)	Sample Type	Date/Time(24hr) Sampled	Dissolved Metals (DIM) Y☐N☐	Field Filtered? Total Metals Y☐N☐	Field Acidified? Organochlorines Y☐N☐	Field Acidified?	Number of Containers
1	MC7 HS3502			2013/10/03 09:00					
2									
3									
4									
5									
6									
7									
8									
9									
10									
11									
12									

B391062

Print name and sign

*Relinquished By:	Date (yy/mm/dd):	Time (24hr):	Received by:	Date (yy/mm/dd)	Time (24 hr):	Time Sensitive
	13/09/04	09:00		2013/10/04	09:00	☐

Laboratory Use Only

Temperature on Receipt (°C)				Custody Seal	Yes	No
A) 5	B) 5	C) 5		Present?	☐	☑
Just sampled & rec'd on ice: ☐				Intact?	☐	☐

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORDS. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

Appendix C

Fish Sampling Results

Appendix C1. Electrofishing Effort and Catch, Blackwater Project, September 2013

Date	Site	Method	Pass #	Section Length (m)	Voltage (V)	Effort (s)	Catch						
							BB	BMC	CCG	LNC	RB	WSU	Total
18-Sep-13	MC1	1-pass	1	195	350	1638	4	0	5	8	39	0	56
19-Sep-13	MC6	1-pass	1	125	350	965	5	0	0	0	3	0	8
20-Sep-13	MC3	3-pass	1	100	350	1100	9	2	0	0	0	6	17
20-Sep-13	MC3	3-pass	2	100	350	1246	14	1	0	0	1	1	17
20-Sep-13	MC3	3-pass	3	100	350	1313	15	1	0	0	0	2	18
20-Sep-13	MC5	3-pass	1	100	350	1233	4	0	0	0	1	1	6
20-Sep-13	MC5	3-pass	2	100	400	1040	0	4	0	0	0	0	4
20-Sep-13	MC5	3-pass	3	100	400	1021	2	0	0	0	0	0	2
21-Sep-13	MC2	1-pass	1	100	350	956	8	1	0	0	0	1	10

Notes:

BB=burbot, BMC=brassy minnow, CCG=slimy sculpin, LNC=longnose dace, RB=rainbow trout, WSU=white sucker

Appendix C2. Minnow Trapping Effort and Catch, Blackwater Project, 2013

Date	Site	Number of traps	Effort (hours)	Catch	
				BB	BMC
18-Sep-13	MC1	2	16	1	0
18-Sep-13	MC2	2	16	0	1
19-Sep-13	MC6	2	40	4	0
01-Oct-13	MC4	5	24	4	1

Notes: BB=burbot, BMC=brassy minnow

Appendix C3. Fish Biological Characteristics, Blackwater Project, 2013

Sampling date	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
18-Sep-13	MC1	EF - single	1	RB	127	16.8
18-Sep-13	MC1	EF - single	2	RB	130	18.3
18-Sep-13	MC1	EF - single	3	RB	132	18.6
18-Sep-13	MC1	EF - single	4	RB	114	14.6
18-Sep-13	MC1	EF - single	5	RB	72	3.9
18-Sep-13	MC1	EF - single	6	RB	134	18.3
18-Sep-13	MC1	EF - single	7	RB	85	5.0
18-Sep-13	MC1	EF - single	8	RB	122	14.1
18-Sep-13	MC1	EF - single	9	RB	132	19.4
18-Sep-13	MC1	EF - single	10	RB	138	21.3
18-Sep-13	MC1	EF - single	11	RB	149	29.9
18-Sep-13	MC1	EF - single	12	RB	124	14.9
18-Sep-13	MC1	EF - single	13	RB	128	18.0
18-Sep-13	MC1	EF - single	14	RB	107	10.2
18-Sep-13	MC1	EF - single	15	RB	122	15.2
18-Sep-13	MC1	EF - single	16	RB	146	27.8
18-Sep-13	MC1	EF - single	17	RB	84	4.8
18-Sep-13	MC1	EF - single	18	RB	152	37.0
18-Sep-13	MC1	EF - single	19	RB	130	17.0
18-Sep-13	MC1	EF - single	20	RB	129	17.5
18-Sep-13	MC1	EF - single	21	RB	146	23.5
18-Sep-13	MC1	EF - single	22	RB	139	20.7
18-Sep-13	MC1	EF - single	23	RB	116	12.5
18-Sep-13	MC1	EF - single	24	RB	127	18.4
18-Sep-13	MC1	EF - single	25	RB	110	10.4
18-Sep-13	MC1	EF - single	26	RB	106	10.0
18-Sep-13	MC1	EF - single	27	RB	98	7.6
18-Sep-13	MC1	EF - single	28	RB	111	11.7
18-Sep-13	MC1	EF - single	29	RB	66	2.5
18-Sep-13	MC1	EF - single	30	RB	72	2.9
18-Sep-13	MC1	EF - single	31	RB	75	3.8
18-Sep-13	MC1	EF - single	32	RB	139	22.3
18-Sep-13	MC1	EF - single	33	RB	66	2.8
18-Sep-13	MC1	EF - single	34	RB	199	80.6
18-Sep-13	MC1	EF - single	35	RB	189	58.0
18-Sep-13	MC1	EF - single	36	RB	75	4.1
18-Sep-13	MC1	EF - single	37	RB	123	17.4
18-Sep-13	MC1	EF - single	38	RB	74	3.4
18-Sep-13	MC1	EF - single	39	RB	72	3.2
18-Sep-13	MC1	EF - single	40	LNC	133	21.7
18-Sep-13	MC1	EF - single	41	LNC	138	27.8
18-Sep-13	MC1	EF - single	42	LNC	109	11.4
18-Sep-13	MC1	EF - single	43	LNC	79	4.2
18-Sep-13	MC1	EF - single	44	LNC	68	3.0
18-Sep-13	MC1	EF - single	45	LNC	108	10.7

Appendix C3. Fish Biological Characteristics, Blackwater Project, 2013

Sampling date	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
18-Sep-13	MC1	EF - single	46	LNC	78	4.3
18-Sep-13	MC1	EF - single	47	LNC	51	1.4
18-Sep-13	MC1	EF - single	48	CCG	75	4.7
18-Sep-13	MC1	EF - single	49	CCG	89	8.5
18-Sep-13	MC1	EF - single	50	CCG	70	3.4
18-Sep-13	MC1	EF - single	51	CCG	75	5.0
18-Sep-13	MC1	EF - single	52	CCG	75	4.8
18-Sep-13	MC1	EF - single	53	BB	165	21.5
18-Sep-13	MC1	EF - single	54	BB	160	21.2
18-Sep-13	MC1	EF - single	55	BB	160	21.4
18-Sep-13	MC1	EF - single	56	BB	NR	NR
19-Sep-13	MC6	EF - single	1	RB	58	2.2
19-Sep-13	MC6	EF - single	2	RB	112	11.4
19-Sep-13	MC6	EF - single	3	RB	125	11.9
19-Sep-13	MC6	EF - single	4	BB	144	16.5
19-Sep-13	MC6	EF - single	5	BB	136	12.7
19-Sep-13	MC6	EF - single	6	BB	130	12.0
19-Sep-13	MC6	EF - single	7	BB	175	36.8
19-Sep-13	MC6	EF - single	8	BB	143	14.7
20-Sep-13	MC3	EF - 3pass	1	BB	230	68.6
20-Sep-13	MC3	EF - 3pass	2	BB	72	2.2
20-Sep-13	MC3	EF - 3pass	3	BB	66	1.7
20-Sep-13	MC3	EF - 3pass	4	BB	60	1.5
20-Sep-13	MC3	EF - 3pass	5	BB	63	1.7
20-Sep-13	MC3	EF - 3pass	6	BB	63	1.4
20-Sep-13	MC3	EF - 3pass	7	BB	62	1.5
20-Sep-13	MC3	EF - 3pass	8	BB	105	6.4
20-Sep-13	MC3	EF - 3pass	9	BMC	83	3.9
20-Sep-13	MC3	EF - 3pass	10	BMC	67	2.0
20-Sep-13	MC3	EF - 3pass	11	BB	148	26.3
20-Sep-13	MC3	EF - 3pass	12	WSU	209	84.8
20-Sep-13	MC3	EF - 3pass	13	WSU	198	71.4
20-Sep-13	MC3	EF - 3pass	14	WSU	130	20.3
20-Sep-13	MC3	EF - 3pass	15	WSU	120	16.6
20-Sep-13	MC3	EF - 3pass	16	WSU	140	19.5
20-Sep-13	MC3	EF - 3pass	17	WSU	135	22.5
20-Sep-13	MC3	EF - 3pass	1	BB	160	21.5
20-Sep-13	MC3	EF - 3pass	2	BB	77	3.6
20-Sep-13	MC3	EF - 3pass	3	BB	74	2.3
20-Sep-13	MC3	EF - 3pass	4	BB	62	1.7
20-Sep-13	MC3	EF - 3pass	5	BB	62	1.5
20-Sep-13	MC3	EF - 3pass	6	BB	66	1.9
20-Sep-13	MC3	EF - 3pass	7	BB	65	1.6
20-Sep-13	MC3	EF - 3pass	8	BB	60	1.4
20-Sep-13	MC3	EF - 3pass	9	BB	92	4.3

Appendix C3. Fish Biological Characteristics, Blackwater Project, 2013

Sampling date	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
20-Sep-13	MC3	EF - 3pass	10	BB	78	2.5
20-Sep-13	MC3	EF - 3pass	11	BB	65	1.7
20-Sep-13	MC3	EF - 3pass	12	BB	61	0.9
20-Sep-13	MC3	EF - 3pass	13	BB	62	1.3
20-Sep-13	MC3	EF - 3pass	14	BB	69	1.9
20-Sep-13	MC3	EF - 3pass	15	WSU	116	14.8
20-Sep-13	MC3	EF - 3pass	16	BMC	89	4.8
20-Sep-13	MC3	EF - 3pass	17	RB	124	14.6
20-Sep-13	MC3	EF - 3pass	1	BB	145	17.8
20-Sep-13	MC3	EF - 3pass	2	BB	65	1.7
20-Sep-13	MC3	EF - 3pass	3	BB	55	1.0
20-Sep-13	MC3	EF - 3pass	4	BB	62	1.5
20-Sep-13	MC3	EF - 3pass	5	BB	75	2.7
20-Sep-13	MC3	EF - 3pass	6	BB	75	2.8
20-Sep-13	MC3	EF - 3pass	7	BB	73	2.1
20-Sep-13	MC3	EF - 3pass	8	BB	55	0.9
20-Sep-13	MC3	EF - 3pass	9	BB	63	1.5
20-Sep-13	MC3	EF - 3pass	10	BB	65	1.8
20-Sep-13	MC3	EF - 3pass	11	BB	58	1.3
20-Sep-13	MC3	EF - 3pass	12	BB	70	1.7
20-Sep-13	MC3	EF - 3pass	13	BB	60	1.4
20-Sep-13	MC3	EF - 3pass	14	BB	110	7.8
20-Sep-13	MC3	EF - 3pass	15	BB	98	5.2
20-Sep-13	MC3	EF - 3pass	16	WSU	124	16.0
20-Sep-13	MC3	EF - 3pass	17	WSU	101	10.0
20-Sep-13	MC3	EF - 3pass	18	BMC	77	4.0
20-Sep-13	MC5	EF - 3pass	1	BB	145	17.5
20-Sep-13	MC5	EF - 3pass	2	BB	147	17.4
20-Sep-13	MC5	EF - 3pass	3	BB	159	23.3
20-Sep-13	MC5	EF - 3pass	4	BB	82	3.4
20-Sep-13	MC5	EF - 3pass	5	WSU	96	7.1
20-Sep-13	MC5	EF - 3pass	6	RB	148	23.3
21-Sep-13	MC2	EF - Single	1	BB	84	3.3
21-Sep-13	MC2	EF - Single	2	BB	96	4.3
21-Sep-13	MC2	EF - Single	3	BB	68	1.8
21-Sep-13	MC2	EF - Single	4	BB	67	1.7
21-Sep-13	MC2	EF - Single	5	BB	64	1.5
21-Sep-13	MC2	EF - Single	6	BB	62	1.2
21-Sep-13	MC2	EF - Single	7	BB	57	1.0
21-Sep-13	MC2	EF - Single	8	WSU	112	13.4
21-Sep-13	MC2	EF - Single	9	BMC	94	6.1
21-Sep-13	MC2	EF - Single	10	BB	134	19.8
21-Sep-13	MC5	EF - 3pass	1	BMC	123	17.1
21-Sep-13	MC5	EF - 3pass	2	BMC	114	11.5
21-Sep-13	MC5	EF - 3pass	3	BMC	117	11.4

Appendix C3. Fish Biological Characteristics, Blackwater Project, 2013

Sampling date	Site	Method	Fish Number	Species	Length (mm)	Weight (g)
21-Sep-13	MC5	EF - 3pass	4	BMC	115	12.5
21-Sep-13	MC5	EF - 3pass	1	BB	117	8.2
21-Sep-13	MC5	EF - 3pass	2	BB	135	12.2
21-Sep-13	MC6	MT	1	BB	135	13.6
21-Sep-13	MC6	MT	2	BB	147	15.4
21-Sep-13	MC6	MT	3	BB	178	28.9
21-Sep-13	MC6	MT	4	BB	160	20.8
01-Oct-13	MC4	MT	1	BMC	79	5.3
01-Oct-13	MC4	MT	2	BB	140	10.0
01-Oct-13	MC4	MT	3	BB	135	14.5
01-Oct-13	MC4	MT	4	BB	185	36.5
01-Oct-13	MC4	MT	5	BB	120	9.1

Notes:

Species: BB=burbot, BMC=brassy minnow, CCG=slimy sculpin, LNC=longnose dace, RB=rainbow trout, WSU=white sucker
Methods: MT=minnow trapping, EF Single=one pass electrofishing, EF-3pass=three pass electrofishing
NR=not recorded

Appendix D

Typical Photographs of Mathews Creek Reaches

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 1 – Alluvial Fan-Delta



Reach 1 – Low Gradient, Sinuous Gravel-Bed Channel

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 2 – Bouldery Canyon



Reach 2 – Cobble-Boulder Bed with Pool-Riffle Morphology and Large Woody Debris (MC1)

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 3 – Irregularly Meandering Meadow



Reach 4 – Sinuous Meadow

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 4 – Low Sinuosity Channel with Herbaceous and Shrubby Banks (MC3)

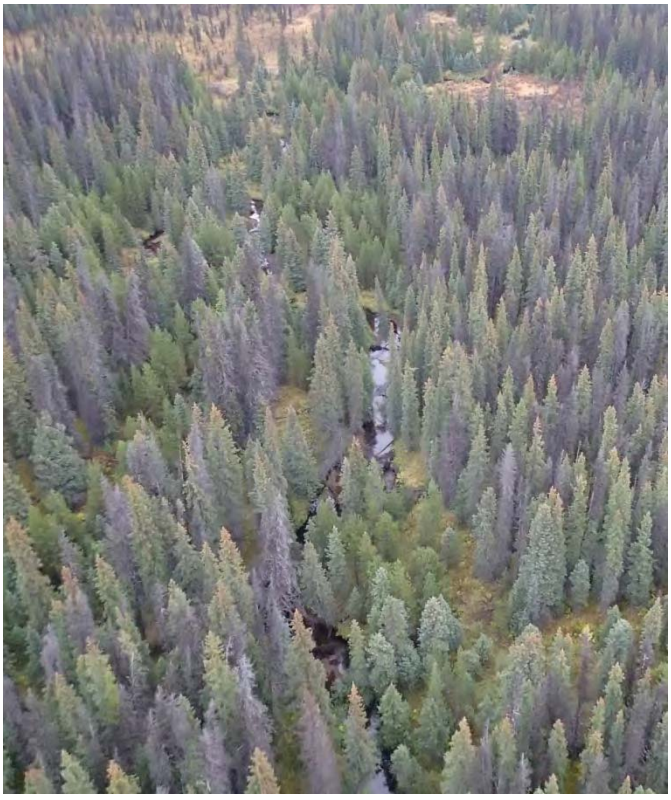


Reach 5 – Tortuously Meandering Meadow

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 5 – Trampled and Collapsed Banks along Ranchland Section of Mathews Creek (MC4)



Reach 6 – Moderate Gradient Forested Meanders

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 6 – Pool-Riffle Morphology, Gravel Substrates and Complex Cover Habitat



