Appendix 14-E

Fish Habitat Offsetting Plan

HARPER CREEK PROJECT

Application for an Environmental Assessment Certificate / Environmental Impact Statement

Prepared for:

HARPER CREEK MINING CORP.

HARPER CREEK PROJECT

Fish Habitat Offsetting Plan

November 2014

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ERM

Harper Creek Mining Corporation

HARPER CREEK PROJECT
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HARPER CREEK PROJECT
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GLOSSARY AND ABBREVIATIONS

Terminology used in this document is defined where it is first used. The following list will assist readers who may choose to review only portions of the document.

AIR	Application Information Requirements
Application	Application for an Environmental Assessment Certificate
BC	British Columbia
BC EAO	British Columbia Environmental Assessment Office
BC ILMB	British Columbia Integrated Land Management Bureau
CEA	Cumulative effects assessment
CEA Agency	Canadian Environmental Assessment Agency
EIS	Environmental Impact Statement
FSR	Forest service road
HCMC	Harper Creek Mining Corporation
km	Kilometre
LSA	Local Study Area
masl	Metres above sea level
PAG	Potentially acid generating
Project	Harper Creek Project
RSA	Regional Study Area
SARA	*Species at Risk Act*
TMF	Tailings management facility
VC	Valued Component
YOY	Young of Year

1. INTRODUCTION

1.1 OVERVIEW OF THE PROPOSED PROJECT

Harper Creek Mining Corporation (HCMC) proposes to construct and operate the Harper Creek Project (the Project), an open-pit copper mine near the community of Vavenby, British Columbia (BC). The Project has an estimated 28-year life-of-mine (LOM) based on a process plant throughput of 70,000 tonnes per day (t/d), or 25 million tonnes per year (t/yr).

The Project is located in the Thompson-Nicola Regional District of BC, approximately 150 km northeast of Kamloops along Yellowhead Highway 5, and approximately 10 km southwest of Vavenby, BC (Figure 1.1-1). The mine area and tailing management facility (TMF) of the Project is situated within the Harper Creek sub-watershed, which drains into the Barrière River sub-watershed, and then to the North Thompson River near the town of Barriere, BC.

The North Thompson River and the Barrière River are large river systems with high fisheries and cultural values. They provide important spawning routes for Chinook Salmon (*Oncorhynchus tshawytscha*), Coho Salmon (*O. kisutch*) and Sockeye Salmon (*O. nerka*), as well as habitat for resident Bull Trout (*Salvelinus confluentus*), Rainbow Trout (*O. mykiss*), and Mountain Whitefish (*Prosopium williamsoni*).

The Project will be comprised as shown in Figure 1.1-2. The Project site area will be located in the upper drainage basin of Harper Creek, a tributary of the Barriére River. The non-PAG waste rock storage area and TMF will be located in two tributaries of Harper Creek, known as P Creek and T Creek, respectively. The mine site area is accessed by existing Forest Service roads, and will be supplied with power by construction of a new 138 kV powerline.

The amended *Fisheries Act* requires an authorization for any works causing "serious harm" to fish The development of the TMF and waste rock storage infrastructure will take place in non-fish bearing portions of T and P Creeks, but will trigger a need to acquire an authorization to cause "serious harm" to fish pursuant to the *Fisheries Act* in the form of habitat loss due to water quantity reductions as are predicted to occur in upper Harper Creek (between P and T creeks), P Creek, and T Creek.

Additional information describing the Project can be found in Chapter 5 Project Description of the Application/EIS. Details on flow effects are found in Chapter 12 Hydrology, and information on the residual effects of the Project on fish can be found in Chapter 14 Fish and Aquatic Resources.

This Fisheries Offsetting Plan (FOP) is concerned exclusively with the design of two offsetting options, Lion Creek and gravel placement in lower Harper Creek, to offset for fisheries loss as a result of the Project infrastructure.

The FOP was developed to meet the amended *Fisheries Act* (i.e., serious harm to fish) requirements and DFO's Fisheries Protection Policy Statement (DFO 2013).

Figure 1.1-1

Project Location

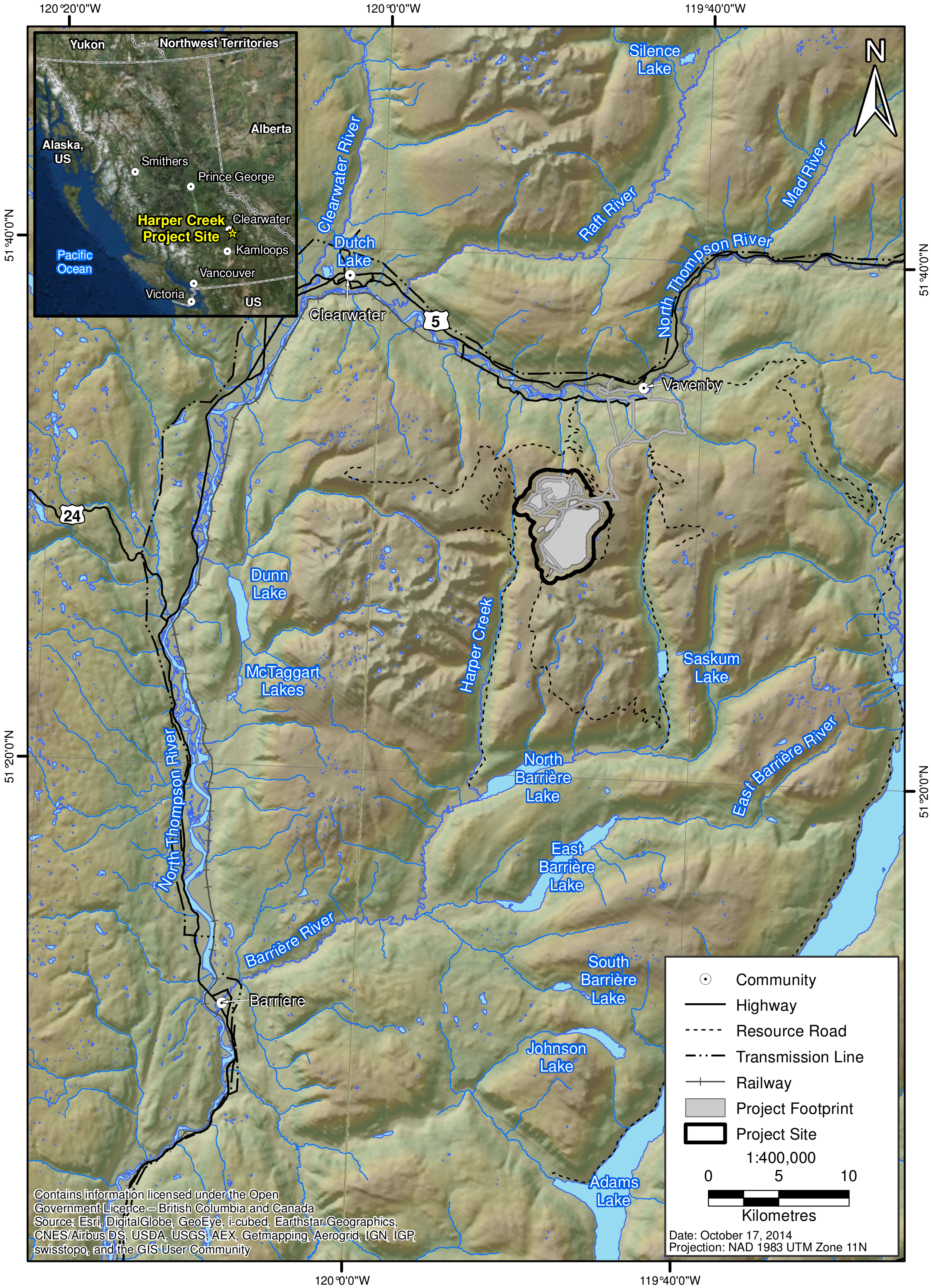
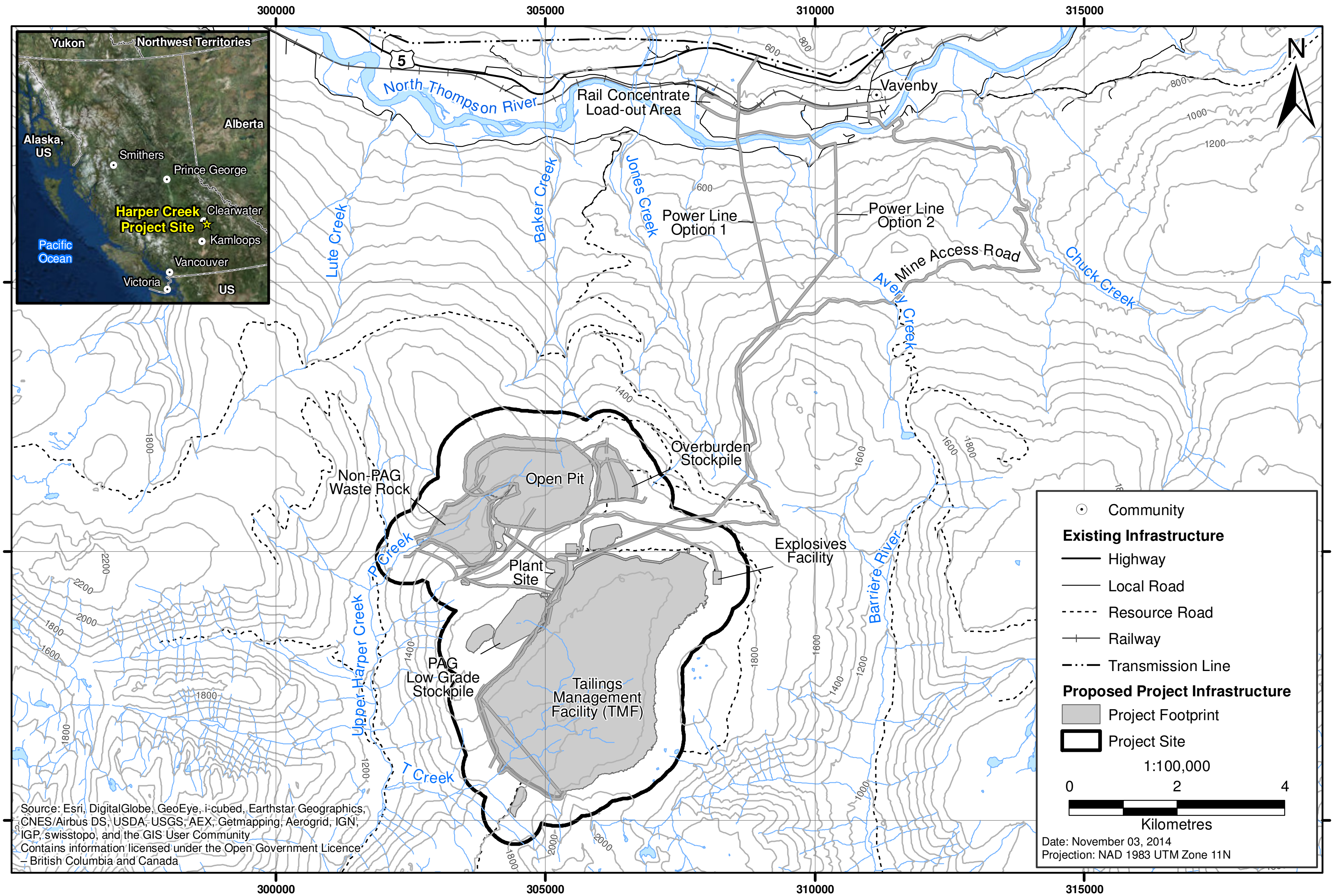


Figure 1.1-2
Project Location and Infrastructure



1.2 REGULATORY AND POLICY FRAMEWORK

1.2.1 *Fisheries Act*

Fish and fish habitat are protected under the federal the *Fisheries Act* (1985). The *Fisheries Act* was amended in November 2012 to shift the mandate of DFO from management of fish habitat to management of fisheries. The amended Act prohibits "serious harm to fish" that are part of a commercial, recreational, or Aboriginal fishery, or to fish that support such a fishery. "Serious harm" is defined to include the killing of fish by means other than fishing, permanent alteration of habitat, and destruction of habitat.