Reach 7 – Unstable Aggrading Channel

Appendix D. Typical Photographs of Mathews Creek Reaches

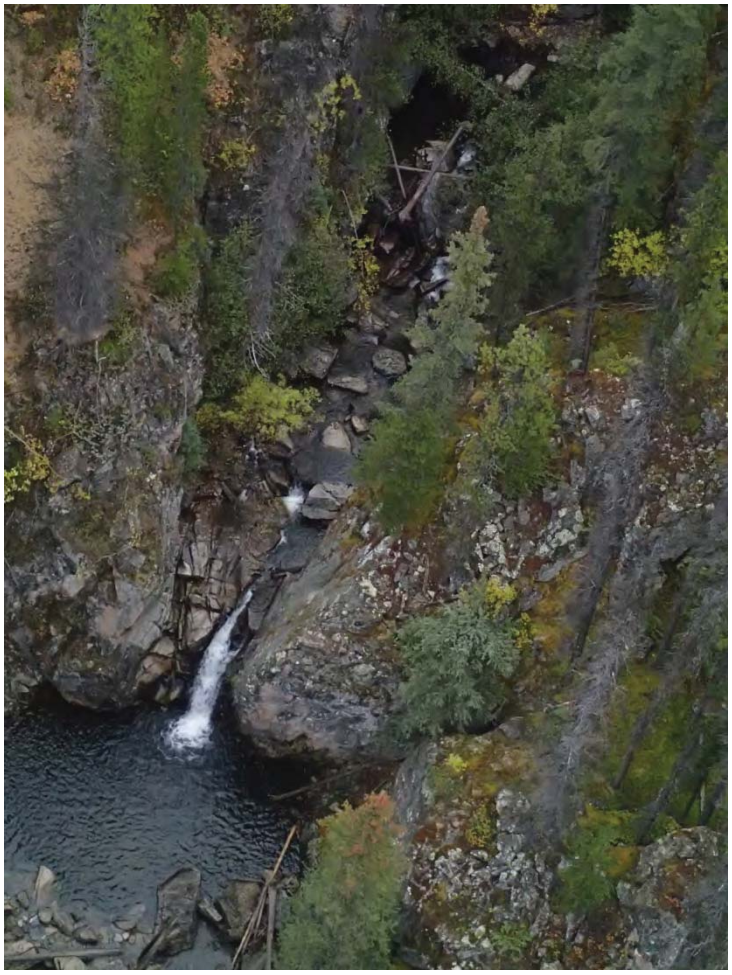


Reach 7 – Gravel Bar and Small Riffle with Some Overhanging Riparian Vegetation (MC6)



Reach 8 – Moderately Steep Sinuous Canyon

Appendix D. Typical Photographs of Mathews Creek Reaches



Reach 9 – Headwater Straight Canyon

Appendix E

Fish Habitat Assessment Results

newgold

Blackwater Project -- Level 1 Habitat Survey Data Form

Stream: Matthews Ck
Reach: 4
Site: MC3
Survey Crew: EC, JC

Start UTM: 10U 359613/5885956
End UTM:
Survey Date: 20/09/2013
(d / m / y)

Weather:
Water temperature: 9.5

Stage: L
Subsampling Fractions: R / P / G / O

Site #	Reach Number	Distance (m)	Habitat Unit Type	Habitat Unit Cat	Length (m)	Gradient (%)	Measured Estimated	Mean Depth Bankfull (m)	Mean Depth Water (m)	Mean Width Bankfull (m)	Mean Width Wetted (m)	Pools Only Max Depth (m)	Pools Only Crest (m)	Pools Only Residual (m)	Pools Only Pool Type	Bed Material Type Dom.	Bed Material Type Sub-Dom.	Spawning Gravel? Type	Spawning Gravel? Amount	Photo #
			P,G,R,C,O	1,2,3				1/4, 1/2, 3/4		3-5 sites					S,D,U	S,G,C,B,R		R,A,AR	N,L,H	U/S, D/S
1		0	P	1	248	0.0	Measured	1.05	0.65	5.9	6.5	1.2	0.6	0.6	S	S	C		N	892,893
2																				
3																				
4																				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				

Site #	Reach Number	Distance (m)	Total LWD Tally	Functional LWD Tally 10 - 20 cm	Functional LWD Tally 20 - 50 cm	Functional LWD Tally > 50 cm	Cover Cover Type	Cover %	Cover Cover Type	Cover %	Offchannel Habitat Type	Offchannel Habitat Access	Offchannel Habitat Length (m)	Disturbance Indicators	Riparian Vegetation Type	Riparian Vegetation Structure R	Riparian Vegetation Structure L	Riparian Vegetation Canopy Closure	Barriers
1		0	0				IV	30	OV	10					G	INT		0	BD
2																			
3																			
4																			
5																			
6																			
7																			
8																			
9																			
10																			
11																			
12																			

HU Type: Pool, Riffle, Glide, Cascade, Other
HU Cat: 1 (Primary), 2(secondary), 3(tertiary)
Pool Type: Scour, Dam, Other
Cover Type: SWD, LWD, B, C, DP, OV, IV
Off-channel type: SC (side channel), SL (slough), PD (off-channel ponds), WL (seasonally flooded wetlands)
Off-channel access: N (no access to fish), P (only at high flows), G (access at most flows)
Dist: SC(bed scour), DW(unveg. Bars), WG(sed. Wedges), MB(elev. Mid-chan. Bar), LR(ext. riffle), F (lim. Pool), MC (braiding), EB(eroding bank), BC(isol. Side chan.), PD(LWD par. to bank), JM(recent LWD jam)

Bed Material: s, si, cl < 2mm | G - 2-64mm | C - 64-256mm | B - 256-4000mm | R - bedrock > 4000mm
Spawning: R - Resident trout and char (>0.1m^2 with 10-75mm) | A - Anadromous salmon (1-2m^2 with 10-150mm)
Amount: N (no suitable habitat), L (Little suitable habitat, isolated pockets), H (extensive areas of spawning gravel)
Riparian: N (un veg'd), G(Grass), SH(shrub herb), D(Decid.), C(Conif.), M(Mix)
Strct: INIT (non-veg), SHR (shb/hb), PS(pole-sap), YF(Young for), MF (Mature)
Canopy: 1 (1-20), 2 (21-40), 3 (41-70), 4 (71-90), 5 (>90)
Barriers: N(no), X(log),CV(Cul), BR(old brdg), LS(landslide),BD(beaver), F(Falls), C(cascade)

newgold

Blackwater Project -- Level 1 Habitat Survey Data Form

Stream: Matthews Ck
Reach: 5
Site: MC4
Survey Crew: RM, RP

Start UTM: 10U 360521/5886651
End UTM: 10U 360633/5886807
Survey Date: 1/10/2013
(d / m / y)

Weather: Cloudy
Water temperature: 5.2 oC

Stage: L-M
Subsampling Fractions: R / P / G / O

Site #	Reach Number	Distance (m)	Habitat Unit Type	Habitat Unit Cat	Length (m)	Gradient (%)	Measured Estimated	Mean Depth Bankfull (m)	Mean Depth Water (m)	Mean Width Bankfull (m)	Mean Width Wetted (m)	Pools Only Max Depth (m)	Pools Only Crest (m)	Pools Only Residual (m)	Pools Only Pool Type	Bed Material Type Dom.	Bed Material Type Sub-Dom.	Spawning Gravel? Type	Spawning Gravel? Amount	Photo #
			P,G,R,C,O	1,2,3				1/4, 1/2, 3/4		3-5 sites					S,D,U	S,G,C,B,R		R,A,AR	N,L,H	U/S, D/S
1	4	0	G	1	100			0.87	0.40	4	3.6					S	G		N	180,181
2	4	100	P	1	10			1.20	0.65	3.45	3.2	1.18	0.5	0.68	S	S			N	182,183
3	4	110	G	1	27			0.87	0.59	4.5	3.3					S	G		N	184,185
4	4	137	P	1	11			1.10	1.85	4.1	3.5	0.85	0.18	0.67	S	S			N	186,187
5	4	148	G	1	15			0.85	0.28	5.2	3.8					S			N	188,189
6	4	163	P	1	10			1.12	0.50	4.9	4.6	0.85	0.18	0.67	S	S			N	190,191
7	4	173	ge collapsed		7															
8	4	180	P	1	23			0.57	0.50	5	3.7	1.13	0.5	0.63	S	S			N	193,194
9	4	203	G	1	14			0.93	0.30	4.67	3.53					S			N	195,196
10	4	217	P	1	7			1.28	0.75	5.6	3.97	1.55	0.2	1.35	S	S			N	197,200
11	4	225	P	1	8			1.20	1.00	4.23	4.13	1.09	0.1	0.99	S	S			N	201,202
12																				

Site #	Reach Number	Distance (m)	Total LWD Tally	Functional LWD Tally 10 - 20 cm	Functional LWD Tally 20 - 50 cm	Functional LWD Tally > 50 cm	Cover Cover Type	Cover %	Cover Cover Type	Cover %	Offchannel Habitat Type	Offchannel Habitat Access	Offchannel Habitat Length (m)	Disturbance Indicators			Riparian Vegetation Type	Riparian Vegetation Structure R	Riparian Vegetation Structure L	Riparian Vegetation Canopy Closure	Barriers
1	4	100	4	4			IV	10	LWD	2				EB			G	SHR		O	
2	4	110	0				DP	20	IV	10				EB			G	SHR		O	
3	4	137	0				IV	5						EB			G			O	
4	4	137	1				DP	70	IV	5				EB			G	SHR		O	
5	4	148	1	1			IV	2						EB			G	SHR		O	
6	4	163	0				IV	10	DP	60				EB	MD		SH	SHR		O	
7																					
8	4	180	1		1		DP	60	IV	10				EB			G	SHR		0	
9	4	14	0				SWD	5	C	30				EB			G	SHR		0	
10	4	7	0				DP	75	SWD	10				EB			G	SHR		0	
11	4	8	0				DP	75	C	25				EB			G	SHR		0	BD
12																					

HU Type: Pool, Riffle, Glide, Cascade, Other
HU Cat: 1 (Primary), 2(secondary), 3(tertiary)
Pool Type: Scour, Dam, Other
Cover Type: SWD, LWD, B, C, DP, OV, IV
Off-channel type: SC (side channel), SL (slough), PD (off-channel ponds), WL (seasonally flooded wetlands)
Off-channel access: N (no access to fish), P (only at high flows), G (access at most flows)
Dist: SC(bed scour), DW(unveg. Bars), WG(sed. Wedges), MB(elev. Mid-chan. Bar), LR(ext. riffle), F (lim. Pool), MC (braiding), EB(eroding bank), BC(isol. Side chan.), PD(LWD par. to bank), JM(recent LWD jam)

Bed Material: s, si, cl < 2mm | G - 2-64mm | C - 64-256mm | B - 256-4000mm | R - bedrock > 4000mm
Spawning: R - Resident trout and char (>0.1m^2 with 10-75mm) | A - Anadromous salmon (1-2m^2 with 10-150mm)
Amount: N (no suitable habitat), L (Little suitable habitat, isolated pockets), H (extensive areas of spawning gravel)
Riparian: N (un veg'd), G(Grass), SH(shrub herb), D(Decid.), C(Conif.), M(Mix)
Strct: INIT (non-veg), SHR (shb/hb), PS(pole-sap), YF(Young for), MF (Mature)
Canopy: 1 (1-20), 2 (21-40), 3 (41-70), 4 (71-90), 5 (>90)
Barriers: N(no), X(log),CV(Cul), BR(old brdg), LS(landslide),BD(beaver), F(Falls), C(cascade)

newgold

Blackwater Project -- Level 1 Habitat Survey Data Form

Stream: Matthews Ck
Reach: 5
Site: MC5
Survey Crew: EC, JC

Start UTM: 10U 362345/5886592
End UTM:
Survey Date: 20/09/2013
(d / m / y)

Weather:
Water temperature: 9.4

Stage: L
Subsampling Fractions: R / P / G / O

Site #	Reach Number	Distance (m)	Habitat Unit Type	Habitat Unit Cat	Length (m)	Gradient (%)	Measured Estimated	Mean Depth Bankfull (m)	Mean Depth Water (m)	Mean Width Bankfull (m)	Mean Width Wetted (m)	Pools Only Max Depth (m)	Pools Only Crest (m)	Pools Only Residual (m)	Pools Only Pool Type	Bed Material Type Dom.	Bed Material Type Sub-Dom.	Spawning Gravel? Type	Spawning Gravel? Amount	Photo #
			P,G,R,C,O	1,2,3				1/4, 1/2, 3/4		3-5 sites					S,D,U	S,G,C,B,R		R,A,AR	N,L,H	U/S, D/S
1		23	G	1	23	0.0	Measured	1.00	0.52	7	7					S			N	
2		26	P	1	3	0.0	Measured	1.90	0.90	7	7	1.2	0.6	0.6	S	S			N	
3		38	P	1	12	0.0	Measured	1.10	0.50	6	6	0.8	0.5	0.3	S	S			N	
4		53	P	1	15	0.0	Measured	1.10	0.70	6	6	1.05	0.5	0.55	S	S			N	
5		85	P	1	32	0.0	Measured	1.30	0.60	4.5	4.5	2	0.5	1.5	S	S			N	
6		99	P	1	14	0.0	Measured	1.00	0.70	4.8	4.8	1	0.7	0.4	S	S			N	
7		110	G	1	11	0.0	Measured	0.65	0.30	4.2	4.2					S			N	
8		156	P	1	16	0.0	Measured	0.90	0.60	4.8	4.8	1	0.6	0.4	S	S			N	
9		185	G	1	29	0.0	Measured	0.80	0.40	7.00	7.00									
10																				
11																				
12																				

Site #	Reach Number	Distance (m)	Total LWD Tally	Functional LWD Tally 10 - 20 cm	Functional LWD Tally 20 - 50 cm	Functional LWD Tally > 50 cm	Cover Cover Type	Cover %	Cover Cover Type	Cover %	Offchannel Habitat Type	Offchannel Habitat Access	Offchannel Habitat Length (m)	Disturbance Indicators	Riparian Vegetation Type	Riparian Vegetation Structure R	Riparian Vegetation Structure L	Riparian Vegetation Canopy Closure	Barriers
1		23					OV	20	B	10					SH	SHR		10	
2		26					B	30	OV	20					SH	SHR		10	
3		38	2	2											SH	SHR		10	
4		53	2	2			LWD	30							SH	SHR		10	
5		85	2	2			OV	60							SH	SHR		10	
6		99					OV	20	IV	10					SH	SHR		10	
7		110					OV	20	IV	20					SH	SHR		10	
8		156					SWD	20	IV	10					SH	SHR		10	
9		185																	
10																			
11																			
12																			

HU Type: Pool, Riffle, Glide, Cascade, Other
HU Cat: 1 (Primary), 2(secondary), 3(tertiary)
Pool Type: Scour, Dam, Other
Cover Type: SWD, LWD, B, C, DP, OV, IV
Off-channel type: SC (side channel), SL (slough), PD (off-channel ponds), WL (seasonally flooded wetlands)
Off-channel access: N (no access to fish), P (only at high flows), G (access at most flows)
Dist: SC(bed scour), DW(unveg. Bars), WG(sed. Wedges), MB(elev. Mid-chan. Bar), LR(ext. riffle), F (lim. Pool), MC (braiding), EB(eroding bank), BC(isol. Side chan.), PD(LWD par. to bank), JM(recent LWD jam)

Bed Material: s, si, cl < 2mm | G - 2-64mm | C - 64-256mm | B - 256-4000mm | R - bedrock > 4000mm
Spawning: R - Resident trout and char (>0.1m^2 with 10-75mm) | A - Anadromous salmon (1-2m^2 with 10-150mm)
Amount: N (no suitable habitat), L (Little suitable habitat, isolated pockets), H (extensive areas of spawning gravel)
Riparian: N (un veg'd), G(Grass), SH(shrub herb), D(Decid.), C(Conif.), M(Mix)
Strct: INIT (non-veg), SHR (shb/hb), PS(pole-sap), YF(Young for), MF (Mature)
Canopy: 1 (1-20), 2 (21-40), 3 (41-70), 4 (71-90), 5 (>90)
Barriers: N(no), X(log),CV(Cul), BR(old brdg), LS(landslide),BD(beaver), F(Falls), C(cascade)

Annex J

Culvert Identification and Prioritization Study

Culverts and Fish Passage Prioritization

Desktop Review

Vanderhoof Forest District

Prepared for:

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1 Introduction

AMEC Environment & Infrastructure (AMEC) is developing a Fish Habitat Mitigation and Compensation Plan (FHMCP) that will be submitted as part of an Environmental Assessment (EA) and project application for the Blackwater Gold Project in December 2013. Potential opportunities to address fish passage issues at stream crossing locations within the Vanderhoof Forest District (the District) are being investigated to support compensation planning. To support future 'ground-truthing' and fish passage assessments, AMEC retained Avison Management Services (Avison) in late September to provide services to conduct a desktop review, GIS analysis, and reporting to identify and prioritize all known stream crossings with fish passage issues.

2 Stream Crossing Identification

In 2012, Ecofor Consultants Ltd. Completed a review[i] of the forest licensee and provincial road crossing databases for the District and a total of 59 crossings were identified. Avison contacted the Ministry of Forests Lands and Natural Resource Operations in Vanderhoof, and with their assistance were able to identify another 11 potentially high priority culverts. Additionally Avison recently completed field work for a Fish and Fish Habitat Assessment for the New Gold – Blackwater Gold Project, another 18 culverts which were identified during this project were added to the list.

3 Desktop Review – Culvert and Fish Passage Prioritization Methodology

3.1 Phase I – Initial Course Filter Approach

An initial course filter approach was implemented to prioritize the 59 culverts identified by Ecofor Consultants Ltd., prior to crews engaging in a field program. The methodology for this course filter approach is as follows.

3.1.1 *Known or Potential Fish Species* – using local knowledge of several Avison staff, identified streams with culvert crossings were assigned points based on known or potential presence of either spawning habitat of fish species, with priority placed on White sturgeon, Chinook, Sockeye, Kokanee salmon and Rainbow trout.

a) Known/Potential Sturgeon Spawning/Rearing Habitat (1 point)
b) Known/Potential Anadromous Salmon Spawning Habitat (1 point)
c) Know/Potential Anadromous Salmon Rearing Habitat (1 point)
d) Known/Potential Kokanee Spawning/Rearing Habitat (1 point)
e) Known/Potential Rainbow Spawning/Rearing Habitat (1 point)

3.1.2 *Socio-economic Impacts of Streams* – using local knowledge of several Avison staff, streams that directly or indirectly support significant aboriginal, recreational, and tourism based commercial fisheries, and that were important to local communities including First Nation Communities were also assigned points as follows.

a) Supports Significant First Nations Fishery (2 points)
b) Supports Significant Recreational Fishery (1 point)
c) Supports Significant Commercial (Tourism) Fishery (1 point)
d) Supports Locally Important Fishery (2 points)

3.1.3 *Linear Length of Potential Upstream Fish Habitat Gained* – an Avison GIS analyst also provided the linear length of potential upstream habitat gained. Points were awarded each culvert for potential habitat gained as follows.

a) Potential Upstream Habitat Gained (<10 km) – (1 point)
b) Potential Upstream Habitat Gained (10 – 20 km) – (2 points)
c) Potential Upstream Habitat Gained (21 – 50 km) – (3 points)
d) Potential Upstream Habitat Gained (50 – 100 km) – (4 points)
e) Potential Upstream Habitat Gained (>100 km) – (5 points)

3.1.4 *Priority Rank* – All points were totaled, and a priority rank was assigned based on total points given.

a) High (8-12 points)
b) Moderately High (5-7 points)
c) Moderate (3-4 points)
d) Moderately Low (2 points)
e) Low (1 points)

3.2 Phase II – Fine Filter Approach

After the initial course filter prioritization was completed, additional culverts were identified by the Vanderhoof Forest District Engineering Officer and by the Fish and Fish Habitat Assessment for the New Gold – Blackwater Gold Project. It soon became apparent that additional refinement of the prioritized list was needed to further narrow and prioritize the growing list. A phase II fine filter approach was implemented using the following criteria, which include assigning a point system to relevant elements.

3.2.1 *Ownership* – Culvert ownership was determined through consultation with the Vanderhoof Forest District Engineering Officer, Forest Licensees, and using the Land and Resource Data Warehouse (LRDW) Forest Tenure Road Segment Lines in Arc Map. After determination of ownership had been conducted, and culverts

know to be under a Forest Licensee Road Permit, we dropped from the list, and only culverts under MFLNRO and MOT ownership were retained.

3.2.2 *Installation Year* – any culvert that was identified by the Vanderhoof Forest District Engineering Officer as recently replaced and not in need of assessment or replacement was dropped from the list.

3.2.3 *Known or Potential Barriers or Obstructions* – Known barriers and obstructions were analyzed using the Freshwater Atlas Obstructions data from the LRDW. Known gradient barriers, or manmade dams were noted and used to assign a negative point value to the affected culvert. Very few gradient barriers exist in the Vanderhoof district relative to other Districts with steeper, more rugged terrain. Beaver dams were noted, but were not assigned a negative value as they are temporary or seasonal obstructions/barriers. Licensee culverts and other unidentified culverts were assumed as potential obstructions/barriers and noted when observed up or down stream of identified culvert using Arc Map, but were not assigned a point value in this analysis. The points assigned this criteria in the table are as follows.

a) Known barriers which will likely preclude culvert replacement (-10 points)

3.2.4 *Known Fish Observations* – We used the Known Fish Observations data from the LRDW to analyze known fish presence up and down stream of identified culverts by species. The Known Fish Observations point data coverage is a dataset that shows all the fish occurrence records for the Province that are currently available from corporate oracle databases. The data are a compilation from several data sources including the Fisheries Information Summary System (FISS) and the Consolidated Waterbody Surveys (CWS). It is assumed that although culverts may pose a temporary obstruction or barrier, fish observations of resident species (i.e. rainbow trout) upstream of culverts are an indication of suitable fish habitat.

The “Known Fish Observations” criteria were used to assign points values to culverts that had fish observations up and/or downstream as follows.

a) Known Sturgeon Observations Downstream of Culvert (1 point)
b) Known Chinook Observations Upstream of Culvert (1 point)
c) Known Chinook Observations Downstream of Culvert (1 point)
d) Known Coho Observations Upstream of Culvert (1 point)
e) Known Coho Observations Downstream of Culvert (1 point)
f) Known Sockeye Observations Upstream of Culvert (1 point)
g) Known Sockeye Observations Downstream of Culvert (1 point)

h) Known Kokanee Observations Upstream of Culvert (1 point)
i) Known Kokanee Observations Downstream of Culvert (1 point)
j) Known Rainbow Trout Observations Upstream of Culvert (1 point)
k) Known Rainbow Trout Observations Downstream of Culvert (1 point)
l) Known Bull Trout Observations Upstream of Culvert (1 point)
m) Known Bull Trout Observations Downstream of Culvert (1 point)
n) Known Dolly Varden Observations Upstream of Culvert (1 point)
o) Known Dolly Varden Observations Downstream of Culvert (1 point)
p) Known Mountain Whitefish Observations Upstream of Culvert (1 point)
q) Known Mountain Whitefish Observations Downstream of Culvert (1 point)

3.2.5 *Pre 1995 Culverts* – Culverts installed prior to 1995 when the Provincial Forest Practice's Code was implemented are assumed to be non-compliant with current culvert installation practices and in need of replacement. Additionally many pre 1995 culverts reverted from licensees back to Provincial ownership and are sometimes referred to as orphaned culverts. The Province is responsible for these culverts, but does not have the current resources to replace them. Culverts installed prior to 1995 were assigned a point value as these are considered a higher priority for replacement as follows.

a) Pre 1995 culvert (1 point)

3.2.6 *Stream Order at Culvert* – This hierarchical system provides a useful way of understanding the water volume, accumulation, and potential size of the stream. Stream order is assumed to be positively correlated with presence/absence of local fish species when combined with connectivity. In the absence of field reconnaissance data we have used stream order as an additional inference to potential habitat gained. Combined with linear length upstream, the larger the order of the stream at the culvert, the more area of potential habitat is gained. Point values were assigned stream order in the table using the following criteria.

a) Stream order 1 (1 point)
b) Stream order 2 (2 points)
c) Stream order 3 (3 points)
d) Stream order 4 (4 points)
e) Stream order 5 (5 points)
f) Stream order 6 (6 points)

3.2.7 Linear Length of Potential Upstream Fish Habitat Gained – an Avison GIS analyst also provided the linear length of potential upstream habitat gained. Points were awarded each culvert for potential habitat gained as follows.

a) Potential Upstream Habitat Gained ≥100 km (5 points)
b) Potential Upstream Habitat Gained 50-99 km (3 points)
c) Potential Upstream Habitat Gained ≤ 49 km (1point)

3.2.8 *Socio-economic Impacts of Streams* – We retained the Socio-economic component in the Phase II fine filter approach to ensure that, stream that directly or indirectly support significant aboriginal, recreational, and tourism based commercial fisheries, are implemented into the prioritization process. The points for these criteria were assigned points as follows.

a) Supports Significant First Nations Fishery – 2 points
b) Supports Significant Recreational Fishery – 1 point
c) Supports Significant Commercial (Tourism) Fishery – 1 point

3.2.9 *Priority Rank* – All points were totaled, and a priority rank was assigned based on total points given.

a) High (≥10points)
b) Moderate (6-9 points)
c) Low (≤5 points)

4 Results

Based on this developed scoring and ranking system, a total of 29 culverts were assessed as “High” priority for further field assessments, with 27 different sites locations (3 culverts at one site). Fifteen culverts were ranked as ``Moderate`` priority, and only three culverts were ranked as ``low`` priority. See Appendix A for a ranking summary.

5 References

Ecofor Consultants. 2012. Off-Site Compensation Options in the Vanderhoof Forest District, Blackwater Gold Project. Draft Report Version 1.0. Prepared for New Gold Inc. Project No.: 2012-2071-21

B.C. Ministry of Environment. 2009. Field assessment for fish passage determination of closed bottomed structures, 3rd edition. Victoria, B.C. http://www.for.gov.bc.ca/ftp/hcp/external/!publish/web/fia/Field_Protocol.pdf (Accessed October 2013).

Mount et al. 2011. GIS Modelling of Fish Habitat and Road Crossings for the Prioritization of Culvert Assessment and Remediation. Streamline Watershed Management Bulletin. Vol 14/No.2 Spring 2011.

6 Metadata Links

Digital Road Atlas (DRA) –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=45674&recordSet=ISO19115

Forest Tenure Road Segment Lines (FTEN Roads) –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=51944&recordSet=ISO19115

Freshwater Atlas: Obstructions –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?from=search&edit=true&showall=showall&recordSet=ISO19115&recordUID=50645

Freshwater Atlas: Stream Network –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=50648&recordSet=ISO19115

Known Fish Observations –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?from=search&edit=true&showall=showall&recordSet=ISO19115&recordUID=43471

Provincial Obstacles to Fish Passage –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?from=search&edit=true&showall=showall&recordSet=ISO19115&recordUID=50219

TRIM Contour lines –
https://apps.gov.bc.ca/pub/geometadata/metadataDetail.do?recordUID=4089&recordSet=ISO19115

Appendices

Appendix A: Culvert Ranking within the Vanderhoof Forest District for the New Gold Culvert and Fish Passage Prioritization Project.

Crossing ID	Easting	Northing	Crossing Creek Name	Crossing Road Name	Ownership	Year Installed	Final Point Total	Final Priority Ranking High(≥10), Mod(6-9), Low(≤5)
2	463818	5967403	Norman Creek	BOBTAIL LAKE FSR	FSR	?	**12**	**High**
3	434491	5944268		BOTTAIL CONNECTOR	FSR	1999	**10**	**High**
8	374923	5958945	Targe Creek	HOLY CROSS FSR	FSR	1981	**10**	**High**
12	412440	5962541		KLUSKUS FSR	FSR	1997	**11**	**High**
13	460476	5952894	Cluculz Creek	BOBTAIL LAKE FSR	FSR	1997	**14**	**High**
14	406843	5938277		KLUSKUS FSR	FSR	?	**15**	**High**
16	398740	5927463	Big Bend Creek	KLUSKUS FSR	FSR	1980	**14**	**High**
17	407485	5898122	Suscha Creek	KLUSKUS FSR	FSR	1980`s	**13**	**High**
19	415341	5968528		KLUSKUS FSR	FSR	1997	**12**	**High**
20	415185	5967875		KLUSKUS FSR	FSR	1997	**14**	**High**
25	423730	5966028	Corkscrew Creek	CORKSCREW FSR	FSR	?	**13**	**High**
26	423730	5966028	Corkscrew Creek	CORKSCREW FSR	FSR	?	**13**	**High**
27	423730	5966028	Corkscrew Creek	CORKSCREW FSR	FSR	?	**13**	**High**
29	409378	5937340		LAVOIE-GOLD ROAD FSR	FSR	?	**18**	**High**
30	408572	5936852	Finger Creek	LAVOIE-GOLD ROAD FSR	FSR	1980	**14**	**High**
36	388362	6008206	Angly Creek	SUTHERLAND FSR	FSR	1970`s	**11**	**High**
39	379689	6014933	Duncan Creek	SUTHERLAND SHOVEL FSR	FSR	1980`s	**13**	**High**
44	459130	5959354	Cluculz Creek	Telegragh Trail	Highways	?	**18**	**High**
49	382246	5952140		Kenny Dam Road	Highways	1960`s	**16**	**High**
51	436580	5936420		BOBTAIL TATUK FSR	FSR	1980`s	**11**	**High**
60	409226	5941021	Cabin creek	Kluskus 56.75km	FSR	?	**14**	**High**
61	408884	5940443	Trib to cabin	Kluskus 57.25 km	FSR	2005	**12**	**High**
63	387960	5910160	Trib to chedakuz creek	Kluskus 113 km	FSR	1980`s	**11**	**High**
66	418737	5966429	Trib to corkscrew creek	corkscrew fsr 4km	FSR	1970`s	**14**	**High**
67	416816	5973555	Trib to Nulki Lake	kluskus 20km and 21km	FSR	1970`s	**12**	**High**
69	373572	5975294		HOLY CROSS BINTA FSR 227.5km	FSR	1980	**10**	**High**
70	403917	5998779	Nine Mile Creek	Settlement road	FSR	?	**19**	**High**
83	416805	5973117		Kluskus FSR	FSR	?	**14**	**High**
89	407960	5938545		Kluskus FSR	FSR	?	**13**	**High**
1	465646	5968464		BOBTAIL LAKE FSR	FSR	?	**9**	**Moderate**
4	466638	5976663		BEVERLY LAKE FSR	FSR	1994	**6**	**Moderate**
5	386321	5978062		HOLY CROSS FSR	FSR	1970	**6**	**Moderate**
6	386569	5977261	Smith Creek	HOLY CROSS FSR	FSR	1980	**8**	**Moderate**
11	374050	5975385		HOLY CROSS BINTA FSR	FSR	1980	**8**	**Moderate**
18	384128	5887209		KLUSKUS FSR	FSR	1995	**9**	**Moderate**
23	369047	5909925		CHEDAKUZ FSR	FSR	1992	**7**	**Moderate**
24	411424	5947289		KLUSKUS FSR	FSR	?	**9**	**Moderate**
32	360346	5897540		MALAPUT FSR	FSR	1991	**6**	**Moderate**
43	405529	6008557		R11286 Q	FSR	?	**7**	**Moderate**
45	411459	5948938		KLUSKUS FSR	FSR	?	**7**	**Moderate**
65	408320	5902699	Trib to blackwater	Blue 16km	FSR	1980	**8**	**Moderate**
74	398443	5911423		Kluskus FSR	FSR	?	**6**	**Moderate**
75	398607	5916799		Kluskus FSR	FSR	?	**8**	**Moderate**
78	409828	5945915		Kluskus FSR	FSR	?	**7**	**Moderate**
9	370584	5940568		HOLY CROSS FSR	FSR	1981	**2**	**low**
62	395715	5911590	Trib to mills lake	Kluskus 105 km	FSR	?	**5**	**Low**
68	370296	5939581	Trib to Nechako	Holy Cross 66km	FSR	1981	**-1**	**Low**

Annex K

Assessment of Fish Passage of Priority Culverts in the Vanderhoof Forest District

Assessment for Fish Passage Status of Selected Priority Culverts in the Vanderhoof Forest District

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1 Introduction

AMEC Environment and Infrastructure (AMEC) are submitting a Fish Habitat Mitigation and Compensation Plan (FHMCP) as part of an Environmental Assessment for the project application of the Blackwater Gold Project in December 2013. Part of the compensation planning of the FHMCP includes investigating possible fish passage issues at stream crossings within the Vanderhoof Forest District. AMEC retained the services of Avison Management Services, Ltd (AMS) to conduct a desktop review of the known stream crossings with fish passage issues and prioritize them. Based on the results of this review, AMS undertook a field assessment of closed bottom structures to ground-truth the high priority sites. The results of the assessments were then used to supplement the desktop review in providing a priority based list of recommended sites for potential stream crossing upgrades.

2 Methods

2.1 Sample Site Selection

A desktop review completed by Olin Albertson of AMS in October 2013, yielded 29 stream crossing locations that were ranked as having a high priority for field visits. Field assessments were undertaken in early November, 2013. Time and resource constraints limited field assessments to only these high priority sites.