The amended Act focuses on "commercial, recreational, or Aboriginal fisheries, and fish that support those fisheries." These fisheries are defined as those fish that fall within the scope of applicable federal or provincial fisheries regulations, as well as fisheries that can be fished by Aboriginal organizations or their members for food, social, or ceremonial purposes, or for purposes set out in land claims agreements. Fish that support a fishery are those that contribute to the productivity of a fishery. These include prey fish and other fish species that may reside in water bodies that contain the commercial, recreational, or Aboriginal fishery, or in waters that are connected to such water bodies.

Under Section 35(2) of the *Fisheries Act* (1985), any project or activity that causes serious harm to fish may require an Authorization. Prior to issuing an Authorization, the Minister must consider four factors listed in Section 6 of the Act:

- 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; and
- the public interest.

Serious harm to fish as the result of habitat degradation or loss and/or flow alteration (DFO 2013) should be avoided or mitigated where possible. Avoidance measures may include relocating infrastructure or by timing certain activities to avoid harm to fish and fish habitat. Mitigation measures are used to reduce the spatial scale, duration, or intensity of an impact where serious harm to fish habitat cannot be completely avoided. Mitigation measures include the implementation of best management practices during all phases of a project.

If serious harm to fish or fish habitat cannot be avoided or mitigated, any residual impact should be addressed by offsetting. Offset measures are those that are taken to replace or enhance fisheries productivity to compensate for unavoidable impacts with the goal of maintaining the productivity of commercial, recreational, or Aboriginal fisheries. There is flexibility in the selection of offsetting measures provided they are focused on improving fisheries productivity. Offsets are most likely to balance losses when they benefit the specific fish populations and areas that are affected by a development site. When determining the location for offsetting, offsets that occur within the vicinity of the site or within the same watershed for the same fish species are preferable; these are referred to as 'in-kind' offsets. Offsetting measures could be undertaken in water bodies or for fish species other than those affected by the site ("out-of-kind" offsets), provided the measures are supported by clear fisheries management objectives or regional restoration priorities.

1.2.2 Fisheries Protection Policy

The Fisheries Protection Policy was developed by DFO (2013) to support DFO and other departments when administering the fisheries protection provisions of the *Fisheries Act,* which include sections 6, 20, 21, 35, 37, and 38. This plan is being prepared because of the requirement under s.37 of the *Fisheries Act* that allows the Minister to request plans and specifications for projects that may cause serious harm to fish. This policy focuses on the management of impacts to fish resulting from habitat degradation or loss and alterations to fish passage and flow.

The plan contained herein has been designed to address "serious harm" to a recreational fishery (i.e., Bull trout and their habitat) in upper Harper Creek, P, and T creeks as a result of changes in flow and habitat loss due to the Harper Creek Project as assessed in detail in Chapter 14 of the Application for an Environmental Assessment Certificate/Environmental Impact Statement (Application/EIS). By way of this FOP HCMC intends to meet the goal and objectives of this policy which are to provide for the sustainability and ongoing productivity of a recreational fishery, and to comply with the fisheries protection provisions of the *Fisheries Act*.

1.2.3 Fisheries Productivity Investment Policy

The Fisheries Productivity Investment Policy provides guidance on undertaking effective measures to offset serious harm to fish that are part of, or that support a commercial, recreational or Aboriginal fishery. The policy is part of a set of guidance documents prepared by DFO in support of recent amendments to the *Fisheries Act* and is intended to assist proponents where activities could result in serious harm to fish. The policy provides an overview of applying offsetting measures for fisheries protection, including objectives, guiding principles, and types of measures. This plan has been developed following the step by step procedures as outlined in this policy (DFO 2013) and provides the information as outlined in the Applications for Authorization under Paragraph 35(2)(b) of the *Fisheries Act* Regulations.

1.2.4 Objectives

The objectives of this FOP are as follows:

- demonstrate that an appropriate approach to avoiding, mitigating and then offsetting serious harm impacts on a fishery has been taken;
- describe the proposed approach to offset residual adverse impacts of the Harper Creek Project on Bull Trout and fish habitat in upper Harper Creek, P, and T creeks;
- demonstrate that the proposed offsetting measures will maintain or improve the productivity of the potentially affected recreational Bull Trout fishery; and
- describe the proposed monitoring and reporting program for each potential offsetting project.

2. EXISTING FISH DISTRIBUTION AND HABITAT

2.1 INTRODUCTION

The following section provides a summary of existing fish habitat, and details regarding the loss of fish habitat due to changes in water quantity described in Chapter 14, Section 14.5.3.1. Detailed habitat descriptions for upper Harper Creek, P Creek, and T Creek are located in Chapter 14, Section 14.4.3, while extensive baseline fish and fish habitat data are presented in Appendix 14-A.

2.2 UPPER HARPER CREEK

For the purposes of this FOP, upper Harper Creek includes reaches 12 to 16 between P and T creeks (Figure 2.1-1). The distance of upper Harper Creek between P and T creeks is approximately 4,500 m. Fish distribution and fish species within upper Harper Creek are discussed in Chapter 14, Section 14.4.3.2, while fish habitat is discussed in Section 14.4.3.4. Bull Trout were the only fish species present in upper Harper Creek, and their relative abundance was approximately three times that observed in lower Harper Creek (Appendix 14-A, Section 4.2). Bull Trout were observed in upper Harper Creek from km 18.5 (immediately above the 2-m waterfall) to the upper portions of the watershed near mainstem km 24.2. All life history stages (including emergent fry, rearing juveniles, resident adults, and adfluvial spawning adults) were present. Baseline studies indicate that the 2-m waterfall at mainstem km 18.5 may differentially restrict adfluvial Bull Trout migration based upon seasonal flow, and adfluvial Bull Trout biological variables (e.g., size, maturity, burst swimming ability). Based upon baseline observations and professional judgment, only larger adfluvial Bull Trout are able to ascend the 2-m falls, and only when freshet flow has declined during mid-summer and into the summer low flow period.

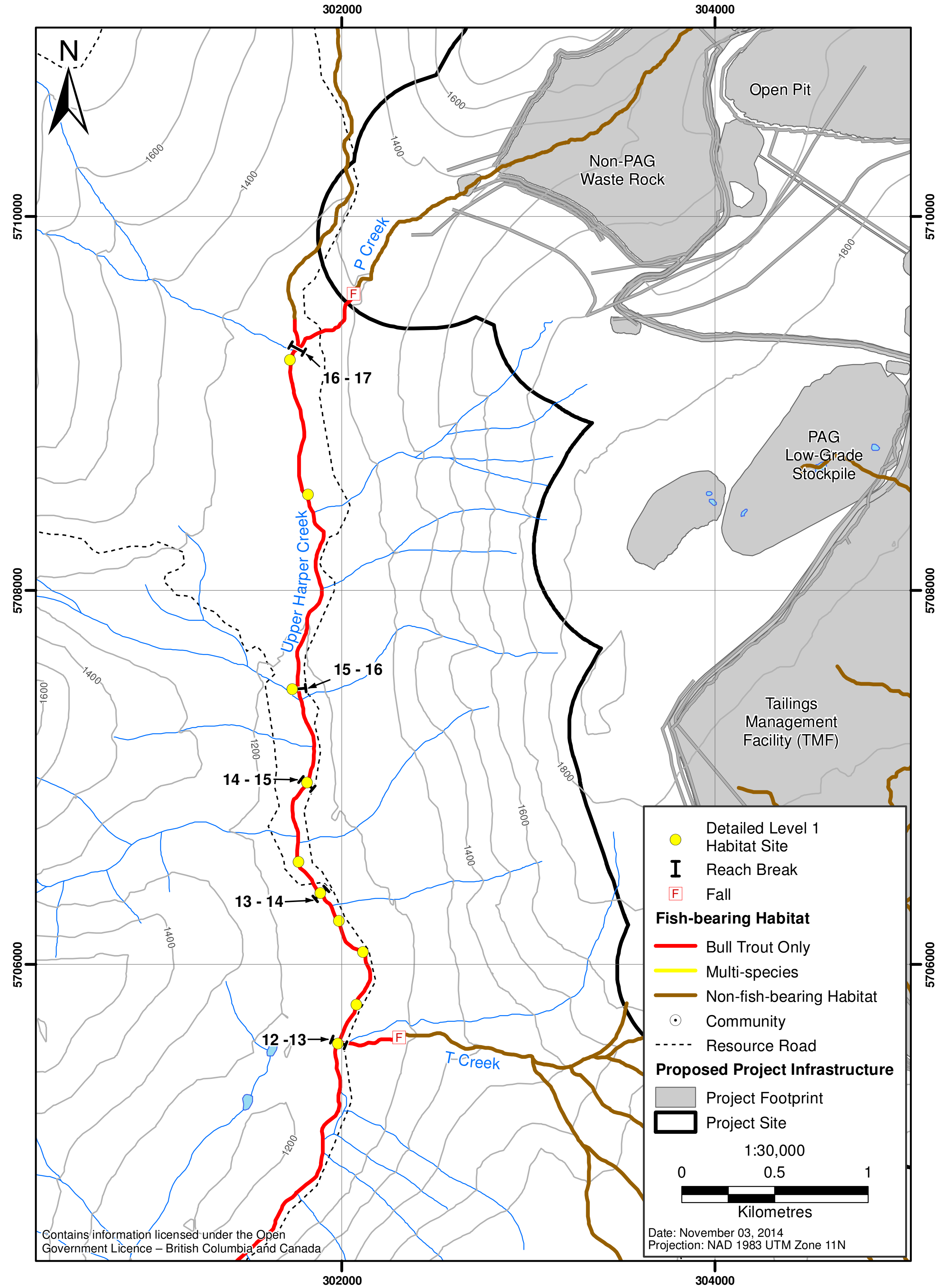
Bull Trout were not captured or observed in 1400s of electrofishing conducted over two years in 2011 and 2013 at sampling sites upstream of km 24.2 (Appendix 14-A; section 4.2.8.1). Therefore, upper Harper Creek upstream of the P Creek confluence (km 24.2) was classified as non-fish-bearing due to the presence of unsuitable habitat (Appendix 14-A, Section 4.2.8.1).

2.2.1 Upper Harper Creek Reach 16

Mesohabitat in reach 16 was most frequently classified as riffles (38%) which had an average length of approximately 21.1 m (Appendix 14-A, Section 4.1.3.3). Pools (33%) were the next most common mesohabitat and the units averaged approximately 12.5 m in length with an average maximum and residual depth of 0.52 m and 0.10 m respectively. Glides and riffle-pools accounted for 17% and 13% of the habitat mapped with a mean length of 21.5 m and 30.6 m, respectively. The dominant bed material in upper Harper Creek is cobble (76%), followed by gravel (26%). The dominant forms of fish cover are provided by large woody debris (36%), deeper pools (37%), overhanging riparian vegetation in the form of overhanging alder (18%), and undercut banks (9%). Stream gradient in upper Harper Creek tends to be low, ranging from 0% to 4%. Diverse habitat complexes consisting of riffles, pools, cascades, and glides were present. Large woody debris and overhanging vegetation supplied abundant cover for fish. As with lower Harper Creek, functional large woody debris and log jams act as important features for gravel catchment and the development of pool habitat. Cobble and gravel were the dominant and sub-dominant substrate types, respectively.