2.2 Field procedures

Stream crossing sites were assessed based on the BC MFLNRO document "Field Assessment for Determining Fish Passage Status of Closed Bottom Structures". The data collected at these sites falls into four categories:

2.2.1 Location and Overview Information

- Date
- Crossing Reference
- Crew Members
- UTM coordinates (NAD 83) in zone-easting-northing format
- Stream name (if it has a gazetted name)
- Road Name
- Road Km Mark
- Road Tenure

2.2.2 Field Observations and Assessment Measurements

- Crossing Type: open-bottomed structure, closed-bottom structure, or other
- Crossing Subtype: bridge, pipe arch, wood box culvert, round culvert, oval culvert, concrete box, or ford
- Culvert Diameter for closed-bottomed structures or the span of the open-bottomed structure

- Culvert Length for closed-bottomed structures or the width of the open-bottomed structure
- Whether or not the culvert has Continuous Embeddedment
- If it is embedded, the average depth of embeddedment at the inlet and outlet which is then used to calculate the average depth of embeddedment throughout the culvert
- Whether or not the culvert resembles the channel
- Whether or not the culvert is Backwatered
- If Backwatered, the percentage of the length of the culvert that is backwatered is recorded.
- The fill depth of the crossing structure
- The Outlet Drop: measured by adding the depth from the lowest point of the culvert outlet to the top of the outlet pool and the depth of the bottom of the outlet control to the top of the outlet pool
- Outlet Pool Depth: measured by subtracting the depth of the bottom of the outlet control to the top of the outlet pool from the total depth of the outlet pool
- Whether or not there is an Inlet Drop
- Culvert Slope measured with a clinometer
- Measurement of high water levels in culvert:[1]
  a) The depth of the water flowing through the culvert
  b) The depth of the dark rust band
  c) The depth of the yellow discolouration in the culvert

2.2.3 Stream Information

- Average Channel Width and Culvert Diameter in order to calculate the Stream Width Ratio (average channel width/culvert diameter)
- Stream Slope measured with a clinometer
- presence/absence of Beaver Activity
- Visual Assessment of fish bearing status
- Habitat Value ranked as low, medium, or high
- Comments describing signs of severe erosion around the culvert
- Comments describing signs of severe channel degradation around the culvert
- Comments describing signs of very high water levels at the inlet if the culvert is suspected of being undersized
- Comments describing the fish habitat present
- Comments on the potential habitat use by fish species documented to be present.

[1] This additional data was collected at the request of AMEC to be used to quantitatively assess whether the culvert creates a velocity barrier for fish.

2.2.4 Photodocumentation

A minimum of five pictures were taken at each crossing site:

- upstream shot from the culvert inlet
- shot of the inlet and inlet pool
- downstream of the culvert outlet
- shot of the outlet and outlet pool
- shot of the culvert barrel
- additional pictures were taken of features of note at the discretion of field crews to supplement comments during the assessment

2.3 Data Analysis

Each stream crossing was scored to determine whether the closed bottom structure was passable, a possible barrier or a barrier to fish passage based on the scoring values found in the BC MFLNRO document "Field Assessment for Determining Fish Passage Status of Closed Bottom Structures". The scoring used is as follows:

Culvert Length:

- Culvert Length < 15m = 0
- Culvert Length 15-30m = 3
- Culvert Length > 30m = 6

Embeddedness:

- No continuous embeddedment = 10
- Continuous embeddedment <20% of culvert diameter or <30cm deep = 5
- Continuous embeddedment >20% of culvert diameter or >30cm deep = 0

Outlet Drop:

- < 15cm = 0
- 15-30cm = 5
- >30cm = 10

Culvert Slope:

- < 1% = 0
- 1-3% = 5
- >3% = 10

Stream Width Ratio:

- <1.0 = 0
- 1-3% = 3
- >3% = 6

Final Score:

- The sum of the five scoring criteria equals the final culvert score.

Final scores of 0-14 indicate a passable stream crossing, 15-19 indicate a potential barrier, and ≥ 20 indicate a barrier to fish passage. The final barrier result for each sample site was recorded in a digital copy of the field data sheet.

The desktop review conducted in October 2013 (see Section 1) provided priority scores for each of the sites assessed in this survey based on several factors: known or potential fish species, socio-economic impact of stream, linear length of potential habitat gained, road ownership, installation year, known/potential barriers or obstructions, known fish observations, and stream order at the culvert. The priority score for each site was added to the final culvert score to give a total score for each stream crossing site. These total scores were used to rank the 29 sample sites in terms of their priority for upgrading.

3 Results

Twenty-six of the 29 sample sites were determined to be barriers based on their final culvert score and two (sites 8 and 13) were determined to be potential barriers. The culvert at site 14 was not assessed because it had recently been removed but that information was not made available during the planning phase of this project. Sites 25, 26, and 27 were actually one site with three culverts. Table 1 provides the ranking of the twenty-nine sites based on their total scores.

Table 1: Culvert rankings based on the sum of the priority score and the culvert score.

Rank	Crossing ID/Site No.	Easting	Northing	Stream Name	Road Name	Ownership	Year Installed	Priority Ranking	Priority Score	Culvert Score	Total Score
1	**44***	459130	5959354	Cluculz Creek	Telegraph Trail	Highways	?	High	18	34	52
2	**70**	403917	5998779	Nine Mile Creek	Settlement road	FSR	?	High	19	31	50
3	**17***	407485	5898122	Suscha Creek	Kluskus FSR	FSR	1980`s	High	13	36	49
4	**30**	408572	5936852	Finger Creek	Lavoie-Gold Road FSR	FSR	1980	High	14	34	48
5	**61**	408884	5940443	Trib to cabin	Kluskus FSR	FSR	2005	High	12	34	46
6	**36**	388362	6008206	Angly Creek	Sutherland FSR	FSR	1970`s	High	11	34	45
7	**69**	373572	5975294		Holy Cross - Binta FSR	FSR	1980	High	10	34	44
8	**83**	416805	5973117	Stoney Creek	Kluskus FSR	FSR	?	High	14	29	43
9	**29***	409378	5937340	Trib to Finger Ck	Lavoie-Gold Road FSR	FSR	?	High	18	24	42
10	**89**	407960	5938545		Kluskus FSR	FSR	?	High	13	29	42
11	**63**	387960	5910160	Trib to Chedakuz Ck	Kluskus FSR	FSR	1980`s	High	11	29	40
12	**16**	398740	5927463	Big Bend Creek	Kluskus FSR	FSR	1980	High	14	24	38
13	**60***	409226	5941021	Cabin creek	Kluskus FSR	FSR	?	High	14	24	38
14	**20**	415185	5967875	Trib to Nulki Lake	Kluskus FSR	FSR	1997	High	14	24	38
15	**27***	423730	5966028	Corkscrew Creek	Corkscrew FSR	FSR	?	High	13	24	37
16	**26***	423730	5966028	Corkscrew	Corkscrew	FSR	?	High	13	24	37

				Creek	FSR						
17	**39**	379689	6014933	Duncan Creek	Sutherland-Shovel FSR	FSR	1980`s	High	13	24	37
18	**49**	382246	5952140	Cutoff Creek	Kenny Dam Road	Highways	1960`s	High	16	21	37
19	**25***	423730	5966028	Corkscrew Creek	Corkscrew FSR	FSR	?	High	13	24	37
20	**2**	463818	5967403	Norman Creek	Bobtail Lake FSR	FSR	?	High	12	24	36
21	**67**	416816	5973555	Trib to Nulki Lake	Kluskus FSR	FSR	1970`s	High	12	24	36
22	**66***	418737	5966429	Trib to corkscrew	Corkscrew FSR	FSR	1970`s	High	14	21	35
23	**3**	434491	5944268		Bobtail Connector FSR	FSR	1999	High	10	24	34
24	**19***	415341	5968528		Kluskus FSR	FSR	1997	High	12	21	33
25	**13***	460476	5952894	Cluculz Creek	Bobtail Lake FSR	FSR	1997	High	14	19	33
26	**51***	436580	5936420		Bobtail-Tatuk FSR	FSR	1980`s	High	11	21	32
27	**12***	412440	5962541	Trib to Nulki Lake	Kluskus FSR	FSR	1997	High	11	21	32
28	**8**	374923	5958945	Targe Creek	Holy Cross FSR	FSR	1981	High	10	18	28
29	**14**	406843	5938277		Kluskus FSR	FSR	?	High	15	ns[1]	15

[1] - Site 14 did not receive a culvert score because no culvert assessment was performed. The culvert had been removed during a road upgrade on the Kluskus FSR, and an open bottomed structure had been installed downstream of the original crossing.
[2] - Culvert scores >= 20 are considered barriers, 15-19 are potential barriers, and <=14 are passable.
* - Sites marked with an asterisk had a shallow valley fill.

4 Discussion and Recommendations

With a majority of the culverts assessed to be barriers in this field survey, the prioritization of sites to be upgraded should focus on the final culvert rankings (Table 1). Selections made from this list should incorporate cost-benefit analyses and the number of barriers affecting a given system in order to maximize the amount of habitat gained for each prescription choice.

Two important sites that should be considered for upgrades are Site 44 and Site 13. Both are located on Cluculz Creek, approximately 5km apart. The culvert crossing at Site 44 scored in the top two in both priority ranking and culvert score and provides a potential habitat gain of 458.1km, making it a prime candidate for a crossing upgrade prescription. Although the crossing at Site 13 was scored as a potential barrier, upgrading Site 13 in conjunction with Site 44 should be strongly considered as it accounts for half of the potential habitat that would be gained from upgrading Site 44. A closer evaluation of the crossing at Site 13 may be warranted to assess its fish passage status.

Of note is also Site 20 and Site 12, they are also located on the same stream, a tributary of Nulki Lake. These two sites were ranked 14th and 27th respectively. If Site 20 is considered for a crossing upgrade, Site 12 should also be considered as 93.4km of the 121.0km of potential habitat gained is above Site 12.

Identifying and assessing forest licensee culverts was beyond the scope of this assessment, but should be considering when conducting a cost-benefit analysis. Further analysis of currently unknown forest licensee culverts both upstream and downstream of the sites identified in this assessment should be conducted to determine if additional barriers exist.

Sites should be considered in the order of their final ranking. Cost-benefit analyses for potential upgrade prescriptions will reveal whether a site prescription is financially viable or not. In order to perform these analyses an engineer will have to develop crossing prescriptions for each site. Table 1 shows which sites had a shallow valley fill. Prescriptions for these sites could potentially be less expensive than prescriptions for sites with a deep valley fill.

The water level and high water mark measurements described in Section 2.2.2 were requested by AMEC for the purpose of calculating the potential for velocity barriers in culverts. If culverts are found to be velocity barriers for fish, then further analysis should be conducted to determine whether in-stream controls (e.g., backwater weirs) can be used to make the crossing passable. This will be more cost effective than replacing culverts with clear-span bridges making it possible to implement a greater number of crossing prescriptions.

5 References

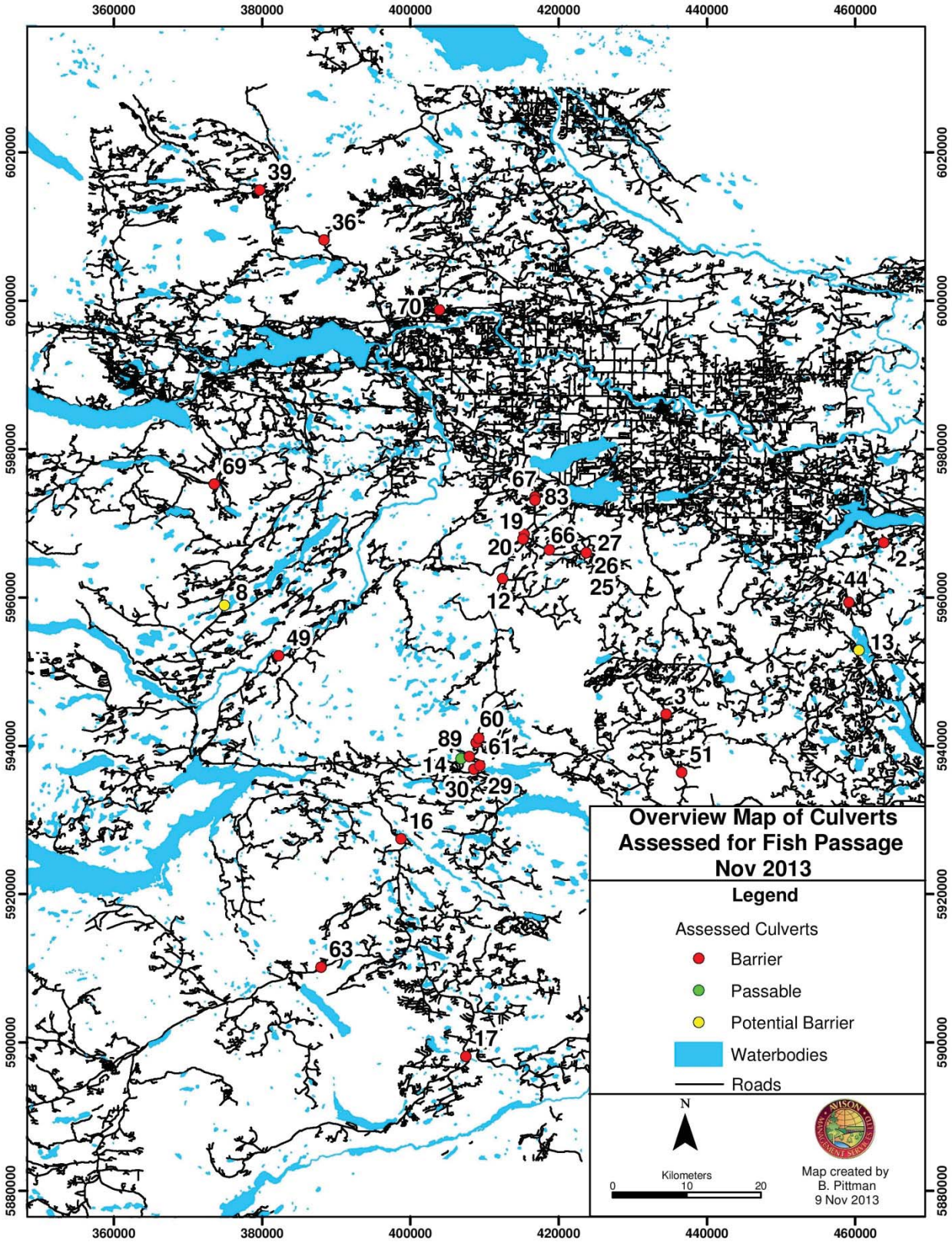
Avison Management Services Ltd, 2013. Culverts and Fish Passage Prioritization - Desktop Review - Vanderhoof Forest District. Prepared for New Gold Inc.

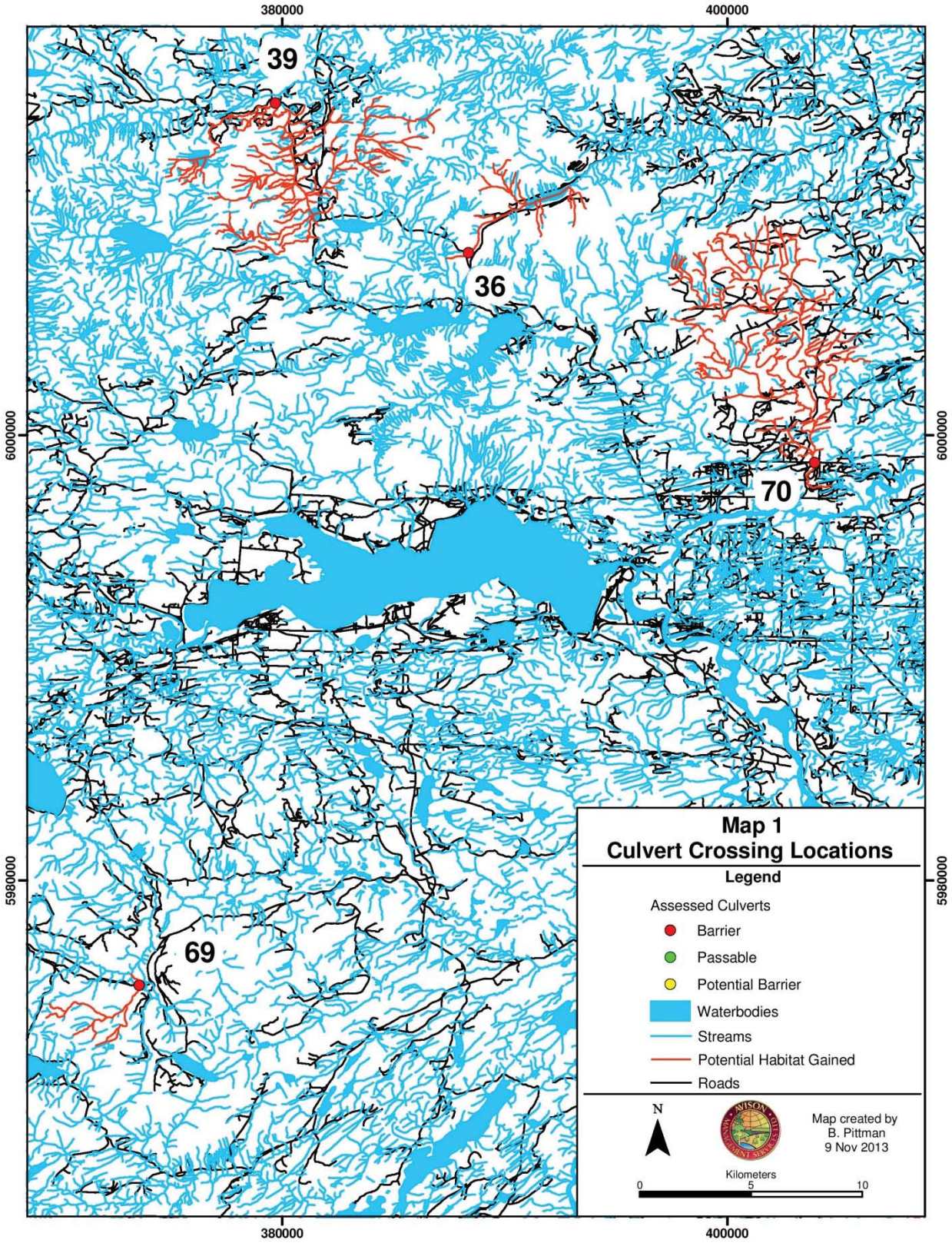
Ecofor Consultants. 2012. Off-Site Compensation Options in the Vanderhoof Forest District, Blackwater Gold Project. Draft Report Version 1.0. Prepared for New Gold Inc. Project No.: 2012-2071-21

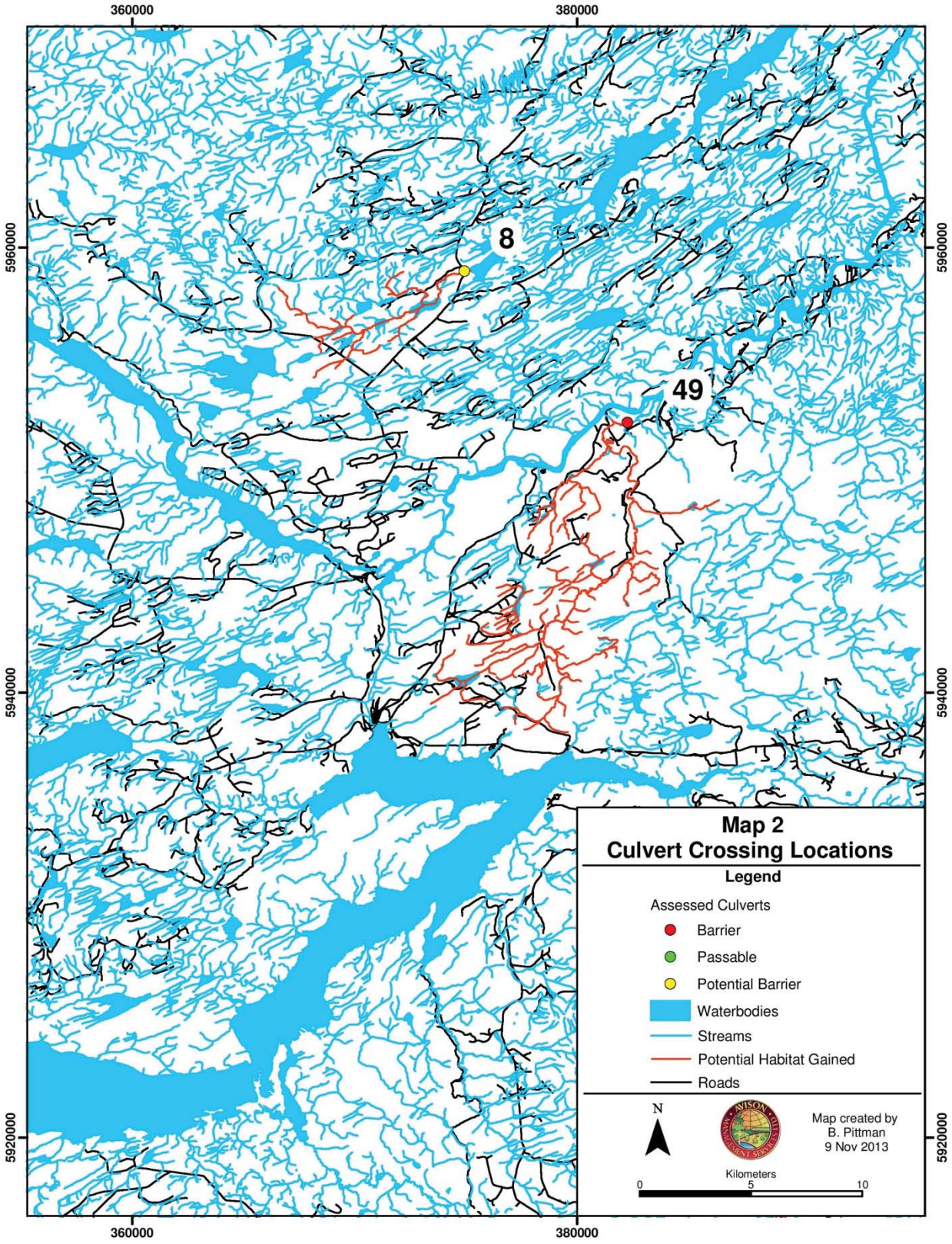
B.C. Ministry of Environment. 2009. Field assessment for fish passage determination of closed bottomed structures, 3rd edition. Victoria, B.C. http://www.for.gov.bc.ca/ftp/hcp/external/!publish/web/fia/Field_Protocol.pdf (Accessed October 2013).

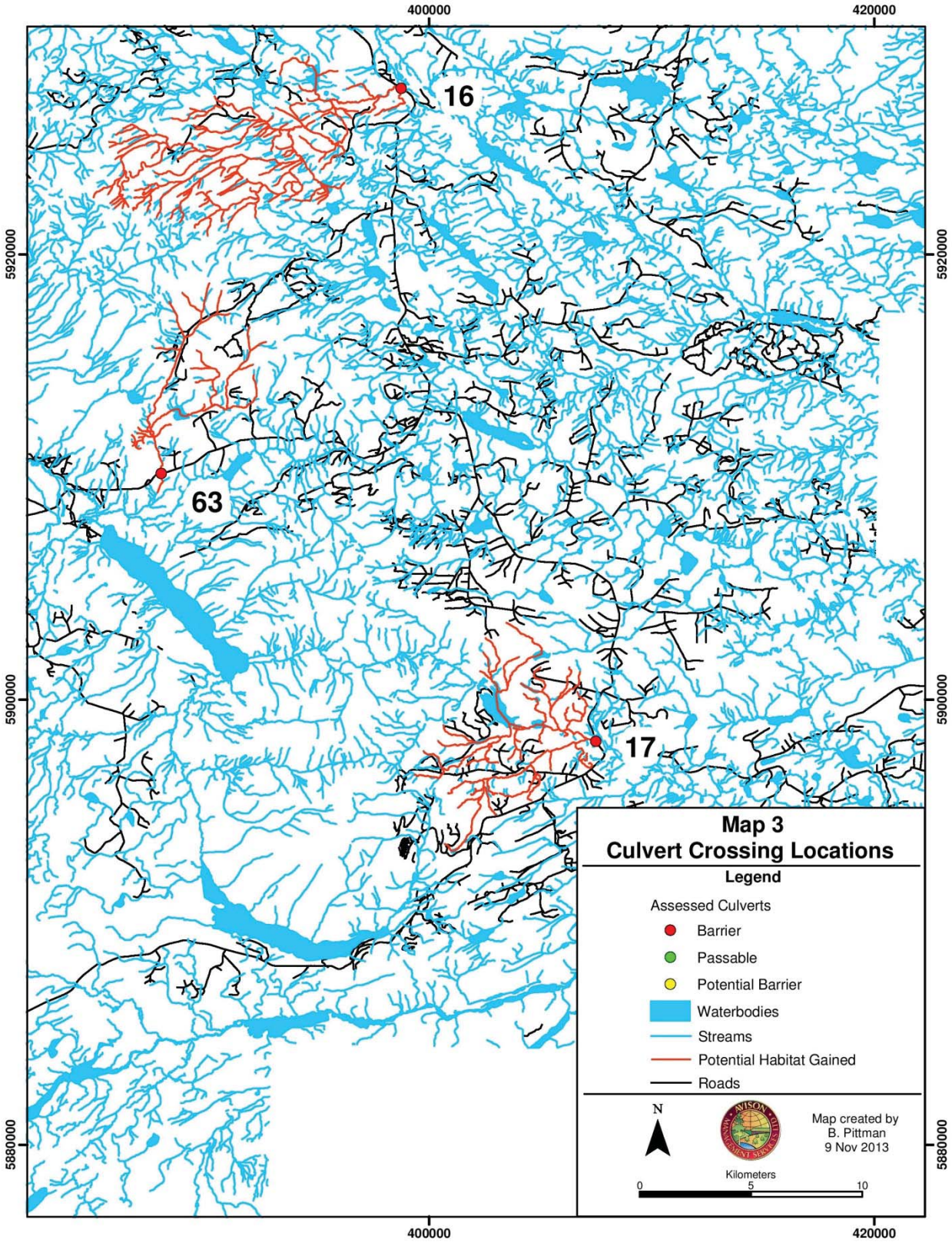
APPENDIX I

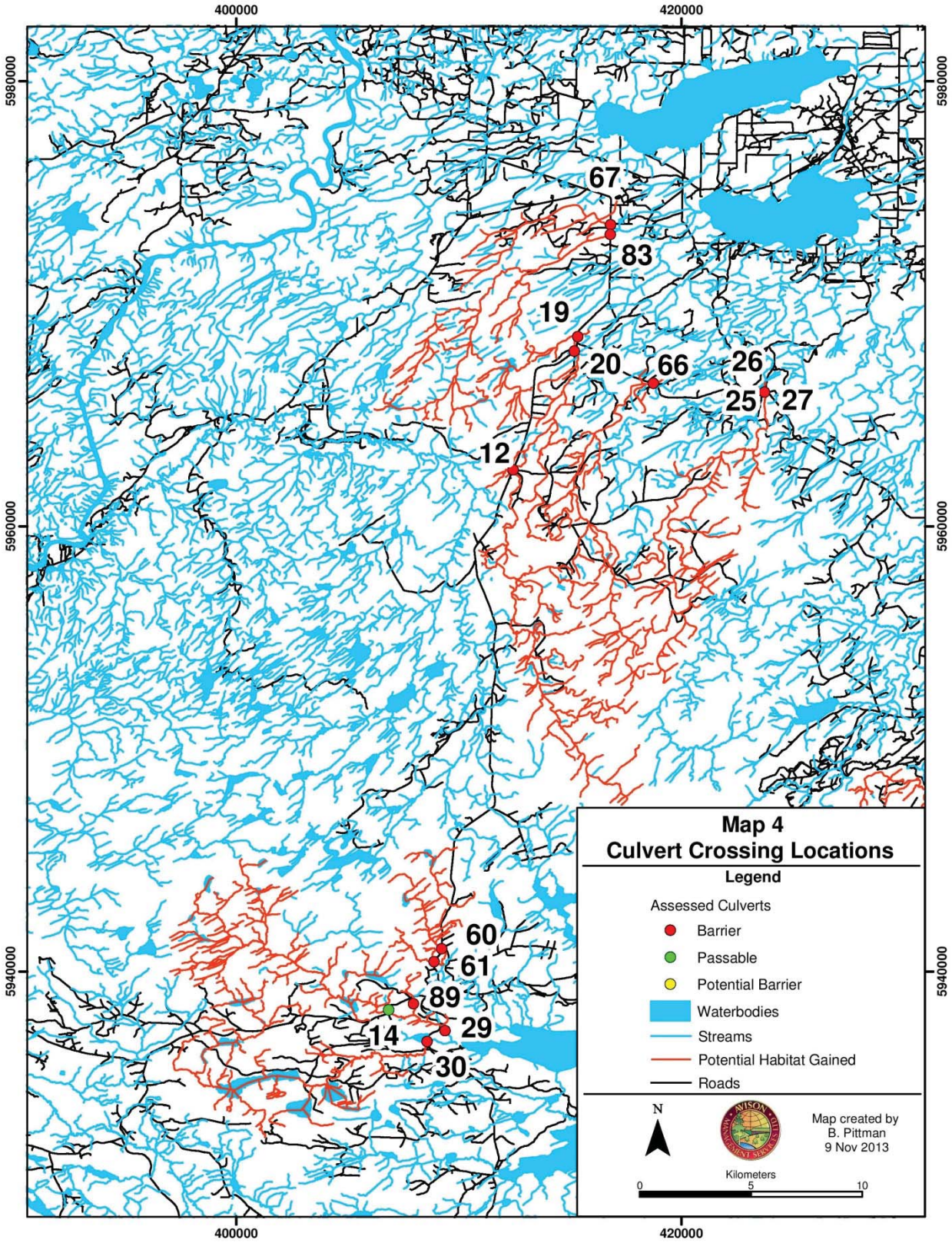
CULVERT ASSESSMENT MAPS

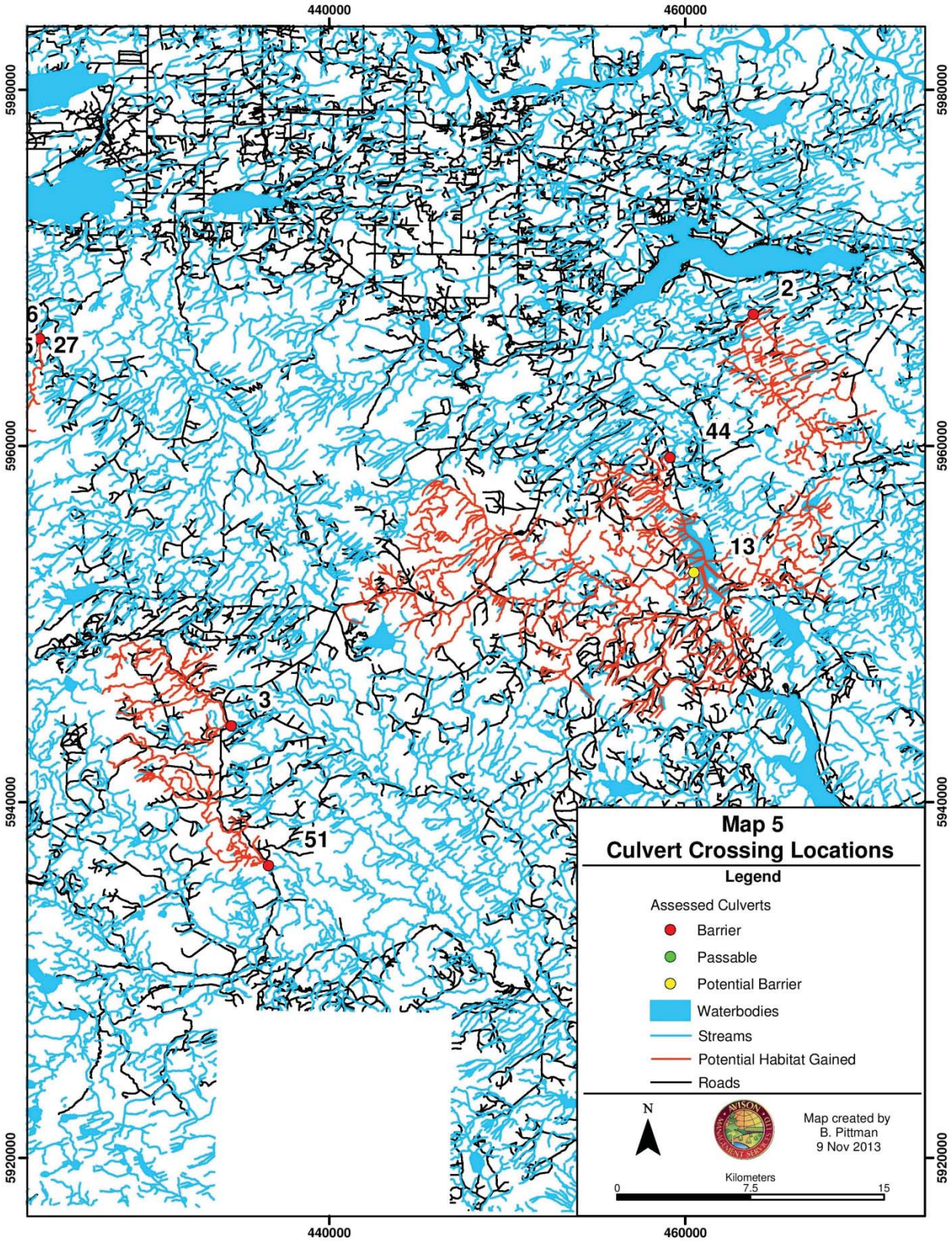

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Overview Map of Culverts Assessed for Fish Passage Nov 2013
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Map created by B. Pittman 9 Nov 2013