Figure 2.1-1

Bull Trout Distribution and Barriers to Migration, Upper Harper Creek, P Creek, and T Creek



2.2.2 Upper Harper Creek Reach 15

Stream morphology of reach 15 was classified as riffle-pool, with glide and riffle habitat representing the dominant and sub-dominant mesohabitat types, respectively (Appendix 14-C). Habitat units ranged in length from 3 m to 78 m, with a mean length of 12.6 m. Cobble and gravel represented the dominant and sub dominant substrate type, respectively. Pea gravel and coarse gravel for adfluvial Bull Trout spawning was abundant in glide and pool habitat units. Overall, habitat was rated as important, with critical adfluvial Bull Trout spawning habitat observed at four pool habitat units within this reach.

2.2.3 Upper Harper Creek Reach 14

Stream morphology in reach 14 was classified as riffle-pool. Pools and glides were the most common mesohabitat type (Appendix 14-C). Habitat units ranged in length from 4 m to 26 m, with a mean of 13.8 m. Cobble and gravel were observed as the dominant and sub-dominant substrate types, respectively. Large woody debris (dominant) and overhanging vegetation (sub dominant) were the most commonly observed cover types. Pea gravel and coarse gravel for adfluvial Bull Trout spawning was present in glide and pool habitat units. Overall, habitat was rated as important, with critical adfluvial Bull Trout spawning habitat observed at glide and pools within this reach.

2.2.4 Upper Harper Creek Reach 13

Stream morphology in reach 13 was classified as step-pool (Appendix 14-C). Mesohabitat units ranged from 4 m to 130 m, with a mean of 22.3 m. This reach was characterized by steeper gradient, long cascades, and coarse substrate (boulder and cobble). Spawning gravel was typically limited to lower gradient habitat types such as glides and pools. Overall, habitat was variable, varied from marginal to important, with critical adfluvial Bull Trout spawning habitat observed at some glide habitat units.

2.2.5 Upper Harper Creek Reach 12

Reach 12 was surveyed near at the confluence of T and Harper creeks (Appendix 14-C). A total of 127 m of fish habitat was divided into 10 habitat units, and classified as riffle-pool morphology. Glide and cascade were the dominant and sub-dominant mesohabitat types, respectively. Mesohabitat units ranged in length from 7 m to 28 m, with a mean of 12.7 m. Cobble (dominant) and gravel (sub dominant) were the most commonly observed substrate type. Coarse gravel and spawning habitat was associated with glide and pool habitat units. Overhanging vegetation and large woody debris formed the majority of fish cover. Overall, habitat was rated as important, with critical adfluvial Bull Trout spawning habitat observed at glide and pools within this reach.

2.2.6 Bull Trout Habitat Use

Bull Trout fry, adfluvial Bull Trout redds, and spawning adfluvial Bull Trout have been consistently observed in upper Harper Creek. The majority of Bull Trout fry were observed downstream of the confluence of T Creek among braided sections of Harper Creek associated with pools, loose cobble and gravel substrate, with large woody debris and riparian cover. The highest density of adfluvial

Bull Trout redds were observed from the confluence of upper Harper and T creeks to approximately 1.5 km upstream on the upper Harper Creek mainstem, in reaches 13 to 15. Bull Trout redd sites were consistently associated with glide or pool tail-outs (which contain slow, laminar or upwelling flow), coarse gravel substrate, and overhanging cover (e.g., overhanging riparian vegetation, large woody debris, or undercut bank). Taken together, the presence of Bull Trout fry and adfluvial Bull Trout redds indicate that upper Harper Creek provides critical habitat for Bull Trout spawning and rearing, and provides habitat for all Bull Trout life stages. Overwintering habitat; however, may be limited due to the low frequency of deep (>1 m) pool habitat. Spawning habitat may also be limited due to the low frequency and availability of suitable spawning habitat in upper Harper Creek.

2.3 T CREEK

T Creek becomes confluent with upper Harper Creek at mainstem km 20.2 (Figure 2.1-1). Reach 1 extends from the T Creek/upper Harper Creek confluence to 336 m upstream, where a 1.8 m waterfall and high gradient cascade, above which T-Creek is non-fish bearing.

Only Bull Trout are present in the lower, 336 m fish-bearing reach of T Creek. Bull Trout captured from lower T Creek were predominantly parr or larger juveniles. Some young of year (YOY) Bull Trout were captured near the T Creek/upper Harper Creek confluence. One adult afluvial Bull Trout was observed in spawning condition in early September 2012; however, spawning pairs and redds were not observed. The relative abundance of Bull Trout juveniles observed within T Creek varied by sampling date and suggests that Bull Trout abundance may be higher during low flow (August–September). The seasonally averaged relative abundance of Bull Trout in lower T Creek is similar to those observed in upper Harper Creek.

The 336 m fish-bearing reach of lower T Creek was categorized into 22 mesohabitat units (Appendix 14-A, Section 4.1.3.4). The most frequent habitat was classified as short pools (32%) which averaged approximately 6.4 m in length with a mean residual depth of 0.38 m. Riffles and glides accounted for 23% and 18% of the habitat mapped with a mean length of 17.3 m and 9.3 m in length, respectively. Cascades and step-pools accounted for approximately 27% of the remaining habitat and these habitats averaged 6.0 to 7.0 m in length although the final 129 m of the fish bearing reach was classified as a high gradient step-pool or cascade with an approximate gradient of between 22% and 27%. Bed material in T Creek is dominated by coarse materials with the vast majority being classified as boulder/cobble (71%), followed by boulder (19%), boulder/gravel (5%) and cobble/boulder (5%). The dominant forms of fish cover are provided by overhead riparian vegetation and boulders, with some sub-dominant cover provided by undercut banks and functional woody debris. Habitat conditions in lower T Creek are suitable for Bull Trout rearing due to the prevalence of rough cobble and boulder channel elements combined with turbulent flow. Late summer and winter low flows may be limiting for Bull Trout due to lack of flow and absence of deep pools.

2.4 P CREEK

The confluence of P Creek and upper Harper Creek is located at mainstem km 24 (Figure 2.1-1). Fish-bearing habitat occurs from the confluence and extends 429 m upstream where a 3 m waterfall, as well as high gradient cascade and multiple small waterfalls, prevent further upstream distribution.

As with T Creek, only Bull Trout are present in the lower, 429 m fish-bearing reach of P Creek. Sampled Bull Trout were predominately juveniles; however, one YOY Bull Trout was observed. Mature, spawning adults were not observed during fish community surveys of P Creek. The relative abundance of Bull Trout in P Creek was slightly less than half the average values observed in T Creek and upper Harper Creek. Densities of juvenile Bull Trout in both T Creek and P Creek averaged approximately 1.5 to 2 times higher than those observed in three East Kootenay watersheds (Appendix 14-A, Section 4.2.4). These data suggest that T and P creeks are productive rearing environments for both juvenile adfluvial and resident Bull Trout.

The 429 m of fish-bearing habitat within lower P-Creek was categorized into 20 different mesohabitat units (Appendix 14-A, Section 4.1.3.2). The most frequent habitat was classified as step-pools (37%) which had an average length of approximately 37 m and an average gradient of about 8%. Short pools (32%) were the next most common mesohabitat and the units averaged approximately 3.8 m in length with a mean residual depth of 0.34 m. Riffles and glides accounted for 16% and 11% of the habitat mapped with a mean length of 42.5 m and 10.5 m in length, respectively. Cascades accounted for 11% of the remaining habitat and these units averaged 10.5 m in length. Bed material in P Creek is dominated by coarse materials with the vast majority being classified as angular cobble (65%), followed by boulder (30%), with a small proportion of sandy fines (5%). The dominant forms of fish cover are provided by overhead riparian vegetation, and boulders with sub-dominant cover provided by functional woody debris. Late summer and winter low flows may be limiting for Bull Trout due to lack of flow, unconfined channel sections, and relative absence of deep pools. Thus, habitat for Bull Trout in lower P Creek is largely confined to juvenile rearing.

3. PROJECT HABITAT LOSS

3.1 INTRODUCTION

Potential effects due to changes in water quantity on fish habitat are outlined in Chapter 14, Section 14.5.1.2. Predicted residual effects due to changes in water quantity are discussed in Chapter 14, Section 14.5.5.3. This analysis determined that significant residual effects on fish habitat due to changes in water quantity (discharge) are predicted to cause “serious harm” in the form of habitat loss at the following water bodies: 1) upper Harper Creek (between P and T creeks); 2) the fish-bearing reach of lower P Creek; and 3) the fish-bearing reach of lower T Creek. Habitat loss in upper Harper Creek is predicted to occur due to a reduction in water quantity resulting from the development of the non-PAG Waste Rock Facility. Habitat loss in P Creek is predicted to occur due to a reduction in water quantity resulting from the development of the non-PAG Waste Rock stockpile. Habitat loss in T Creek is predicted to occur due to the development of the TMF. Methods used to determine residual effects resulting from changes in water quantity and the significance of effects are presented in Chapter 14, Section 14.5.3.1, and discussed in detail for each water body where habitat loss is predicted.

Potential changes in stream discharge in upper Harper Creek, P Creek, and T Creek due to the TMF and waste rock storage development were assessed quantitatively using a watershed model issued by Knight Piesold (Chapter 12). The physical fish habitat analyses follow guidelines from BC Instream Flow Assessment Methods (Lewis et al. 2004). Bull Trout was selected as the target species for this physical habitat impact assessment as it is the only species inhabiting upper Harper Creek, P Creek and T Creek.

3.2 CALCULATION OF HABITAT LOSS

<u>P and T Creeks</u>

The calculation of habitat losses for P and T Creeks was completed using a one-dimensional Physical Habitat Simulation (PHABSIM) modelling of Weighted Usable Area (WUA) reported in the Instream Flow Assessment (Appendix 14-D). This analysis provided a measure of the WUA for fry, juvenile rearing and spawning across all months and during all mine phases, from Pre-Mine through Post-Closure. To evaluate the potential habitat losses, the monthly WUA for each mine phase (see Appendix B2 within Appendix 14-D: Instream Flow Assessment) was evaluated to determine the *Maximum Reduction in WUA* (MRA) for each life stage. The MRA was assessed as the largest reduction in WUA across the Operations, Closure and Post-Closure phases. MRA (in percent) was then multiplied by the Pre-Mine WUA ($T_M PM$) for each life stage, to obtain the life stage specific loss in WUA (see equation 1). Life stage specific losses in WUA were then summed across to obtain a Total Area of Habitat Loss ($T_{H,T}$ and $T_{H,P}$ for T and P creeks respectively).

$$WUA\ Loss = \sum_{fry,rearing,spawning}(T_M PM * MRA) \qquad \text{(Equation 1)}$$

Upper Harper Creek between P and T Creeks

Instream flow modeling of upper Harper Creek between P and T creeks was not provided within the Instream Flow Assessment (Appendix 14-D). The calculation of habitat losses for this section of upper Harper Creek (between P and T creeks) was completed using an empirically derived relationship between modeled discharge and WUA loss in P and T creeks and using habitat specific data from baseline reports (Appendices 14-A and 14-C). This approach utilized two *scaling factors* to generate the upper and lower bounds of predicted habitat losses in upper Harper Creek. The *scaling factors* (*SF1* and *SF2*) were generated independently for P and T creeks from the relationship between WUA, total stream habitat area and a measure of *Discharge Based Habitat Loss*, which used the maximum reduction in discharge from the watershed model upon which the Instream Flow Assessment was based (Appendix 14-D).