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Culvert Crossing Locations
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B. Pittman
9 Nov 2013
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Map 2
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Culvert Crossing Locations
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Map 5
Culvert Crossing Locations
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B. Pittman
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APPENDIX II

CULVERT ASSESSMENT DATA TABLES

Table 2: Site Location and Overview Information

Site ID	Date of Assessment (MM-DD-YY)	Crew	UTM Zone	Easting	Northing	Stream Name	Road Name	Road KM Mark	Road Tenure
2	1-Nov-13	CM,CC	10	463818	5967403	Norman Creek	Bobtail Lake FSR	22.50	FSR
3	1-Nov-13	CM,CC	10	434491	5944268		Bobtail Lake Connector	66.50	FSR
8	1-Nov-13	BP,OA	10	374923	5958945	Targe Creek	Holy Cross FSR		FSR
12	31-Oct-13	CM,CC	10	412440	5962541		Kluzkuz FSR	34.00	FSR
13	1-Nov-13	CM,CC	10	460476	5952894	Cluculz Creek	Bobtail Lake FSR	11.50	FSR
16	31-Oct-13	BP,OA	10	398740	5927463	Big Bend Creek	Kluzkuz FSR	84.00	FSR
17	31-Oct-13	BP,OA	10	407485	5898122	Suscha Creek	Kluzkuz-Blue FSR		FSR
19	31-Oct-13	CM,CC	10	415341	5968528		Kluzkuz FSR	26.50	FSR
20	31-Oct-13	CM,CC	10	415185	5967875		Kluzkuz FSR	27.00	FSR
25	31-Oct-13	CM,CC	10	423730	5966028	Corkscrew Creek	Corkscrew FSR		FSR
26	31-Oct-13	CM,CC	10	423730	5966028	Corkscrew Creek	Corkscrew(Gold) FSR		FSR
27	31-Oct-13	CM,CC	10	423730	5966028	Corkscrew Creek	Corkscrew(Gold) FSR		FSR
29	31-Oct-13	CM,CC,BP,OA	10	409378	5937340		Lavoie-Gold Road FSR		FSR
30	31-Oct-13	CM,CC,BP,OA	10	408572	5936852	Finger Creek	Lavoie-Gold Road FSR		FSR
36	1-Nov-13	BP,OA	10	388362	6008206	Angly Creek	Sutherland FSR		FSR
39	1-Nov-13	BP,OA	10	379689	6014933	Duncan Creek	Trout FSR		FSR
44	1-Nov-13	CM,CC	10	459130	5959354	Cluculz Creek	Blackwater Road	5.50	Highways
49	1-Nov-13	BP,OA	10	382246	5952140		Kenny Dam Road		Highways
51	1-Nov-13	CM,CC	10	436580	5936420		Otter FSR	9.00	FSR
60	31-Oct-13	CM,CC	10	409226	5941021	Cabin Creek	Kluskus FSR	56.75	FSR
61	31-Oct-13	CM,CC	10	408884	5940443	Trib to Cabin ck	Kluskus FSR	57.25	FSR
63	31-Oct-13	BP,OA	10	373572	5975394	Trib to Chedakuz ck	Kluskus FSR	113.00	FSR
66	31-Oct-13	CM,CC	10	418737	5966429	Trib to Corkscrew ck	Corkscrew FSR	4.50	FSR
67	1-Nov-13	CM,CC	10	416816	5973555	Trib to Nulki lk	Kluskus FSR	20.50	FSR
69	1-Nov-13	BP,OA	10	373572	5975294		Holy Cross-Binta FSR	227.50	FSR
70	1-Nov-13	BP,OA	10	403917	5998799	Nine Mile	Settlement Road		FSR

						Creek			
83	31-Oct-13	BP,OA	10	416805	5973117		Kluskus FSR	21	FSR
89	31-Oct-13	BP,OA	10	407960	5938545		Kluskus FSR		FSR

Table 3: Field Observations and Assessment Measurements

Site ID	Crossing Type	Crossing Subtype	Diam. (m)	Length (m)	Cont. Emb.	Av. D. E. (m)	Res. Ch.	BW (%)	Fill D. (m)	OD (m)	OPD (m)	In. D. (m)	Culvert Slope (%)
2	CBS	RC	1.84	15.30	No		No	0.00	2.10	0	0.64	No	2
3	CBS	RC	2	20.80	No		No	0.00	3.40	0.11	0.27	No	1
8	CBS	RC	2.00	12.10	No		No	0.00	3.00	0	0.10	No	1
12	CBS	RC	4.10	19.00	No		No	0.00	0.50	0	0.49	No	1
13	CBS	RC	4.70	21.50	Yes	0.06	Yes	0.00	0.36	0	0.36	No	2
16	CBS	RC	1.78	24.50	No		No	0.00	1.50	0	0.38	No	1
17	CBS	RC	1.80	12.50	No		No	0.00	0.60	0.43	0.62	Yes	3
19	CBS	RC	2.00	20.90	No		No	0.00	0.55	0	0.22	No	2
20	CBS	RC	1.72	18.70	No		No	100.00	0.60	0	0.33	No	1
25	CBS	RC	1.83	16.10	No		No	0.00	0.37	0	0.18	No	2
26	CBS	RC	1.83	16.10	No		No	0.00	0.37	0	0.18	No	2
27	CBS	RC	1.83	16.10	No		No	0.00	0.37	0	0.18	No	2
29	CBS	RC	3.03	21.15	No		No	30.00	1.64	0	0.64	No	2
30	CBS	RC	1.58	21.56	No		No	0.00	1.74	0.17	0.52	No	3
36	CBS	RC	1.48	27.10	No		No	0.00	9.99	0.27	0.36	No	4
39	CBS	RC	2.60	24.35	No		No	40.00	2.50	0	0.90	No	2
44	CBS	RC	2.40	24.80	No		No	0.00	2.30	0.51	0.27	No	1
49	CBS	RC	1.90	12.00	No		No	0.00	0.35	0	0.44	No	1
51	CBS	RC	1.17	10.00	No		No	0.00	0.40	0.12	0.27	No	2
60	CBS	RC	1.51	22.60	No		No	0.00	0.89	0.24	0.48	No	0
61	CBS	RC	0.62	26.60	No		No	100.00	3.90	0.475	0.47	No	1
63	CBS	RC	1.52	24.70	No		No	0.00	4.30	0	0.33	No	4
66	CBS	RC	1.40	11.50	No		No	100.00	0.34	0	0.53	No	1
67	CBS	RC	0.93	17.00	No		No	0.00	2.20	0		No	1
69	CBS	RC	2.20	37.00	No		No	0.00	3.00	1.61	0.19	No	2
70	CBS	RC	1.59	12.10	No		No	0.00	0.40	0.45	1.14	No	1
83	CBS	RC	1.56	22	No		No	0.00	1.6	0	0.85	No	3
89	CBS	RC	0.94	75	No		No	0.00	10	0		No	6

Notes: CBS = Closed-Bottomed Culvert; RC = Round Culvert; Diam. = Diameter; Cont. Emb. = presence/absence of continuous embeddedment; Av. D. E. = average depth of embeddedment if present; Res. Ch. = does crossing bottom resemble channel; BW = backwatering, values of 0 indicate no backwatering; Fill D. = fill depth; OD = outlet drop; OPD = outlet pool depth; In.D. = presence/absence of an inlet drop.

Table 4: Stream Information

Site ID	ACW (m)	Stream Slope (%)	Beaver Activity	Fish Obs.	Valley Fill	Habitat Value
2	2.40	2.5	Yes	No	Deep Fill	Medium
3	4.88	3.5	No	Yes	Deep Fill	Medium
8	2.29	1.5	No	No	Deep Fill	Medium
12	4.90	3	No	No	Shallow Fill	Medium
13	6.70	3.5	No	No	Shallow Fill	Medium
16	5.75	1.5	Yes	No	Deep Fill	High
17	3.15	3	No	Yes	Shallow Fill	High
19	2.35	3	No	No	Shallow Fill	Medium
20	2.60	2	Yes	No	Shallow Fill	Medium
25	4.30	4.5	No	No	Shallow Fill	Medium
26	4.30	4.5	No	No	Shallow Fill	Medium
27	4.30	4.5	No	No	Shallow Fill	Medium
29	4.53	3.5	No	Yes	Shallow Fill	Medium
30	4.80	2.5	No	No	Deep Fill	Medium
36	3.30	4	No	No	Deep Fill	High
39	4.65	1.5	No	Yes	Deep Fill	High
44	8.68	3	No	No	Shallow Fill	Medium
49	4.30	1	Yes	No	Deep Fill	High
51	4.40	4	No	No	Shallow Fill	Medium
60	2.10	1.5	No	No	Shallow Fill	Medium
61	0.94	1.5	No	No	Deep Fill	Low
63	2.88	2	No	No	Deep Fill	High
66	3.89	2	Yes	No	Shallow Fill	Medium
67	1.70	1	No	No	Deep Fill	Low
69	2.30	4	No	No	Deep Fill	High
70	5.10	2	Yes	No	Deep Fill	High
83	2.2	2	No	No	Deep Fill	High
89	0.98	6.5	No	No	Deep Fill	Low

Note: ACW = average channel width

Table 5: Additional measurements and comments

Site ID	Assessment Comment	Water level in culvert (m)	Dark rust high water line (m)	Yellow high water line (m)	Signs of severe erosion	Signs of channel degradation	Signs of very high water levels at inlet (if culvert is suspected to be undersized)	Fish habitat description	Potential habitat use by fish species documented to be present.
2	1-2 cm of ice on water surface. Some blockage @ culvert inlet due to beaver activity as well as metal grate.	0.41	0.9	0.98			Currently flooded due to beaver activity so other high water signs cannot be seen if they are there.	V. fine substrate so poor spawning. Lots of cover for rearing juveniles with an abundance of instream vegetation.	
3	2 culverts, one lower by ~20cm. Stagnant water in higher culvert (little to no flow)	0.32	0.57	0.67				Cobble substrate with some gravels. Low water stage. Good cover from willow, alder, and woody debris. Good flow, some deep pools.	Moderate spawning and rearing. Potential o/w downstream.
8	no outlet pool. River otter found in trap @ outlet of culvert. Woody and wire fence debris stuck in middle of culvert.	0.245	0.935	1.175				Overall good fish habitat. Gravels present throughout with moderate spawning suitability. Lots of cover so great rearing habitat.	

12	Higher gradient and faster flow of water u/s going into culvert than coming out of it.	0.29	0.665	0.69		Mostly cobble substrate with some gravels. Decent amount of cover from overhanging veg, some big boulders @ outlet. Really good flow with medium water stage.	Poor spawning, excellent rearing, and good OW. Lots of cover, great flow, good water levels
13		0.45	0.67	0.69		Cobble/gravel substrate with boulders throughout. Good cover from woody debris, alder, willow, and surrounding coniferous forest. High water velocities with medium water stage.	poor spawning, good rearing and overwintering.
16	Beaver damming seen within culvert and throughout reach. ~10m d/s is a beaver dam shaping outlet pool. 3 culverts at crossing, lowest one used for measurements.	0.64	0.69	0.83	Wide pool @ inlet. Wetted width here is ~10m which is 4m greater than average channel width	Lots of cover, plenty of functional LWD and deeper pools. Gravels suitable for spawning seen in some spots.	Rearing and spawning

17	Two culverts. Only lower one has water flowing through it. Outlet drop and Unembeddedness alone create fish passage barrier.	0.16	0.31	0.47	Some small rip-rap placed u/s of inlet. Could have been done to prevent further channel deg and increasing the inlet drop size.		Good rearing stream. Marginal/moderate spawning gravels. No instream overwintering hab. b/ stream has direct connectivity to Euchiniko Lake d/s and Suscha Lake u/s.	RB and LSU documented u/s and d/s of culvert.
19	lots of deadfall and debris near culvert inlet and in surrounding area.	0.16	0.43	0.495			Gravel/cobble substrate throughout with lots of cover from sedge and other veg. Good flow. Still moderate water stage.	ok spawning. Good rearing. Marginal OW because of lack of deep pools.
20	Beaver dam throughout reach and inside culvert. Channel widths highly variable due to beaver activities.	ns	ns	ns		unable to tell due to beaver activity	v. fine substrate. Lots of cover from overhanging veg (sedge and alder) and functional woody debris from beaver activity.	Poor spawning, moderate rearing. Marginal instream OW.
25	3 culverts all similar height but the lowest (by about 10cm) used for measurements. Slight debris jam at culvert inlet.	0.25	0.565	0.69			Cobble substrate with some gravels. Good flow and moderate cover from overhanging veg and some woody debris.	ok spawning. Good rearing. Ok o/w.

26	3 culverts all similar height but the lowest (by about 10cm) used for measurements. Slight debris jam at culvert inlet.	0.25	0.565	0.69		Cobble substrate with some gravels. Good flow and moderate cover from overhanging veg and some woody debris.	ok spawning. Good rearing. Ok o/w.
27	3 culverts all similar height but the lowest (by about 10cm) used for measurements. Slight debris jam at culvert inlet.	0.25	0.565	0.69		Cobble substrate with some gravels. Good flow and moderate cover from overhanging veg and some woody debris.	ok spawning. Good rearing. Ok o/w.
29	d/s wider and gentler slope. u/s much more narrow.	0.1	0.57	0.67		Good flow. Lots of cover (boulders and woody debris). Gravels dominate substrate. Medium water stage.	Good spawning and rearing habitat to be reclaimed if this culvert is fixed.
30	2 culverts crossing an angle under rd. Same size, one is ~30cm lower. Stream runs along road d/s of crossing -> culvert placement may have been an issue.	0.1	0.545	0.66		tons of cover from veg and woody debris. Cobble and moss throughout channel. Mostly fines and cobbles. Lakes u/s and waterfalls so potentially limiting connectivity.	very good rearing. Poor spawning. Instream OW nil. Rainbow sightings documented u/s.

36	Two culverts. Smaller culver higher than larger w/ no water flow. Very nice stream with great habitat and there is a lake u/s	0.19	0.38	0.62			Great fish stream. Gravels suitable for spawning, plenty of cover, and direct connectivity to u/s lake.	Spawning, rearing, and overwintering potential high at this site.
39	Large outlet pool which appears to have been made larger by erosional processes. See picture of culvert outlet	0.25	0.82	1.2	Bank erosion noticed on banks at culvert outlet. Road material is being eroded into stream.		gravel cobble substrate, moderate cover, trace overwintering.	Good spawning habitat, fair rearing habitat, and poor overwintering.
44	2 culverts. One slightly lower than the other. The higher one is dry.	0.27	0.94	0.95	Some undercutting and bank erosion.	large pools u/s and d/s of culvert. Could be due to only one of the two culverts at the crossing with flowing water.	Gravel/cobble substrate. Moderate water level. Lots of cover from willow, sedges, and woody debris. V. deep outlet pool and other deep pools throughout.	Good spawning, rearing, and overwintering throughout surveyed reach.
49	4 culverts. One with notable flow. Two others with minimal flow. One with no flow. Dominant culvert is crushed and diameter represents widest opening for culvert in crushed state.	0.49	0.59	0.61	road material is eroding off into stream where the culvert is located.	mechanical removal of beaver construction and the presence of a newer 4th culvert indicate that inlet flooding has been an issue.	Nice S3 stream with plenty of cover. Surveyed reach has little to no gravels. Direct tributary to the Nechako river.	Good rearing habitat to be reclaimed if this culvert is fixed.

51	2 culverts. Small logjam at culvert inlet. Culverts nearly same height, one several cm lower.	0.15	0.46	0.55			Cobble dom. Boulders and gravels present too. Lots of overhanging veg and some woody debris. Medium water stage with good flows.	ok spawning, good rearing
60		0.15	0.56	0.62			lots of cover (overhanging veg, instream veg, and woody debris) Some deep pools. Mostly cobble substrate with some fines.	good spawning, great rearing, moderate OW (some deep pools)
61	Tons of backwatering. Culvert broken on d/s side of crossing. Huge outlet drop and d/s of crossing the channel is narrower than the reach u/s of the crossing.	0.03	0.17	0.18		entire area around inlet is flooded. Culvert is far too small for the amount of water in the area.	lots of cover. Gravel dom substrate.	Good spawning and rearing habitat to be reclaimed if this culvert is fixed.