Discharge Based Habitat Loss

Discharge based habitat loss ($D_{L,P}$, $D_{L,T}$, $D_{L,H}$ for P, T and upper Harper creeks) was calculated as a reduction in total baseline habitat ($T_{B,P}$, $T_{B,T}$, $T_{B,H}$ for P, T and upper Harper creeks) in equal proportion to the maximum reduction in discharge predicted using the watershed model (see equation 2)

$$D_L = T_B * MRD \qquad \text{(Equation 2)}$$

Maximum reductions in discharge (MRD) was taken as the largest reduction in discharge predicted from Pre-Mine (or BC Modified Tenant Guideline) during the operations, closure and Post-Closure phases. The magnitude (% change) in discharge was estimated in one of two ways, depending on whether or not the threshold values were met in the Pre-Mine phase:

1. If the BC Modified Tenant threshold was met for pre-mine discharge, the % change was calculated for the month in which the difference between threshold value and discharge during mine-life was at its maximum; or
2. If Pre-Mine discharge was less than the BC Modified Tenant threshold, the % change was calculated for the month in which the difference between Pre-Mine discharge and discharge during mine life was at its maximum.

For example, in Table 3.2-1 discharge is predicted to be at its lowest (64% of Pre-Mine) from the watershed model in March of year 27 of Operations II. This occurs during the adult Bull Trout egg incubation stage from December to March. For the calculations described above, this yields a MRD of 36%. To obtain the Discharge Based Habitat loss (D_L), the total habitat area (T_B) is multiplied by MRD. If 1,000 m^2 of habitat was available, this would yield a discharged based habitat loss (D_L) of 360 m^2 of habitat and the amount of habitat remaining would equal 640 m^2.

The modeling of discharge from each stream was taken from the following nodes of the watershed model (Appendix 14-D):

- upper Harper Creek was taken from Node 8 (Harper Creek Below P Creek Confluence; Table 3.2-1);

- P Creek was taken from Node 5 (P Creek at Harper Creek Confluence; Appendix A); and
- T Creek was taken from Node 3 (T Creek at Harper Creek Confluence; Appendix B).

Calculation of Scaling Factors

Scaling Factor 1 (*SF1-T*, and *SF1-P* for T and P Creeks respectively) provides an estimate of Pre-Mine WUA based on its relationship with total baseline habitat in P and T creeks. Scaling factor 1 is calculated as the ratio of Pre-Mine WUA ($T_{M,T}PM$ and $T_{M,P}PM$ for T and P creeks respectively) to the total baseline habitat area ($T_{B,T}$ and $T_{B,P}$ for T and P creeks respectively; see equation 3).

$$SF1 = \frac{T_M PM}{T_B} \qquad \text{(Equation 3)}$$

Total baseline habitat area (T_B) is a product of stream length by average channel width. For T and P creeks, the respective values of *scaling factor 1* are: *SF1-T* = 0.32 and *SF1-P* = 0.17.

Total baseline habitat area (T_B) is a product of stream length by average channel width. For T and P creeks, the respective values of *scaling factor 1* are: *SF1-T* = 0.32 and *SF1-P* = 0.17.

Scaling Factor 2 (*SF2-T*, and *SF2-P* for T and P creeks respectively) provides an estimate of WUA loss based on its relationship to reductions in habitat due to predicted reductions in discharge in the watershed model. Scaling factor 2 is the ratio of lost WUA ($T_{M,T}Loss$ and $T_{M,P}Loss$ for T and P creeks respectively) to the Discharge Based Habitat Loss ($D_{L,T}$ and $D_{L,P}$ for T and P creeks respectively; see equation 4).

$$SF2 = \frac{T_M Loss}{D_L} \qquad \text{(Equation 4)}$$

For T and P creeks, *SF2-T* and *SF2-P* both equaled 0.78.

Calculating Lower and Upper Bounds of Habitat Loss

The lower bounds of the habitat loss for upper Harper Creek were calculated by first multiplying the total baseline habitat area in upper Harper Creek ($T_{B,H}$) by SF1 to estimate the WUA for upper Harper Creek in the Pre-Mine phase ($T_{M,H}$). *SF1-T* (T Creek Scaling Factor 1) was used in this calculation because discharge in T Creek stream morphology was most similar to that of upper Harper Creek (Table 3.2-2). The final estimate for the lower bounds of habitat loss was estimated by multiplying the pre-mine WUA estimate ($T_{M,H}PM$) by SF2. The lower bound estimate assumes that WUA in upper Harper Creek scales to total available habitat in proportion to observations in T Creek and that reduction in WUA scales with discharge in proportion to that observed in P and T creeks.

The upper bound estimate was taken as the discharge based habitat loss ($D_{L,H}$). This estimate assumes that all baseline stream habitat in upper Harper Creek is usable by fish and that habitat loss is equal to the proportional reduction in discharge.

Table 3.2-1. Summary of Watershed Model Predicted Discharge at Node 8 (Harper Creek Below P-Creek Confluence)

Mine Stage			Mean Monthly Discharge												Average Annual
Year	Description	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
-	Pre-Mine	m³/s	0.04	0.04	0.03	0.30	1.29	1.00	0.32	0.13	0.09	0.10	0.07	0.05	0.29
		%MAD	14%	13%	12%	105%	445%	345%	110%	45%	30%	35%	24%	17%	100%
		%Pre-Mine	-	-	-	-	-	-	-	-	-	-	-	-	-
-1	End of Construction	m³/s	0.05	0.05	0.04	0.34	1.28	0.95	0.32	0.14	0.08	0.10	0.08	0.05	0.29
		% Pre-Mine MAD	18%	16%	15%	119%	442%	325%	111%	47%	28%	34%	27%	19%	98%
		%Pre-Mine	125%	126%	127%	113%	99%	94%	101%	103%	91%	99%	111%	111%	108%
10	Operations I	m³/s	0.03	0.02	0.02	0.26	0.90	0.60	0.22	0.10	0.06	0.08	0.06	0.03	0.20
		% Pre-Mine MAD	10%	8%	8%	91%	311%	206%	76%	33%	20%	27%	19%	12%	69%
		%Pre-Mine	69%	65%	66%	87%	70%	60%	69%	73%	66%	77%	79%	71%	71%
22	Operations I	m³/s	0.03	0.02	0.02	0.26	0.90	0.59	0.21	0.09	0.06	0.08	0.06	0.03	0.20
		% Pre-Mine MAD	10%	8%	8%	91%	309%	202%	74%	33%	20%	27%	19%	12%	68%
		%Pre-Mine	69%	65%	66%	87%	69%	59%	67%	72%	66%	77%	79%	71%	71%
27	Operations II	m³/s	0.03	0.02	0.02	0.27	0.92	0.62	0.23	0.10	0.06	0.08	0.06	0.03	0.20
		% Pre-Mine MAD	10%	8%	7%	92%	316%	215%	78%	35%	21%	27%	19%	12%	70%
		%Pre-Mine	69%	65%	64%	87%	71%	62%	71%	78%	68%	77%	79%	71%	72%
30	Closure	m³/s	0.03	0.02	0.02	0.27	0.93	0.64	0.23	0.10	0.06	0.08	0.06	0.03	0.21
		% Pre-Mine MAD	10%	8%	8%	92%	319%	219%	81%	36%	21%	27%	19%	12%	71%
		%Pre-Mine	69%	65%	66%	88%	72%	64%	73%	79%	68%	77%	79%	71%	73%
50	Post-Closure	m³/s	0.03	0.02	0.02	0.27	0.93	0.64	0.23	0.10	0.06	0.08	0.06	0.03	0.21
		% Pre-Mine MAD	10%	8%	8%	92%	319%	219%	81%	35%	21%	27%	19%	12%	71%
		%Pre-Mine	69%	65%	66%	88%	72%	64%	73%	78%	68%	77%	79%	71%	73%

Table 3.2-2. Summary of Existing Habitat Types for upper Harper Creek, P Creek, and T Creek

	Total Surveyed Area*	Cascade		Glide		Pool		Riffle	
Stream	m^2	m^2	%	m^2	%	m^2	%	m^2	%
T Creek	2,420	868	36%	290	12%	395	16%	867	36%
P Creek	2,763	1,763	64%	222	8%	137	5%	641	23%
Upper Harper Creek Reach 12	4,640	1,160	0.25	2,181	0.47	232	0.05	1,021	0.22
Upper Harper Creek Reach 13	4,860	3,062	0.63	1,021	0.21	194	0.04	583	0.12
Upper Harper Creek Reach 14	2,820	818	0.29	931	0.33	423	0.15	649	0.23
Upper Harper Creek Reach 15	9,600	1,536	0.16	3,168	0.33	1,152	0.12	3,744	0.39
Upper Harper Creek Reach 16	16,000	2,880	0.18	3,200	0.2	2,240	0.14	7,520	0.47
Upper Harper Creek Reach Total	37,920	9,456	25%	10,500	28%	4,241	11%	13,517	36%

3.2.1 Upper Harper Creek

Bull trout habitat loss in upper Harper Creek (between P and T creeks) was calculated using a lower and upper bound as described in previous sections. The lower and upper bounds to habitat loss are 9,643 and 13,651 m^2 respectively (Table 3.2-3). Habitat loss in upper Harper Creek is predicted to continue for more than 50 years over all mine phases, including Post-Closure.

3.2.2 P Creek

Projected Bull Trout habitat loss of WUA in P Creek totals 324 m^2 (Table 3.2-4) and is predicted to continue for more than 50 years over all mine phases, including Post-Closure.

3.2.3 T Creek

Projected Bull trout habitat loss of WUA in T Creek totals 514 m^2 (Table 3.2-5) and is predicted to continue for up to 27 years during the Construction and Operations phases. Discharge is predicted to increase in T Creek during the Closure and Post-Closure phases.

3.3 HABITAT LOSS SUMMARY

For water quantity loss downstream of the proposed TMF and waste rock storage stockpile, data required for calculating habitat budgets included Level 1 habitat data, instream flow data, and water quantity modelling data (Appendix 14-A, 14-C and 14-D). The lower and upper bounds indicated that a total habitat loss of 10,482 to 14,490 m^2 (1.04 and 1.45 ha) respectively of Bull Trout fish habitat may be lost due to reductions in water quantity from T Creek, P Creek, and upper Harper Creek.

Table 3.2-3. Predicted Habitat Loss in Upper Harper Creek (between P and T Creeks)

	Modeled Bull Trout Habitat Total ($T_{M,H}$)	Total Baseline Habitat ($T_{B,H}$)	Discharge Based Habitat Loss ($D_{L,H}$)	Lower Bound Estimate ($T_{M,H}$ * $SF2$)	Upper Bound Estimate ($D_{L,H}$)
Pre-Mine Habitat (m^2)	12,363 $T_{M,H}PM$= ($T_{B,H}$ * $SF1\text{-}T$)	37,920	37,920		
Maximum Loss (%)	-	-	36% (MRD)		
Summary of Habitat Loss (m^2)	-	-	13,651	9,643	13,651

Notes: MRD = maximum reduction in discharge

Table 3.2-4. Predicted Habitat Loss in P Creek

	Modeled Bull Trout Habitat (WUA)					
	Fry	Juvenile Rearing	Spawning	Total ($T_{M,P}$)	Total Baseline Habitat ($T_{B,P}$)	Discharge Based Habitat Loss ($D_{L,P}$)
Pre-Mine Habitat (m^2)	407	53	0	460 ($T_{M,P}$ PM)	2,708	460
Maximum Loss (%)	68% (MRA)	88% (MRA)	0% (MRA)	-	-	90% (MRD)
Summary of Habitat Loss (m^2)	277	47	0	324 ($T_{M,T}$ Loss)	-	414

Notes: MRA = maximum reduction in WUA, MRD = maximum reduction in discharge

Table 3.2-5. Predicted Habitat Loss in T Creek

	Modeled Bull Trout Habitat (WUA)					
	Fry	Juvenile Rearing	Spawning	Total ($T_{M,T}$)	Total Baseline Habitat ($T_{B,T}$)	Discharge Based Habitat Loss ($D_{L,T}$)
Pre-Mine Habitat (m^2)	232	439	118	789 ($T_{M,T}$ PM)	2,420	789
Maximum Loss (%)	64% (MRA)	61% (MRA)	83% (MRA)	-	-	83% (MRD)
Summary of Habitat Loss (m^2)	148	268	98	514 ($T_{M,T}$ Loss)	-	655

Notes: MRA = maximum reduction in WUA, MRD = maximum reduction in discharge

4. FISHERIES PROTECTION MEASURES

Prior to implementing a strategy to offset fish habitat loss, other measures were first used to avoid and then mitigate downstream effects on fish and fish habitat as a result of the Project; these are summarized below and also provided in Chapter 24 (Environmental Management Plans and Reporting).