63	Culvert boughs in middle from road compaction. Bank erosion indicates potential freshet velocity barrier with this high gradient culvert.	0.26	0.68	0.76	at outlet there is evidence of past bank erosion on both banks (see pic 645). It appears to happen during freshet when the top culvert has water flowing through it.			Gravel/cobble substrate. Plenty of cover. Trace deep pools.	good spawning and rearing stream.
66	2 culverts, 0.4m height difference between the two. Beaver dam inside higher culvert and another ~7m d/s of crossing. Entire area appears flooded.	ns	ns	ns		difficult to tell with flooding from beaver dam		u/s: wetland type with fine substrate with sedges surrounding stream. d/s: gravel/cobble substrate with lots of woody debris and overhanging veg	very good rearing stream, but spawning habitat unknown as u/s of the crossing is wetland type while d/s of crossing has spawning habitat. Fair overwintering.
67	Channel dry at time of survey. Private property on both sides of the crossing and bordered by fencing.	dry	0.13	0.2	v. undercut banks			cobble substrate (some gravels) with good cover	dry stream. If it had water it would have good rearing and fair spawning.

69	Outlet drop and culvert length make for a definite barrier.	0.07	0.2	0.29		gravels and cobble present, but very low flows. Moderate cover in overhanging veg	some rearing hab to be gained, but no spawning or overwintering habitat to be gained
70	2 culverts @ crossing. Lower one measured. Both overhanging @ outlet. Signs of beaver and cattle activity noted in immediate area surrounding stream crossing.	0.31	0.68	0.79		lots of cover (overhanging veg and instream woody debris) mostly fine substrate with occasional gravels	Good rearing habitat, poor spawning habitat, and no overwintering habitat
83	S3	0.12	0.39	0.83	Some erosion from road on d/s end of crossing. Risk of road material making its way into stream see pic 662	gravels are dominant substrate type. Plenty of cover.	good rearing and spawning habitat.
89	V. long culvert on small S4 with marginal fish habitat. Length of culvert alone creates migration barrier.	0.03	0.12	0.26		v. low water stage. Moderate amount of cover. No deep pools.	overall poor fish habitat.

Table 6: Scoring Data

Site ID	SWR	Culvert Length Score	Embed Score	Outlet Drop Score	Culvert Slope Score	SWR Score	Final Score	Barrier Result
2	1.30	3	10	0	5	6	24	Barrier
3	2.44	3	10	0	5	6	24	Barrier
8	1.15	0	10	0	5	3	18	Potential
12	1.20	3	10	0	5	3	21	Barrier
13	1.43	3	5	0	5	6	19	Potential
16	3.23	3	10	0	5	6	24	Barrier
17	1.75	0	10	10	10	6	36	Barrier
19	1.18	3	10	0	5	3	21	Barrier
20	1.51	3	10	0	5	6	24	Barrier
25	2.35	3	10	0	5	6	24	Barrier
26	2.35	3	10	0	5	6	24	Barrier
27	2.35	3	10	0	5	6	24	Barrier
29	1.50	3	10	0	5	6	24	Barrier
30	3.04	3	10	5	10	6	34	Barrier
36	2.23	3	10	5	10	6	34	Barrier
39	1.79	3	10	0	5	6	24	Barrier
44	3.62	3	10	10	5	6	34	Barrier
49	2.26	0	10	0	5	6	21	Barrier
51	3.76	0	10	0	5	6	21	Barrier
60	1.39	3	10	5	0	6	24	Barrier
61	1.52	3	10	10	5	6	34	Barrier
63	1.89	3	10	0	10	6	29	Barrier
66	2.78	0	10	0	5	6	21	Barrier
67	1.83	3	10	0	5	6	24	Barrier
69	1.05	6	10	10	5	3	34	Barrier
70	3.21	0	10	10	5	6	31	Barrier
83	1.41	3	10	0	10	6	29	Barrier
89	1.04	6	10	0	10	3	29	Barrier

SWR = stream width ratio = (average channel width)/(culvert diameter)

APPENDIX III

CULVERT ASSESSMENT PHOTODOCUMENTATION

Photodocumentation – Site 2



Roll BP31 - #547: upstream shot from inlet



Roll BP31 - #544: inlet pool and culvert inlet



Roll BP31 - #548: downstream shot from outlet



Roll BP31 - #544: outlet pool and culvert outlet



Roll BP31 - #550: culvert barrel

Photodocumentation – Site 3



Roll BP31 - #565: upstream shot from inlet



Roll BP31 - #566: inlet pool and culvert inlet



Roll BP31 - #567: downstream shot from outlet



Roll BP31 - #569: outlet pool and culvert outlet



Roll BP 31 - #569: culvert barrel

Photodocumentation – Site 8



Roll OA1 - #671: upstream shot from inlet



Roll OA1 - #672: inlet pool and culvert inlet



Roll OA1 - #675: downstream shot from outlet



Roll OA1 - #676: outlet pool and culvert outlet



Roll OA1 - #673: culvert barrel

Photodocumentation – Site 12



Roll CM - #18: upstream shot from inlet



Roll CM - #19: inlet pool and culvert inlet



Roll CM - #15: downstream shot from outlet



Roll CM - #16: outlet pool and culvert outlet



Roll CM - #17: culvert barrel

Photodocumentation – Site 13



Roll BP31 - #560: upstream shot from inlet



Roll BP31 - #561: inlet pool and culvert inlet



Roll BP31 - #564: downstream shot from outlet



Roll BP31 - #563: outlet pool and culvert outlet



Roll BP31 - #562: culvert barrel

Photodocumentation – Site 16



Roll OA1 - #641: upstream shot from culvert inlet



Roll OA1 - #640: inlet pool and culvert inlet



Roll OA1 - #637: downstream shot from outlet



Roll OA1 - #638: outlet pool and culvert outlet



Roll OA1 - #639: culvert barrel

Photodocumentation – Site 17



Roll OA1 - #648: upstream shot from inlet



Roll OA1 - #649: inlet pool and culvert inlet



Roll OA1 - #650: downstream shot from outlet



Roll OA1 - #651: outlet pool and culvert outlet



Roll OA1 - #647: culvert barrel

Photodocumentation – Site19



Roll CM - #34: upstream shot from inlet



Roll CM - #35: inlet pool and culvert inlet



Roll CM - #32: downstream shot from outlet



Roll CM - #31: outlet pool and culvert outlet



Roll CM - #33: culvert barrel

Photodocumentation – Site 20



Roll CM - #24: upstream shot from inlet. Note beaver damming directly u/s of culvert



Roll CM - #25: upstream shot from inlet. Note amount of flooding as a result of beaver activities



Roll CM - #29: inlet pool and culvert inlet



Roll CM - #22: downstream shot from outlet

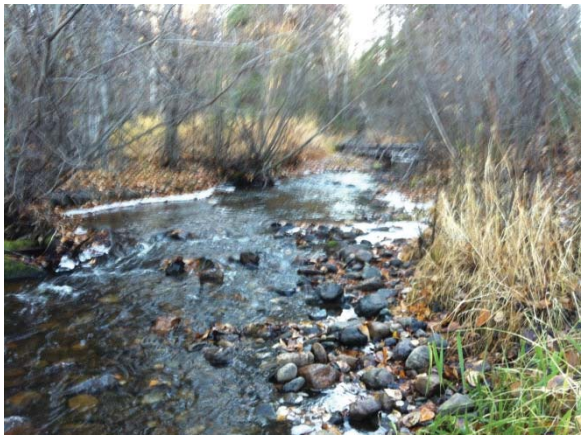


Roll CM - #21: outlet pool and culvert outlet



Roll CM - #23: culvert barrel with significant debris jam built by beavers

Photodocumentation – Site 25, 26, 27



Roll CM - #46: upstream shot from inlet



Roll CM - #45: inlet pool and culvert inlet



Roll CM - #42: downstream shot from outlet



Roll CM - #43: outlet pool and culvert outlet



Roll CM - #44: culvert barrel

Photodocumentation – Site 29



Roll CM - #2: upstream shot from inlet



Roll CM - #3: inlet pool and culvert inlet



Roll BP31 - #542: downstream shot from outlet



Roll BP31 - #541: outlet pool and culvert outlet



Roll BP31 - #543: culvert barrel

Photodocumentation – Site 30



Roll BP31 - #536: upstream shot from inlet



Roll BP31 - #537: inlet pool and culvert inlet



Roll BP31 - #539: downstream shot from outlet



Roll BP31 - #540: outlet pool and culvert outlet



Roll BP31 - #538: culvert barrel

Photodocumentation – Site 36



Roll OA1 - #687: upstream shot from inlet



Roll OA1 - #688: inlet pool and culvert inlet



Roll OA1 - #691: downstream shot from outlet



Roll OA1 - #690: outlet pool and culvert outlet



Roll OA1 - #689: culvert barrel

Photodocumentation – Site 39



Roll OA1 - #682: upstream shot from inlet



Roll OA1 - #683: inlet pool and culvert inlet



Roll OA1 - #686: downstream shot from outlet



Roll OA1 - #685: outlet pool and culvert outlet. Note erosion on right bank



Roll OA1 - #684: culvert barrel

Photodocumentation – Site 44



Roll BP31 - #551: upstream shot from inlet



Roll BP31 - #552: inlet pool and culvert inlet



Roll BP31 - #554: downstream shot from outlet



Roll BP31 - #555: outlet pool and culvert outlet



Roll BP31 - #553: culvert barrel



Roll BP31 - #557: bank erosion found on left bank of outlet pool.

Photodocumentation – Site 49



Roll OA1 - #668: upstream shot from inlet



Roll OA1 - #667: inlet pool and culvert inlet



Roll OA1 - #664: downstream shot from outlet



Roll OA1 - #665: outlet pool and culvert outlet



Roll OA1 - #666: culvert barrel



Roll OA1 - #669: culvert outlet for 4th culvert found at crossing. This culvert drains flood water due to beaver activity.

Photodocumentation – Site 51



Roll BP31 - #573: upstream shot from inlet



Roll BP31 - #574: inlet pool and culvert inlet



Roll BP31 - #575: downstream shot from outlet



Roll BP - #576: outlet pool and culvert outlet



Roll BP31 - #577: culvert barrel

Photodocumentation – Site 60



Roll CM - #13: upstream shot from inlet



Roll CM - #14: inlet pool and culvert inlet



Roll CM - #10: downstream shot from outlet



Roll CM - #11: outlet pool and culvert outlet



Roll CM - #12: culvert barrel

Photodocumentation – Site 61



Roll CM - #6: upstream shot from inlet. Lots of flooding because culvert set too high



Roll CM - #7: culvert inlet. Culvert is set too high to accommodate flows



Roll CM - #5: downstream shot from outlet



Roll CM - #4: outlet pool and culvert outlet



Roll CM - #8: culvert barrel

Photodocumentation – Site 63



Roll OA1 - #642: upstream shot from inlet



Roll OA1 - #644: inlet pool and culvert inlet



Roll OA1 - #646: downstream shot from outlet



Roll OA1 - #645: outlet pool and culvert outlet



Roll OA1 - #643: culvert barrel

Photodocumentation – Site 66



Roll CM - #36: upstream shot from inlet



Roll CM - #37: inlet pool and culvert inlet



Roll CM - #39: downstream shot from outlet



Roll CM - #40: outlet pool and culvert outlet



Roll CM - #38: culvert barrel



Roll CM - #41: beaver activity downstream of culvert crossing

Photodocumentation – Site 67



Roll BP31 - #578: upstream shot from inlet



Roll BP31 - #579: culvert inlet



Roll BP31 - #580: downstream shot from outlet



Roll BP31 - #581: culvert outlet



Roll BP31 - #582: culvert barrel

Photodocumentation – Site 69



Roll OA1 - #677: upstream shot from inlet



Roll OA1 - #678: inlet pool and culvert inlet



Roll OA1 - #681: downstream shot from outlet



Roll OA1 - #680: culvert outlet



Roll OA1 - #679: culvert barrel

Photodocumentation – Site 70



Roll OA1 - #692: upstream shot from inlet



Roll OA1 - #693: inlet pool and culvert inlet



Roll OA1 - #696: downstream shot from outlet



Roll OA1 - #695: outlet pool and culvert outlet



Roll OA1 - #694: culvert barrel

Photodocumentation – Site 83



Roll OA1 - #659: upstream shot from inlet



Roll OA1 - #661: inlet pool and culvert inlet



Roll OA1 - #663: downstream shot from outlet



Roll OA1 - #662: outlet pool and culvert outlet



Roll OA1 - #660: culvert barrel

Photodocumentation – Site 89



Roll OA1 - #652: upstream shot from inlet



Roll OA1 - #653: inlet pool and culvert inlet



Roll OA1 - #655: downstream shot from outlet



Roll OA1 - #656: outlet pool and culvert outlet



Roll OA1 - #654: culvert barrel



Roll OA1 - #658: wide angle shot of culvert outlet to show large fill depth

Annex L
Fish Habitat Offsetting Opportunities in Swanson Creek

PALMER
ENVIRONMENTAL
CONSULTING
GROUP INC.

*475 Howe Street, Suite 1030, Vancouver, BC V6C 2B3 **t** 604-629-9075*

December 2, 2013

Brett McLeod
Fisheries Biologist
AMEC Environment & Infrastructure
Suite 600, 4445 Lougheed Highway
Burnaby, BC V5C 0E4

Dear Mr. McLeod,

Re: Blackwater Project – Fish Habitat Compensation Opportunities along Swanson Creek

Palmer Environmental Consulting Group Inc. is pleased to submit the attached final letter report summarizing fish habitat opportunities along Swanson Creek, in support of the Fish Habitat Mitigation and Compensation Plan being prepared by AMEC Environment & Infrastructure for New Gold's proposed Blackwater Project.

This document provides an overview of channel morphology and the fish habitat and community along lower Swanson Creek, documents the condition and effectiveness of previous restoration efforts, and identifies additional valuable opportunities for fish habitat compensation through habitat restoration and enhancement.

If you or technical reviewers have any questions, please feel free to contact Robin McKillop or Rick Palmer at 604-629-9075.

We appreciate the opportunity to work with you on this interesting project.

Yours truly,

Palmer Environmental Consulting Group Inc.

Robin McKillop, M.Sc., P.Geo.
Senior Habitat Restoration Specialist

Rick Palmer, M.Sc., R.P.Bio.
President, Senior Fisheries Biologist

Introduction

AMEC Environment & Infrastructure (AMEC) is developing a Fish Habitat Mitigation and Compensation Plan (FHMCP) in support of New Gold's proposed Blackwater Project, in central British Columbia. One of the compensation opportunities that has been identified is the restoration and enhancement of Swanson Creek, a productive tributary of Nechako River that is recovering slowly from both natural and anthropogenic disturbances. In support of its FHMCP, AMEC retained Palmer Environmental Consulting Group Inc. (PECG) to conduct field reconnaissance along lower Swanson Creek and provide a preliminary overview of fish habitat compensation opportunities.

Swanson Creek was first identified as a candidate for habitat restoration through Fish Habitat Assessment Procedure (FHAP) surveys conducted as part of the British Columbia Watershed Restoration Program (WRP) by ARC Environmental Ltd. (ARC), with support from Triton Environmental Consultants Ltd., in the fall of 1996 (ARC, 1998). The 1999-2000 annual report on aquatic rehabilitation projects made possible through the WRP describes the work completed, including installation of large woody debris structures along the main channel and habitat enhancement along two groundwater-fed side channels (Underhill, 2000). In its community fisheries profile, Saik'uz First Nation reiterates the importance of past (and future) restoration efforts along Swanson Creek for the Nechako River fishery (Upper Fraser Fisheries Conservation Alliance, 2009). In October 2013, representatives from PECG, New Gold and Saik'uz First Nation completed field reconnaissance along Swanson Creek to examine previous restoration works and identify additional fish habitat compensation opportunities.

This document characterizes the channel morphology, fish habitat and fish community of Swanson Creek, documents the condition and effectiveness of previous restoration efforts, and identifies additional valuable opportunities for fish habitat compensation through habitat restoration and enhancement.

Overview of Swanson Creek

Swanson Creek has an important role in supporting the Nechako River fishery, based on historical presence of rainbow trout, Chinook salmon and mountain whitefish (Tredger, 1985; Envirocon, 1984; NFCP, unpublished). With no documented spawning in Nechako River itself, production must come from tributaries such as Swanson Creek, portions of which are suitable for spawning and rearing (ARC, 1998). Numerous rainbow trout were captured during sampling in the fall of 1996, including young-of-the-year, as well as in the summer of 1997 (ARC, 1998). More than 25 rainbow trout were observed near the entrance to a side channel by PECG during field reconnaissance in October 2013. Saik'uz First Nation notes an important coexistence of the three main fish species that utilize the Nechako River tributaries, including Swanson Creek: Chinook salmon spawn in Nechako River in fall, then, after emergence in the spring, rear in the lower reaches of the tributaries; rainbow trout spawn in the spring in the upper reaches of the tributaries and then move downstream to rear during the summer; and mountain whitefish spawn in the tributaries during the late fall (pers. comm., Scott McIntosh, Saik'uz First Nation representative).

Swanson Creek flows northwestward from its headwaters at Boomerang Lake 25 km downstream to its mouth on the south side of Nechako River, approximately 28 downstream from the Kenney Dam. Its largely undisturbed watershed is characterized by rolling, forested hills underlain by a blanket of till, with large, gravelly glacial outwash terraces along the Swanson Creek valley (Plouffe et al., 2004). Over the past 10,000 years, Swanson Creek has incised through the terraces and now exhibits a partly confined, irregular meandering to wandering pattern along its narrow floodplain. Swanson Creek has a relatively uniform longitudinal profile, apart from minor breaks-in-slope, until its gradient drops abruptly at its alluvial fan on which the Big Valley Ranch is situated (**Figure 1**).

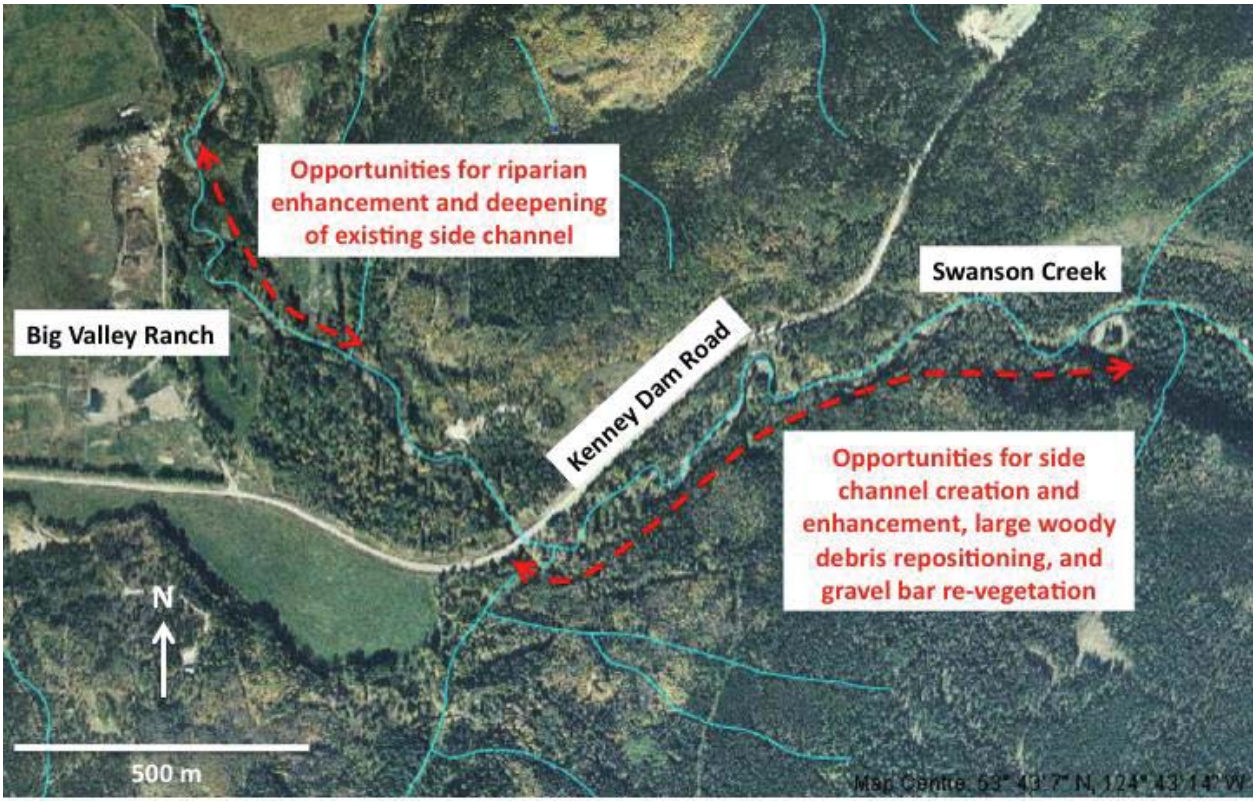


Figure 1. Lower Swanson Creek Overview Map

The channel morphology of lower Swanson Creek was significantly altered by a flood that occurred during a major rainstorm in June 1993, possibly accompanied by the outburst from a breached beaver dam upstream (ARC, 1998). A large volume of coarse bed material and large woody debris derived from the erosion of high, unstable cut-banks in the middle reaches of Swanson Creek was transported downstream and deposited where the gradient begins to drop, beginning upstream of Kenney Dam Road (**Figure 1**). Sudden aggradation of the channel transformed the typical pool-riffle morphology into long, shallow riffles. As much as 94% of Swanson Creek, just upstream of Kenney Dam Road, was described

as riffle habitat by ARC (1998). A cobble-boulder lag that has formed on the surface of most of the riffles has inhibited their migration and resculpting by normal flows. The aggradation also caused locally significant channel widening and cut-off important side channel habitat. Bankfull widths of about 20 m were measured in 1996 by ARC (1998) and again by PECG in 2013. Logjams formed at meander bends, locally spanning the channel and forcing avulsions. The culvert through which Swanson Creek flows beneath the Kenney Dam Road was washed out. The large, unvegetated gravel bars preserved along the lowermost reach of the creek, including at its confluence with Nechako River, are a testament to the geomorphological significance of this flood event (**Figure 2**). Rapid snowmelt during the spring freshet in 1997 led to flooding that further inhibited the natural recovery of channel morphology and aquatic habitat.



Figure 2. Large Gravel Bars at Mouth of Swanson Creek

Riparian vegetation and bank cover features are discontinuous, mainly present where Swanson Creek flows along the toe of one of its forested valley sides. The localized braiding caused by past flood disturbance and exacerbated by channel-spanning logjams has minimized contact of the channel with overhanging riparian vegetation and functional stream-edge woody debris (**Figure 3**). On the alluvial fan of Swanson Creek, downstream of Kenney Dam Road, riparian vegetation and bank stability have been impacted by ranching activity, including cattle grazing.



Figure 3. Logjam in Swanson Creek Upstream of Kenney Dam Road

Summary of Previous Habitat Restoration Work

The fish habitat assessment work completed by ARC Environmental (1998) culminated in the identification of several opportunities for habitat restoration and enhancement targeting the preferences of rainbow trout:

- Forming step-pools along the main creek, immediately upstream of the Kenney Dam Road, using native materials;
- Positioning large woody debris along the main creek to promote natural stabilization and expedite channel recovery;
- Disaggregating logjams that could form impoundments subject to future, sudden breaches;
- Establishing a connection to a side channel immediately upstream of Kenney Dam Road, and modifying its form to better meet spawning and rearing habitat requirements;
- Establishing a connection to a side channel approximately 0.5 km downstream of the Kenney Dam Road;
- Erecting fences to deter cattle from trampling the creek banks and bed, and direct them to alternate watering areas; and
- Re-establishing a riparian zone in impacted areas of the alluvial fan and on wide gravel bars, once the channel has further stabilized.

Several elements of these recommendations were implemented according to Underhill (2000) and based on recent field inspections completed by PECG, New Gold and a representative from Saik'uz First Nation involved in the previous restoration work:

- **Groundwater-fed Side Channel (lower site)** – About 1.3 km upstream from the mouth of Swanson Creek (downstream of Kenney Dam Road), an existing, groundwater-fed channel, originally inaccessible to fish, was deepened and widened. Large woody debris was placed in the channel to provide refugia for juvenile rainbow trout and Chinook salmon that could now access it through its excavated entrance. Underhill (2000) notes a follow-up recommendation for further deepening of the side channel, to increase its potential for overwintering.
- **Groundwater-fed Side Channel (upper site)** – About 3.3 km upstream from the mouth of Swanson Creek (upstream of Kenney Dam Road), an abandoned side channel was excavated and the natural habitat features were enhanced to include pool-riffle morphology and habitat complexes (**Figure 4**). The headpond was deepened to intercept additional groundwater.
- **Main Creek** – Along an 800 m-long section of Swanson Creek, centred about 2.8 km upstream of its mouth (upstream of Kenney Dam Road), large woody debris structures were installed, mainly along the left bank (**Figure 5**). Also, portions of the armour layer on one riffle were removed to promote down-cutting and restoration of more typical channel morphology. Underhill (2000) notes a follow-up recommendation for additional habitat complexing to enhance channel stability and improve fish habitat.



Figure 4. Previously Enhanced Groundwater-fed Side Channel



Figure 5. Boulder-buttressed Large Woody Debris Structure along Swanson Creek

Field observations made of the latter two restoration efforts during the October 2013 site reconnaissance are acknowledged below, where appropriate.

Opportunities for Additional Fish Habitat Compensation

The field reconnaissance completed in October 2013 confirmed the effectiveness of most previous restoration work, pending local maintenance requirements, and identified additional opportunities for fish habitat compensation through habitat restoration and enhancement along lower Swanson Creek. The natural, flood-induced disturbance regime must be considered, however, in the development of plans for additional habitat compensation. Similar aggradation, widening and shallowing to those observed along lower Swanson Creek in response to the 1993 and 1997 floods may occur again during future floods. The natural channel instability in the vicinity of Kenney Dam Road relates to its position at the transition from a steeper gradient to a gentler gradient, where bed material naturally deposits; the high sediment supply of upstream reaches that undercut several unstable cut-banks along the outside of meanders; and the independent or combined effects of floods produced by intense rainstorms, rapid snowmelt, or outbursts from breached beaver dams or logjams. Where possible, fish habitat compensation efforts should prioritize the restoration, creation, enhancement and protection of off-channel spawning and rearing habitat, as well as the re-establishment of riparian habitats. Efforts along the main channel should focus on maintenance of existing works and inexpensive measures that accommodate, or at least do not inhibit, future adjustments in channel morphology.

The initial aim of the opportunities described below is to further assist the channel in recovering from past disturbances, recognizing its natural susceptibility to future floods, and restore habitat conditions more conducive to the rearing of Chinook salmon, and the spawning and rearing of rainbow trout and mountain whitefish. The ultimate objective is to help increase the productive capacity of habitat along Swanson Creek. Four main opportunities have been identified:

1. Enhancement of Groundwater-fed Side Channels

Groundwater-fed side channels represent valuable opportunities for fish habitat compensation, especially for Chinook salmon, which are of primary interest to Saik'uz First Nation. The groundwater-fed channel upstream of Kenney Dam Road is relatively narrow and has become partly blocked with organic debris (**Figure 6**). Consideration should be given to deepening its headpond, pools and connection to Swanson Creek, in order to intercept more groundwater and accommodate fish passage into and out of the channel during summer and fall low flows. A deeper, wider channel would be more likely to be used for overwintering beneath a cover of ice, and would be less likely to become blocked by organic matter. If deemed necessary, a small set-back berm could be constructed alongside its upstream end in order to protect it from future channel migration within the main channel. A "leaky" bank composed of large cobbles and boulders could be incorporated into the berm near the headpond, to allow surface water to periodically enter the side channel and help flush downstream any organic material that accumulates.



Figure 6. Groundwater-fed Channel Virtually Blocked by Organic Litter

Opportunities to create new groundwater-fed side channels also exist upstream of Kenney Dam Road. Where the main creek follows one side of the valley, a side channel could be excavated along the toe of the opposite valley side, where groundwater discharges to surface at the base of high, gravelly terraces. As described above, a "leaky" bank entrance to the side channel could be constructed if desired to allow periodic through-flow of surface water. The channel would have an open connection to the main creek at its downstream end, with a downstream skew in order to minimize influence on local hydraulic processes and sediment transport.

The existing groundwater-fed side channel that was connected to the main channel at the site downstream of Kenney Dam Road through previous restoration efforts should be re-examined (**Figure 1**). If appropriate, the side channel should be deepened in accordance with the recommendation provided by Underhill (2000), in order to increase its potential use for overwintering. Consideration must be given to groundwater levels relative to the creek bed, given the side channel's position alongside the fan channel of Swanson Creek, which has been identified at least locally as a "losing" reach (i.e., surface water infiltrates downward to the groundwater table) (ARC, 1998).

2. Maintenance and Repositioning of Large Woody Debris Structures

A number of large woody debris structures – mainly root wads cabled to boulders – were placed along the edge of the channel, upstream of Kenney Dam Road. Most are intact and provide moderate cover habitat where small pools have formed at their base (**Figure 7**). Some, however, have settled or otherwise shifted, resulting in suspension of boulders by the cables or collapse of the boulders into the main creek (**Figure 8**). Minimal effort would be required to restore the integrity of these large woody debris structures. Furthermore, some of the structures would be best repositioned along the outside of bends where scour pools are most likely to form.

Consideration should be given to removing, or at least disaggregating, anomalously large woody debris jams that span the channel or have become pinned against one bank (**Figure 3**). Although functional large woody debris has an important ecological and geomorphological role, such large accumulations may impede fish passage during certain flow conditions or may form temporary impoundments, with the potential to breach suddenly and severely scour the channel bed and banks downstream.



Figure 7. Large Woody Debris Structure with Small Pool at its Base



Figure 8. Cabled Boulder Detached from Large Woody Debris Structure

3. Stabilization of Large Lateral Bars for In-stream Benefits

Large, poorly vegetated gravel bars, apparently formed during the 1993 flood, still flank portions of lower Swanson Creek upstream and downstream of Kenney Dam Road. The bars separate the channel from mature riparian vegetation, which would otherwise provide important cover habitat. Even though the bars are composed of a mixture of sand, gravel and cobble, the cobbley lag that has formed on their surface inhibits the colonization and growth of vegetation. One technique that has been successful in both the stabilization and revegetation of gravel bars is to install in their surface rows of live stakes (e.g., willows) roughly perpendicular to flow (**Figure 9**, Polster, D., 2012).



Figure 9. Example of Gravel Bar Live Staking (from D. Polster, 2012)

The willows root effectively in the finer, subsurface material, with improved access to the groundwater table, and begin to grow rows of low shrubs. The shrubs reduce surface velocities and promote the deposition of fine sediments over just a few years (or moderate floods). As the fine sediment accumulates, and the willows continue to grow, the height of the bar alongside the channel increases and better confines flow to its natural, bankfull width. The narrower channel will naturally deepen and increase its capacity to form and mobilize riffles, which in turn will promote pool formation and deepening at locations that 'fit' the overall morphology at the time.

4. Restoration of Banks and Riparian Vegetation in Ranchland

Along the portion of Swanson Creek that descends its gentle alluvial fan, within the Big Valley Ranch, cattle grazing and trampling have removed riparian vegetation and destabilized channel banks (**Figure 1**). Consideration should be given to requesting approval from the ranch owners to restore and re-vegetate the banks and, ideally, implement measures to deter cattle from accessing the creek (e.g., set-back fencing, boulder pavements, off-channel watering holes, etc.).

Conclusion

Lower Swanson Creek is well suited to fish habitat compensation, with a variety of valuable opportunities for restoring in-stream and riparian habitats along the main channel, and for enhancing and creating new spawning and rearing habitats for rainbow trout and Chinook salmon in side channels.

References

ARC Environmental Ltd., 1998. Selected Nechako River Tributaries: Fish Habitat Assessment and Inventory. Prepared for Ministry of Environment, Lands and Parks, Omenica Region, March 1998, 80 pp. plus appendices.

Envirocon, 1984. Environmental Studies Associated with the Proposed Kemano Completion Hydroelectric Development, Vol. 5, 415, pp.

Plouffe, A., Levson, V.M. and Mate, D.J., 2004. Surficial geology, Nechako River, British Columbia. Geological Survey of Canada, Map 2067A, scale 1:250,000.

Polster, D., 2012. Live Gravel Bar Staking, Octawanch and San Juan Rivers. Oral presentation provided to Palmer Environmental Consulting Group Inc., 22 pp.

Tredger, D., Yaworski, B. and Ptolemy, J., 1985. Nechako River Tributary Reconnaissance. Reconnaissance Report, 1985.

Underhill, D. (ed.), 2000. Annual Compendium of Aquatic Rehabilitation Projects for the Watershed Restoration Program, 1999 – 2000. Watershed Restoration Project Report No. 18, 2000, Watershed Restoration Program, Ministry of Environment, Lands and Parks and Ministry of Forests.

Upper Fraser Fisheries Conservation Alliance, 2009. Community Fisheries Profile for Saik'uz First Nation. Prepared for Saik'uz First Nation, March 15, 2009, 37 pp.