4.1 AVOIDANCE MEASURES

The following measures have been incorporated in order to avoid affecting fish or fish habitat productivity:

- the Project Site, with associated infrastructure, has been located in an area where adjacent waterways are non-fish bearing;
- the Project footprint has been minimized as much as possible through Project re-design; for example, the waste rock and LGO stockpiles were relocated to reduce the size of the Project footprint;
- natural drainage networks will be maintained or restored in order to mitigate potential effects on flow in downstream watercourses (Section 24.13, Site Water Management Plan);
  - non-contact water is intercepted and directed away from working or areas disturbed by the Project;
- the use of freshwater for Project activities has been minimized by recycling water from the TMF or open pit to the process plant to the maximum practical extent (Section 24.13);
- stream crossings, where required, will be designed to avoid direct impacts on fish (Section 24.6, Fish and Aquatic Effects Management and Monitoring Plan); and
- riparian areas will be protected with setbacks (Section 24.6).

4.2 MITIGATION MEASURES

Additional mitigation measures to minimize the potential for effects to fish and fish habitat are described in Sections 11.5.2.1 (Hydrogeology Chapter, Groundwater Quantity Mitigation Measures), 12.5.2 (Hydrology Chapter, Mitigation Measures), 14.5.2.2 (Fish and Aquatic Resources Chapter, Mitigation Measures for Changes in Water Quantity), 24.6 (Fish and Aquatic Effects Management and Monitoring Plan), 24.8 (Groundwater Management Plan) and 24.13 (Site Water Management Plan). The primary mitigation measures are outlined in the Site Water Management Plan (Section 24.13).

In addition to the Project design features described in the Project Description (Chapter 5) and in the Site Water Management Plan (Section 24.13), adaptive management will be implemented so that field observations of changing environmental conditions and limitations or deficiencies in existing water management structures are recognized and corrected wherever possible (Section 24.13).

When properly implemented, adaptive management enables a cost- and time-effective hierarchical response to potential water management issues. Best management practices (BMPs) and a corresponding inspection, maintenance, and monitoring program constitute the basis of water management planning. The adaptive management approach promotes proactive measures, with the caveat that contingency plans and materials should be in place so that additional measures can be quickly implemented if needed.

5. HABITAT OFFSETTING

5.1 INTRODUCTION

The Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO 2013) describes four guiding principles for the consideration of fisheries offsetting projects:

1. Offsetting measures must support fisheries management objectives or local restoration priorities.
2. Benefits from offsetting measures must balance project impacts.
3. Offsetting measures must provide additional benefits to the fishery.
4. Offsetting measures must generate self-sustaining benefits over the long term.

Offsetting may be accomplished through a variety of methods including habitat restoration or enhancement, habitat creation, chemical or biological manipulations, and complementary measures such as funding scientific research. Habitat enhancement and creation are generally preferred over chemical and biological manipulations and complementary measures; however, the latter may be considered when enhancement or creation opportunities are particularly rare across a landscape. In situations where offsets are realized away from a project site, a robust rationale is required and should be communicated to potentially affected parties. This FOP considers offsetting measures to enhance and create habitat.

To reduce the amount of time between the Project impact occurring and the offset being effective at replacing lost productivity, the construction and establishment of the offset projects are scheduled to occur prior to the start of the Project. By timing this activity early, overall impacts to fisheries productivity are reduced.

5.2 OFFSETTING OPTIONS AND SCREENING

5.2.1 Identification of Potential Projects

Desktop analyses were completed to scope preliminary offsetting projects. Offsetting project locations were initially selected through desktop literature reviews, including historical consulting, DFO, and MOE reports. In addition, Google Earth™ and other satellite imagery available online (e.g., Bing Maps™) were used to identify potential offsetting project sites. For each site, habitat limitations are summarized, biological objectives are identified, and physical techniques to achieve the objectives are summarized.

A summary of fish species and life history stages present at each preliminary project is presented in Table 5.2-1. Bull Trout and Coho Salmon were selected as target species, and priorities were assigned to each preliminary offsetting site based upon field assessment data and offsetting concept techniques (Table 5.2-2). Target species-specific life history stages were identified for each preliminary offsetting site.

Table 5.2-1. Summary of Fish Species and Life History Stages Present at each Project Site

Potential Offsetting Site	Species	Life History Stage Currently Present				
					Adult	
		Fry	Parr +1	Parr +2	Rearing	Spawning
Lion Creek offsetting area	Coho					
	Bull Trout (resident)					
	Bull Trout (adfluvial)					
	Rainbow Trout					
Harper Creek Spawning Gravel	Coho	X	X	X		X
	Bull Trout (resident)	X	X	X	X	X
	Bull Trout (adfluvial)	X	X	X	X	X
	Rainbow Trout	X	X	X	X	X
Chuck Creek Culvert	Coho	Y	Y	Y	Y	Y
	Bull Trout (resident)	X	X	X	X	X
	Bull Trout (adfluvial)	Y	Y	Y	Y	Y
	Rainbow Trout	X	X	X	X	X

Notes:
X = present throughout area
Y = present downstream of obstruction

Overall, a total of three potential fish habitat offsetting sites were identified in close proximity to the Project (Figure 5.2-1):

- Lion Creek off-channel complex;
- Lower Harper Creek spawning gravel placement;
- Chuck Creek passage improvements.

Each preliminary offsetting project was screened according to a set of high level criteria (Table 5.2-3). These criteria included: DFO hierarchy for offsetting, regional fisheries management objectives, technical and economic feasibility, stability and permanency, and biological relevance.

The DFO hierarchy for offsetting was classified for each offsetting site. The classifications are as follows:

1. replacing lost habitat with the same habitat in the same ecological unit;
2. increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit;
3. a) replacing lost habitat with like-for-like habitat in another ecological unit;
   b) replacing lost habitat with like-for-unlike habitat in another ecological unit; and
4. using artificial production (i.e., building hatcheries or fertilizing lakes).

Table 5.2-2. General Offsetting Concepts and Techniques

Concept Number	Target Species	Target Life Stages	Target Habitat	Primary Objective	Secondary Objective	Physical Technique
1	CO, RB, BT	Fry, Parr, Adult	Off-channel rearing, Overwintering habitat	Enhance/create overwintering and rearing habitat in off-channel areas by modifying ponds, beaver dams, wetlands, small floodplain tributaries to create low velocity, deep ponds with channels and complex woody debris cover	Combine spawning sites within outlet channels to seed habitat	Excavate ponds, join existing ponds with channels, or berm flow to backwater areas to create/enhance deep winter refuge habitat along floodplain at low risk of damage from mainstem, dig around beaver dams to create fish access
2	CO, RB, BT	Fry, Parr	Side-channel rearing	Enhance/create rearing habitat in side-channels exposed to mainstem flows	-	Extend existing side channels and construct new side-channels with regulated water intakes; add complex with woody debris, boulder clusters and scour structures to increase fry/parr shear zones, slow areas and abundant cover, particularly if clear tributary flows into side-channel
3	CO, RB, BT	Fry, Parr, Adult	All habitats with obstructed access (i.e., beaver dams)	Restore fish access to existing habitat through improvements	-	Restore fish access through beaver dams with various techniques
4	CO, RB, BT	Adult	Spawning habitat	Improve/create spawning habitat with gravel placements	Improve invertebrate production in gravels	Add gravel to inlet/outlet streams and/or gravel retention structures to improve abundance and quality of spawning area

Notes:
Dashes indicate not applicable
Species: BT = Bull Trout, CO = Coho Salmon, RB = Rainbow Trout

Figure 5.2-1

Potential Offsetting Site Locations

ERM

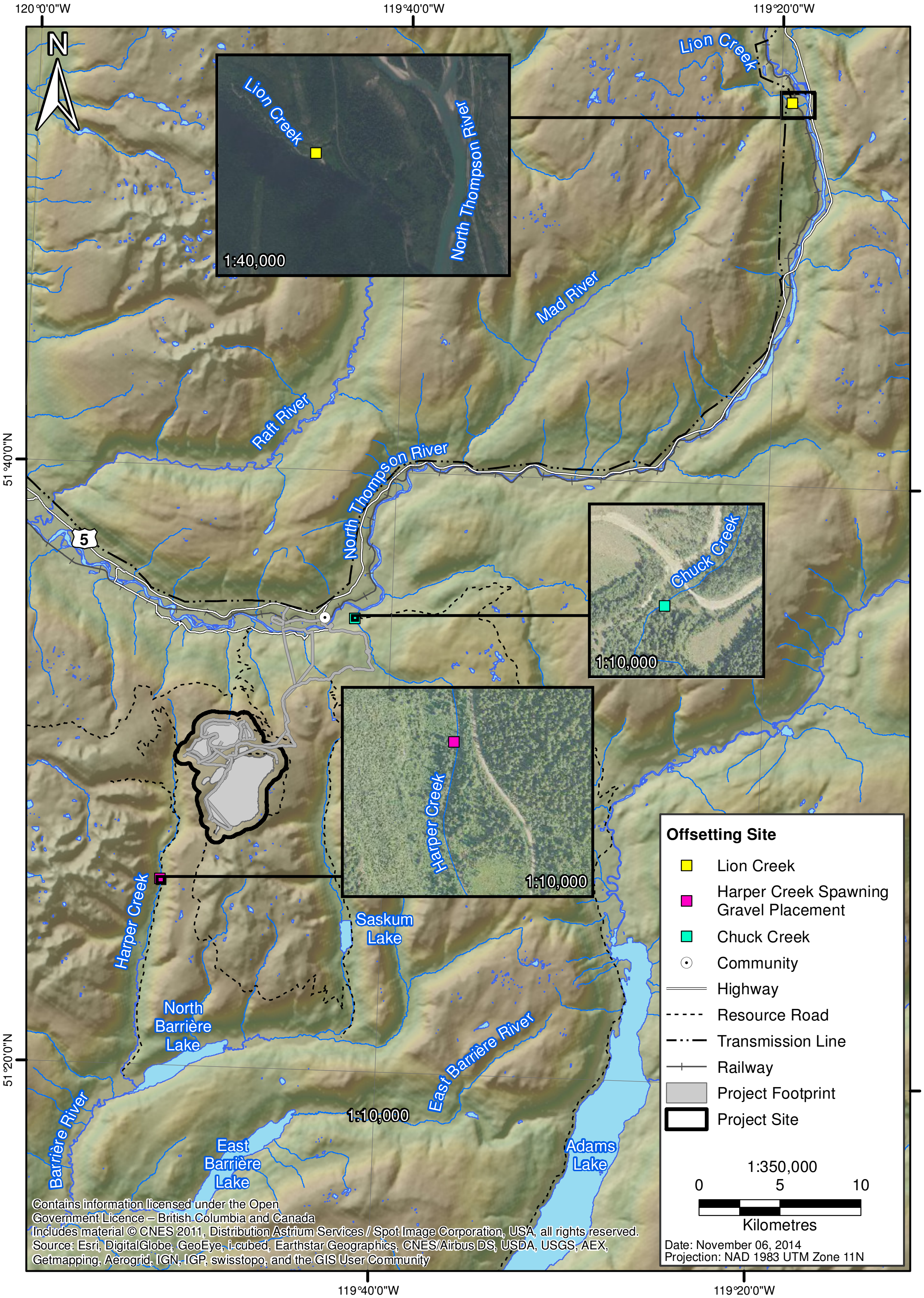


Table 5.2-3. Project Screening Criteria for Offsetting Sites

Waterbody	Site Number	Compensation Project Type	Screening Criteria: DFO Hierarchy for Compensation	Regional Fisheries Management Objectives	Technically Feasible	Economically Feasible	Stable and Permanent	Able to Offset for Habitat Losses	Biologically Relevant
Lion Creek	1	Off-channel pond creation and fish passage enhancement	3b Increase productive capacity of unlike habitat in a different EU	Addresses MOE objectives	Yes	Yes	Yes Long term benefit	Yes Large project 1.1 ha technically feasible	Yes Bull Trout and Coho multispecies benefit
Harper Creek	2	Stream spawning habitat creation	1 Replacing lost habitat with the same habitat in the same ecological unit	Addresses MOE objectives	Yes	Yes	Yes Long term benefit, Flow reduction improve stability	Yes In-kind offsetting 400 m²	Yes Bull Trout specific benefit
	3	Off-channel pond creation	1 Replacing lost habitat with the same habitat in the same ecological unit	Addresses MOE objectives	Area available not large enough to meet offsetting requirements	Yes	Yes Long term benefit	No Will need more than one other site to meet offsetting requirements	Yes Bull Trout and Coho multispecies benefit
	4	Fish passage enhancement	2 Increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit	Addresses MOE objectives	Yes but is currently passable at some flows for some fish	Yes	Yes Long term benefit	No Currently passable at some flows for some fish	Yes Bull Trout and Coho multispecies benefit
Chuck Creek	5	Fish passage enhancement	2 Increasing the productive capacity of existing habitat with unlike habitat in the same ecological unit	Addresses MOE objectives	Yes , but it is not an "orphaned" structure to meet Fisheries Offsetting requirements	Yes	Yes Long term benefit	N Does not meet Fisheries Offsetting requirements	Yes Bull Trout and Coho multispecies benefit

Notes: Dashes indicate not applicable
EU = ecological unit; DFO Hierarchy for Compensation: refer to Section 5.2 for definitions

Regional fish and fish habitat objectives specifically relevant to the study area watersheds have not been developed by the MOE. In lieu of this, provincial fisheries management objectives developed by the MOE for species other than migratory Pacific Salmon (BC MOE 2010) were applied for screening purposes. These objectives broadly include:

- maintenance of healthy fish habitat;
- Maintenance or enhancement of indigenous fish populations;
- sustainable water quality and use;
- effective management and stewardship of fish and wildlife species, ecosystems and protected areas;
- shared stewardship with Aboriginal Groups to protect the environment; and
- increasing and diversifying angling opportunities for recreation and employment.

Similarly DFO has not developed specific regional objectives for the study area watersheds. However, DFO is responsible for the management of migratory Pacific salmon; therefore this was taken into consideration during the screening.

The preliminary offsetting projects were screened to be consistent with habitat projects in the North Thompson drainage that are implemented by various organizations including Federal and Provincial governments, First Nations, and stakeholder groups. All preliminary offsetting projects fulfilled DFO's and/or MOE's regional fisheries management objectives. All projects are economically feasible, stable and permanent. The majority of projects have the potential for multispecies benefit.

A holistic approach was implemented to prioritize the preliminary offsetting sites, with the primary objective of balancing the impacts with the offset projects to achieve an offsetting ratio of approximately 2:1. The approach took into consideration the screening results; site-specific risks; uncertainty, and opportunities; fish habitat area and productivity gained from preliminary offsetting sites; site access; design complexity; and construction costs.

Sites were selected based upon their location relative to the Project area, accessibility for Bull Trout and Coho Salmon, current habitat complexity, future potential habitat complexity, site accessibility, and ease of potential habitat enhancement or creation work. Sites were prioritized based upon the feasibility of proposed habitat offsetting and scale of the potential habitat improvements. Sites that did not provide significant opportunities for habitat enhancement or creation were not assessed further.

Based on the review it was determined that Lion Creek and the placement of spawning gravel in Harper Creek would be the most productive habitat creation and enhancement options. These options were further evaluated and designed to a technically feasible level, and are presented in the following sections. Both an in-kind offset project (lower Harper Creek) and an out-of-kind offset project (Lion Creek) were chosen as appropriate offsetting measures.

6. TECHNICALLY FEASIBLE OPTIONS

6.1 LION CREEK

6.1.1 Site Description

6.1.1.1 Location

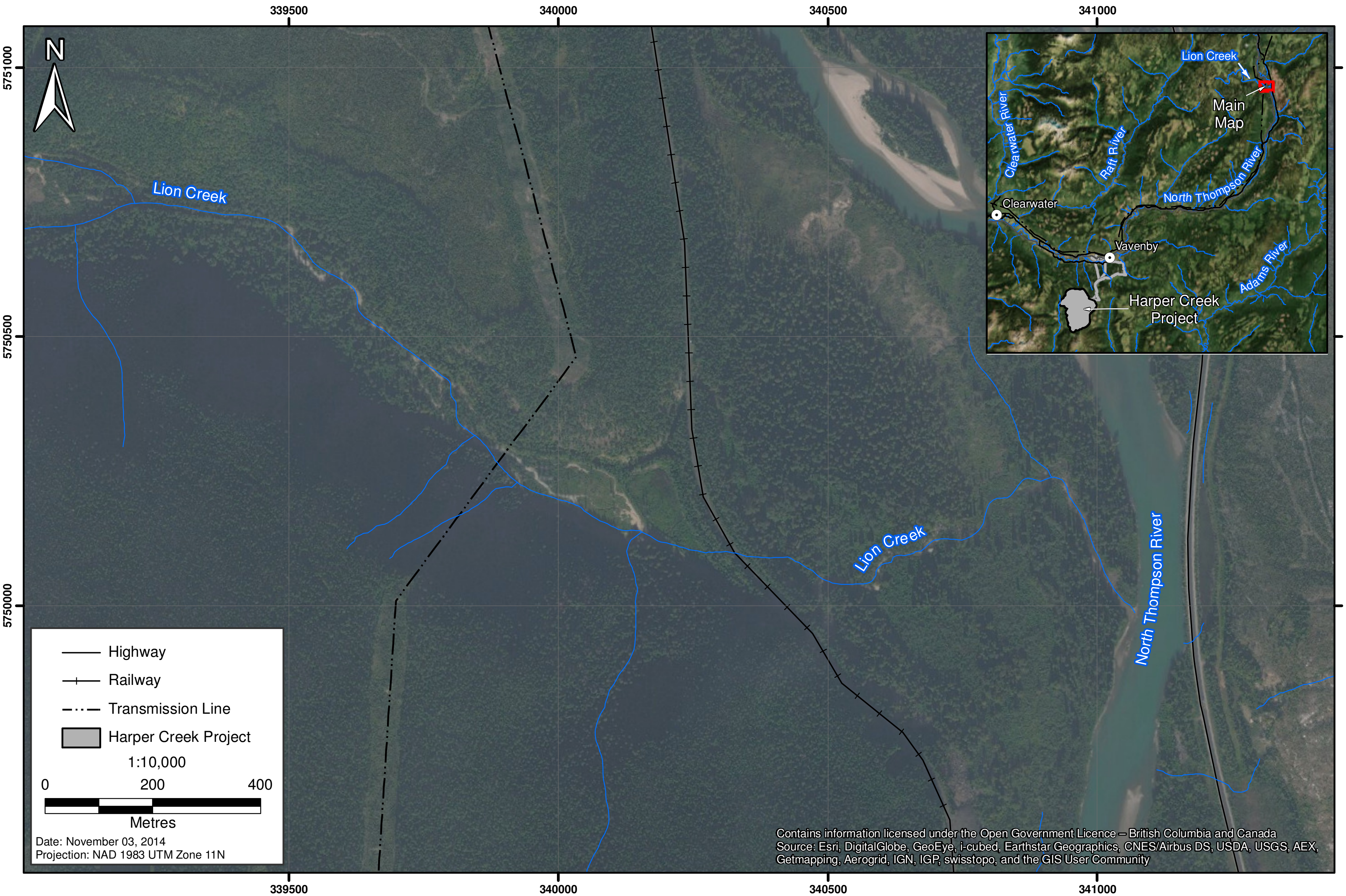
Lion Creek (also referred to as Lyon Creek) is listed as watershed code 129-613200 and waterbody identifier 00000UNTH. The confluence of Lion Creek and the North Thompson River is located at UTM 11U 341060E 5749987N (Figure 6.1-1). For the purposes of this FOP, Lion Creek is divided into two main reaches: lower and upper Lion Creek. Lower Lion Creek is delineated from the CN Rail crossing (UTM 11U 340100E 5750218N) downstream to its confluence with the North Thompson River. Upper Lion Creek is delineated from the CN Rail crossing to the upper headwaters.

This offsetting project is adjacent to the floodplain of Lion Creek (Plates 6.1-1 and 6.1-2). Much of the area is seasonally wetted and poorly connected (Plate 6.1-3). This lack of connectivity may result in habitat isolation, fish stranding and fish predation within the remaining wetted areas. Fish access to upper Lion Creek may occur through the CN Rail bedrock tunnel (Plate 6.1-4) by anadromous and adfluvial fish, and by resident fish moving downstream from the upper watershed.

Plate 6.1-1. Area adjacent to the base of the rail grade east of the existing berm, August 2014.

Figure 6.1-1
Location of Lion Creek

ERM



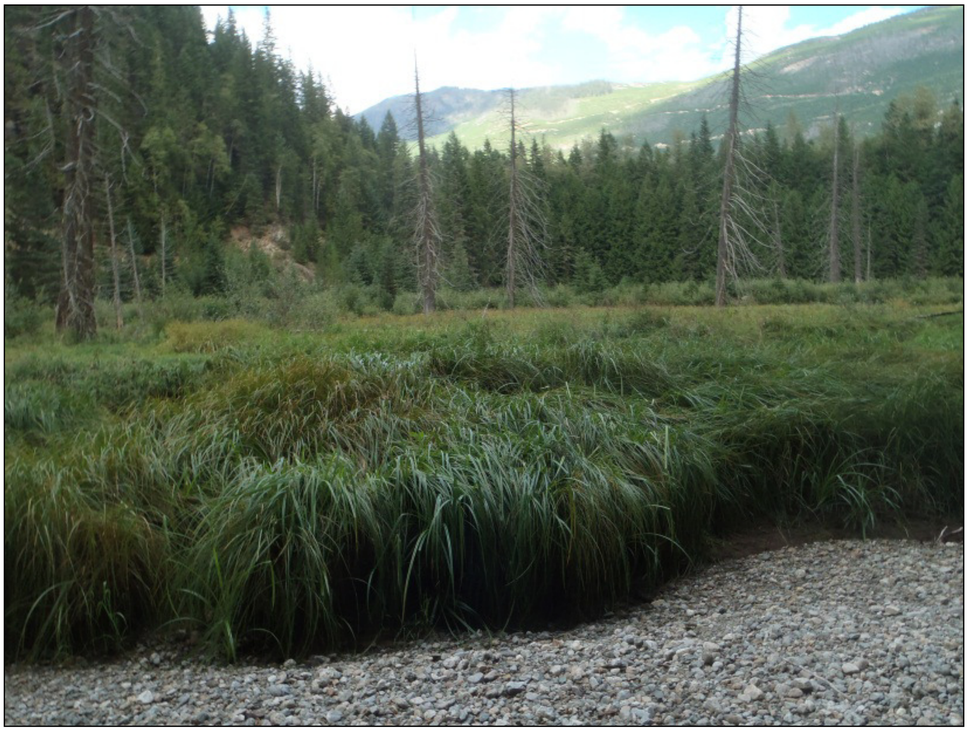


Plate 6.1-2. Lion Creek flood plain upstream of the berm looking east towards the rail grade, August 2014.

Plate 6.1-3. Seasonally inundated side channel of Upper Lion Creek, August 2014.

Plate 6.1-4. Lion Creek immediately upstream of the CN Rail bedrock tunnel, August 2014.

6.1.1.2 Vegetation and Wildlife

The Lion Creek site is largely covered by grasses and sedges that are seasonally inundated. There are a few trees that likely provide habitat value. These larger trees were identified in the topographic survey. The valley walls are predominately dominated by a canopy of cedar (*Thuja* spp.) and Douglas fir (*Pseudotsuga menziesii*). The understory is composed devils club (*Oplopanax horridus*), alder (*Alnus* spp.), and willow (*Salix* spp.). Plant communities within the wetted areas are typically grasses and sedges, with willow and other small shrubs.

During the site visits wildlife presence was noted, specifically:

- recent beaver dam construction activity (Plate 6.1-5);
- ungulate tracks (Mule deer [*Odocoileus hemionus*] and Moose [*Alces alces andersoni*], were also observed; and
- kingfishers and frogs.

6.1.1.3 Archaeology

Based on a search of the BC Archaeological Site Database (accessed October 9, 2014) there are no archaeological sites recorded within 5 km of the offsetting site location.

6.1.1.4 Fish Community and Habitat

The fish community of Lion Creek has been characterized through numerous historical studies (FISS 2014). Historical documentation shows that a total of eight fish species inhabit Lion Creek, including: Bull Trout, Chinook Salmon, Coho Salmon, Dolly Varden (*Salvelinus malma*), Mountain Whitefish, Rainbow Trout, Sculpin (*Cottus* spp.), and Sockeye Salmon. Lower Lion Creek is a major spawning location for Chinook, Coho, and Sockeye Salmon migrating from the North Thompson River.

Plate 6.1-5. Beaver activity at Lion Creek.

Habitat use by spawning Chinook, Coho, and Sockeye Salmon appears to be restricted to the lower reaches downstream of the CN Rail crossing. At this location, several small (< 1 m) cascades may impede further upstream migration by adult salmon (Plate 6.1-6).

Plate 6.1-6. Cascade immediately downstream of the CN Rail water tunnel, Lion Creek, August 2014.

In addition, migrating salmon must also enter and proceed through a blasted bedrock tunnel under the CN Rail crossing. Based upon observations of flow and discharge, this bedrock tunnel does not appear to restrict flow and is not likely to be a barrier for migrating fish. Migration into upper Lion Creek may be further restricted due to the presence of beaver dams and beaver activity at the upstream end of the bedrock tunnel.

Additional current fish and fish habitat information is described in Section 6.1.5.5 below.

6.1.2 Objectives and Technique

The objectives for the Lion Creek habitat enhancement and creation offsetting project are:

- to create 1.1 ha of high quality overwintering and rearing pond habitat for Coho Salmon;
- to enhance the functional aspects of wetland ecosystems (e.g., nutrient recycling, water storage, water quality improvement, and fish and wildlife habitat); and
- to provide spawning, incubation, and rearing habitat for Coho Salmon and Bull Trout using gravel substrate, large woody debris, and deep pools within the constructed channels.

Currently, the Lion Creek site consists of approximately 3 ha of existing seasonally wetted, shallow, discontinuous, and marginal fish habitat. The creation and enhancement of habitat at Lion Creek will provide up to an estimated 1.1 ha of high quality and productive multi-species spawning and rearing habitat.

6.1.3 Methodology

6.1.3.1 Desktop Analysis

Fish habitat offsetting planning is an iterative process. Offsetting planning requires knowledge of project related fish habitat impacts, fish presence and distribution within the study area, quality of habitat impacted, population size and demography of impacted species.

A desktop analysis was conducted prior to commencing fieldwork for offsetting project identification and assessment. Professional, local knowledge of the area was also utilized. A background literature review was completed for watersheds within and outside of the fisheries study area boundaries. In addition, a background literature review was completed for species-specific habitat limiting factors based upon peer-reviewed papers. The watershed literature reviews focused on the identification of factors limiting productive capacity within individual watersheds, which include understanding the species and life history stages present, identification of known key habitats (e.g., over-wintering and spawning areas), and identification of anthropogenic impacts within watersheds.

6.1.3.2 Field Assessment

<u>Site Identification</u>

Sites were groundtruthed on multiple occasions to refine site objectives; identify opportunities, site-specific constraints, biological relevance, stability, permanence, target species, target habitat, and target life history stage. Assessment of site-specific constraints and opportunities included: water supply magnitude and dependability, flood risk, water quality, sediment supply, gradient, soil stability, site constructability and access, construction costs, stability and durability of instream structures, obstructions and beaver dam risk, and time to full functionality of site.

A qualitative feasibility assessment, based upon professional experience, was conducted in 2014 for each proposed offsetting site. These assessments were conducted by a water resources engineer to determine the technical feasibility of the sites.

Topography

Site topography was evaluated using air photos, topographic survey information and ground-truthing. A detailed topographic survey was conducted from August 25-26, 2014 at Lion Creek using a Nikon Nivo 3M (Model A151438) Total Station. This survey captured information with regards to the existing Lion Creek channel, water surfaces, existing berm, and key features (e.g., trees, wetlands).

Fish Habitat

The objective of the fish habitat surveys was to use a standardized approach to describe baseline (pre-construction) conditions of fish habitat at the Lion Creek site. Existing habitat was documented using the Fish Habitat Assessment Protocol (FHAP; Johnston and Slaney 1996). FHAP was conducted at existing representative target habitat types, including beaver impoundments, riffles, pools, and riffle/pool complexes.

FHAP assessments involved differentiating the stream into separate habitat units such as riffles, cascades, glides and pools, and then measuring an array of physical attributes for each habitat unit (Table 6.1-1). These attributes included data on mean depth, mean width, substrate composition, observations on flow conditions, fish cover, potential barriers, bank stability, and bank height. Data were collected with a measuring tape, metre stick, and range finder. At each site, UTM coordinates (NAD 87) were recorded with a handheld Garmin 60CSx GPS unit. A minimum of two photographs (e.g., upstream and downstream) were taken to document each stream site. Additional photographs were taken of stream features (e.g., barriers or falls) and UTM coordinates were recorded using a hand-held GPS unit.

Table 6.1-1. Fish Habitat Assessment Variables

Substrate Types	Physical Measurements	Habitat	Cover
• % Sand	• Length (m)	• Habitat Type	• % Deep Pool
• % Gravel	• Mean Depth (m)	• Pool Type	• % Boulder
• % Cobble	• Bankfull Depth (m)	• Pool Residual Depth	• % Instream Vegetation
• % Boulder	• Wetted Width (m)	• Bank Stability	• % Undercut
• % Bedrock	• Bankfull Width (m)	• Confinement	• % Large Woody Debris
• Bank Texture	• Gradient (%)	• Hill-slope Coupling	• % Small Woody Debris
	• Bank Height (m)	• Stream Pattern	• % Canopy Closure
		• Islands/Bars	• % Riparian Cover
		• Fish Passage Barriers	• % Overhanging Vegetation

Stream habitats within these sites were separated into the following habitat units:

- Pool – low velocity area with smooth, non-turbulent flow, low gradient (near 0%), and a concave bottom;
- Glide – an area of smooth, non-turbulent flowing water with moderate velocity and gradient less than 4%;
- Riffle – an area of turbulent, fast-flowing water with a gradient less than 4%; and
- Cascade – high gradient (> 4%) area of turbulent, fast-flowing water.

Data collected for each habitat variable were used to evaluate the overall quality of fish habitat. Professional knowledge and expertise was used to rank habitat suitability for each fish life history stage (i.e., spawning, rearing, and over-wintering) and overall habitat quality (categorized as none, poor, fair, or good; Table 6.1-2).

Table 6.1-2. Life History Habitat Suitability and Overall Habitat Quality Criteria

Life Stage Suitability Rank	Criteria
None	No habitat present for any life history stage
Poor	Most of the necessary physical/biological components of the habitat for this life history stage are missing or severely deficient
Fair	Some of the necessary physical/biological components of the habitat for this life history stage are present, but a key component is missing
Good	All of the necessary physical/biological components of the habitat for this life history stage are present
Overall Habitat Quality Rank	**Criteria**
None	No habitat present
Marginal	Low productive capacity
Important	Common habitat which supplies basic needs of fish (typically includes rearing habitat with some spawning habitat potential)
Critical	Rare or exceptionally productive or unusual habitat with very high habitat values which are of uncommon and/or highly valuable

Fish Community

Lion Creek was sampled using a Smith-Root LR 24 backpack electrofisher and Gee minnow traps following *RISC Fish Collection Methods and Standards* (RISC 1997), *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Standards and Procedures* (RISC 2001) and the *Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: Fish Collection Field Guide* (RISC 1999). Backpack electrofishing was conducted at riffles and riffle/pool target habitat types. Electrofishing site length and effort varied depending upon target habitat type. Three-pass depletion electrofishing surveys were used to estimate fish abundance at each target habitat site where stream cover and water depth permitted. A systematic sweep was conducted across the entire wetted width from the downstream to the upstream site boundary (Stanfield 2005). Electrofishing effort was not pre-determined due to differences between site and available habitat. Electrofisher variables such as voltage (V), frequency (Hz), pulse width (ms), and duty cycle (%) were set at 450 V, 30 Hz, 4 ms, and 12%. These settings remained consistent for all survey sites.

Minnow traps were used in beaver impoundment and pool habitat types where depth was greater than 0.5 m. Minnow traps consisted of two wire mesh cylinders (mesh size 0.63 cm) locked together using a clip attached to a rope and marker buoy. Each trap was baited with a roe sac or commercial crab bait. Minnow traps were set overnight for approximately 24 hours, and retrieved the following day. All traps were marked with contact information and the fish collection permit number.

Captured fish were identified to species and given a unique sample number. The life history stage (i.e., fry, 0+; parr, 1+; parr, 2+; or adult) was recorded. Length was measured to the nearest 1 mm with a measuring board. Species with a forked tail (e.g., Bull Trout) were measured from the nose to the tail notch for fork length (FL). Species without a forked tail (e.g., Sculpin spp.) were measured from the nose to the end of the tail for total length (TL). Wet weight was collected (to the nearest 0.01 g) with an Ohaus Scout 200 g scale. Observations were recorded on the general condition of each fish, noting the presence of deformities, erosions, lesions, and tumours (DELTs). All captured target species (e.g., Bull Trout or Coho Salmon) were sampled scales and fin rays. Scales were collected with tweezers below the posterior margin of the dorsal fin on the left side of the sampled fish. Two to three rays of the left pelvic fin were also collected with scissors or pliers. Aging structures were placed in envelopes labelled with the site, date, species, and sample number.

6.1.4 Feasibility Assessment

Based on the office review and the field data observation, the feasibility of the Lion Creek Site was assessed. Isolated standing water elevations were compared to flowing surface water for groundwater flow development. Soils were evaluated for groundwater development potential and site rehabilitation.

Site topography was evaluated using air photos and topographic survey information and subsequent ground-truthing. To aid in design evaluation, topographic features, such as remnant channels and ground water seeps, were identified to optimize the water supply and pond and channel alignments on the site.

Construction feasibility was assessed primarily in terms of earthworks volumes, water management, and sediment and erosion control as well as site access.

Table 6.1-3 summarize the criteria evaluated for the site and describes the benefits of these features. Additional biological criteria are shown in Appendix C.

Table 6.1-3. Summary of Criteria and Benefits for Selecting Lion Creek Site

Criteria	Description	Reason	Benefit
Area	Scale of site	A larger site able to provide more habitat as well as reduce construction, maintenance and monitoring costs	1.2 ha of wetted habitat
Water Supply	Groundwater	Groundwater has habitat benefits including temperature buffering, flow consistency and low turbidity	Improved water quality and productivity (e.g., turbidity and temperature) for fish After excavation, groundwater provides connectivity and habitat at low flows
Topography	Water level relationships	Water supply feasibility determination	Groundwater development
	Remnant channel identification	Able to use natural topography	Reduce excavation and site disturbance Groundwater development
Earthworks	Subsurface building materials	Suitability for spawning, berm construction, bank stability	Subsurface materials are suitable for berm construction, spawning substrate and for ground water development
	Flood risk	Risk to site	Reduced maintenance Site located in wider reach of the Creek
Biological	Habitat types	Wetland/shallow pond	Increased summer fish productivity and supports ecosystem approach
		Stream	Spawning areas to 'seed' site
		Overwintering	Deeper areas are below expected ice cover Groundwater has habitat benefits including temperature buffering, flow consistency and low turbidity
	Fish presence	Species	Only sculpin present, all habitat constructed is new Coho and Bull Trout downstream for recruitment
		Fish Recruitment into site	Access is into Lion Creek with holding area and flow present
Maintenance Considerations	Beaver	Maintenance	Beaver are present in the area - incorporate plans for mitigating them
	Sedimentation	Productivity and maintenance	Groundwater is the primary water source and will have low turbidity Site will be bermed using spoil material to provide protection from sediment and bedload transport

6.1.5 Results and Observations

6.1.5.1 Basin Description

The Lion Creek drainage basin is located in the Interior Plateau in the Monashee Mountains and extends south and west, covering approximately 48 km^2 (Rood 1995). The project site is upstream of the CN Rail culvert crossing approximately 700m upstream of the confluence with the North Thompson. The project is mainly located on the floodplain surface. Ecosystems within the Project site are dominated by a canopy of cedar and Douglas fir. The understory is composed devils club, alder, and willow. The wetland areas are grasses and sedges. Soils are primarily alluvial in origin consisting of a well-graded mix of cobbles, gravels and sands with a few boulders.

In addition to the CN Rail ROW, historical logging activities are found within the watershed area as well as a power line ROW and historic highway road alignment.

6.1.5.2 Channel Geomorphology

Lion Creek is a gravel-based pool and riffle channel system. There is some functional large woody debris (LWD) found within the channel itself, although most LWD occurs along the channel margin and in large accumulations (i.e., jams). Substrate consists of coarse sands, gravels, and cobbles. There are some larger boulders along the stream margins where the creek meets the valley edge (Plate 6.1-7). Due to the bedload deposition and low water levels during the summer, the Lion Creek mainstem is not continuous upstream of the CN Rail crossing. Shallow, isolated pools become more frequent progressing upstream of this location.

Plate 6.1-7. Typical stream channel upstream of water tunnel.

The dominant controlling feature of the Site is the railway water tunnel (Plate 6.1-8). It is clear from field investigations and aerial photo review that Lion Creek once had an active flood plain associated with its confluence with the North Thompson River. However, since construction of the railway in the 1920s, a large part of the flood plain is no longer active. The high water level upstream of the railway appears to be controlled by the water tunnel. Beaver also appear to influence the channel alignment.

Plate 6.1-8. Upstream end of CN Rail water tunnel.

6.1.5.3 Hydrology

Reporting of surface water hydrology for Lion Creek is based upon DFO documentation of the North Thompson watershed and field observations in 2014. The Lion Creek watershed is 48 km^2, with approximately 10% of the watershed logged (Rood 1995). The mean annual flow for Lion Creek is 0.9 m^3/s with a peak flood of 8.6 m^3/s (Rood 1995). Generally, peak annual flows occur in June and are related to snowmelt. During the fall, increased flows occur in response to intense rainfall events. Winter low flows tend to develop by mid-November and continue until spring freshet. Lion Creek has a 7-day winter low flow of 0.061 m^3/s, and 7-day summer flow of 0.069 m^3/s (Rood 1995). The mean August and September monthly flows are 0.17 and 0.14 m^3/s, respectively (Rood 1995). Instream low flows during summer and winter are reported to limit fish habitat in Lion Creek (Rood 1995). Surface water flow was measured at the CN Rail tunnel on Aug 26, 2014 as 0.23 m^3/s (Appendix D).

There is one water license (C060981; Appendix E) held by DFO on Lion Creek for conservation purposes. The license is for 0.23 m^3/s. This license was intended for construction of an enhancement facility (i.e., hatchery) that has not been built to date. The identified point of diversion for the license is downstream of the CN Rail.

As there are no plans for a surface water intake at the Lion Creek site, a water license should not be required for this project. The development of Lion Creek as an offsetting site is based upon groundwater supply, and thus should not impact the water license for the planned enhancement facility. The proposed offsetting project is non-consumptive and flows will remain unchanged downstream of the CN rail grade.

6.1.5.4 *Groundwater*

Observations regarding groundwater were made during onsite field surveys. The upper reach of Lion Creek is fed largely by groundwater. The water appeared to be at or near the surface in a variety of locations suggesting sources from both the alluvial fan and the hillside. A significant seep was observed from the river right hillside (UTM 11U 0339977 E 5750186 N; Plate 6.1-9), and seepage flow was measured as 0.10 m^3/s on Aug 26, 2014 (Appendix A).

Plate 6.1-9. Arrow points to location of groundwater seepage from hillside.

In the area located between the berm and the rail grade there are a series of shallow small pools and flowing channels. The water surface in this area is below the Lion Creek water surface elevation at the tunnel entrance. Based on visual observation of flowing water and its direction, it is suspected that this water is continuing subsurface through the rail grade, likely through the original Lion Creek channel alignment prior to the rail being constructed. This is not an uncommon occurrence and has been observed at other rail grades in the BC Interior.

6.1.5.5 *Fish Habitat*

The existing fish habitat at the Lion Creek site was accessed in low flow conditions on September9, 2014. A total of five (5) sites were surveyed for fish habitat using FHAP (Figure 6.1-2). Table 6.1-4 shows the UTM coordinates for the five FHAP sites and their associated representative habitat types.

Figure 6.1-2
Fish Habitat and Fish Community Sites, Lion Creek

ERM

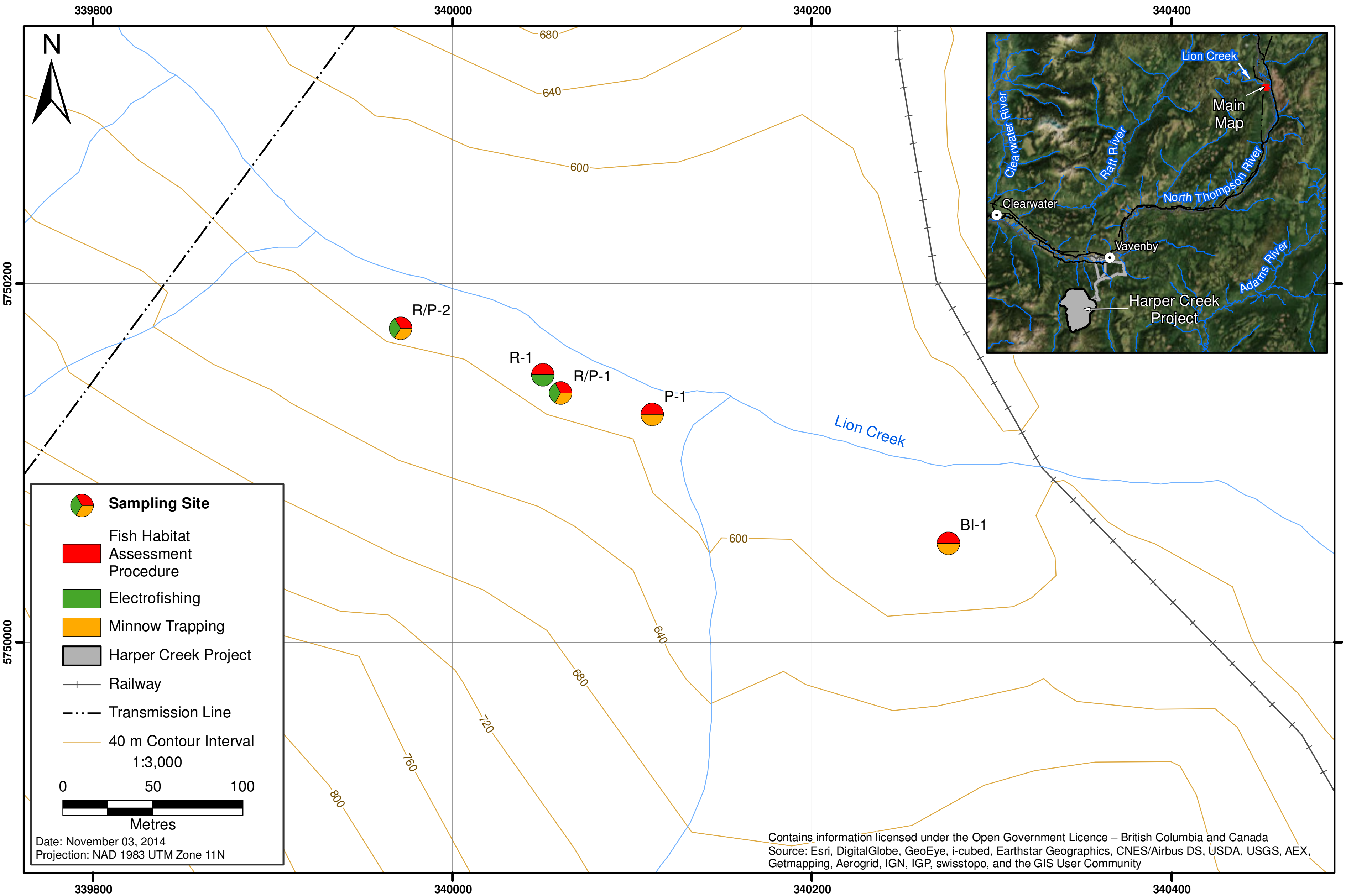


Table 6.1-4. Fish Habitat and Community Sites

Site	Target Habitat Type	UTM Coordinate			FHAP	Fish Community	
		Zone	Easting	Northing		EF	MT
BI-1	Beaver impoundment	11U	340276	5750055	X	—	X
P-1	Pool	11U	340111	5750127	X	—	X
R-1	Riffle	11U	340050	5750149	X	X	—
R/P-1	Riffle-pool	11U	340060	5750139	X	X	X
R/P-2	Riffle-pool	11U	339971	5750175	X	X	X

Notes:
X = sampling conducted
Dashes (—) = data not collected

Site BI-1 (Beaver Impoundment 1) was located immediately upstream from the CN rail tunnel. A series of ephemeral beaver dams were constructed within the mainstem of Lion Creek creating a series of step-pool habitat (Plate 6.1-10). Mean bankfull and wetted width was 10 m and 9 m, respectively. Mean bankfull and wetted depth was 1 m and 0.4 m, respectively. Fines were observed as the dominant substrate type, while gravel was observed as the subdominant substrate type. Cover for fish was limited to deep pool, with traces of boulder, overhanging vegetation, small and large woody debris, and undercut bank. Rearing habitat was rated as fair due to the abundance of cover for juvenile fish. Migratory and overwintering habitats were rated as poor due to the presence of beaver dams, and lack of depth, respectively. Spawning was rated as none due to the abundance of fine substrate. Overall, fish habitat within site BI-1 was rated as marginal.

Plate 6.1-10. Beaver impoundment located immediately upstream of the CN Rail tunnel.

Site P-1 (Pool 1) was located upstream from site BI-1, and above the series of beaver dams. This site was representative of existing deep (> 1 m) pool habitat at the Lion Creek site (Plate 6.1-11). Mean bankfull and wetted width was 13 m and 11 m, respectively. Mean bankfull and wetted depth was 1.2 m and 0.7 m, respectively. Fines and gravel were observed in equal proportion. Scour pool depth ranged from a maximum of 1.2 m to a crest depth of 0.3 m. Cover for fish was limited to deep pool (50%), with traces of small and large woody debris (10% each), and undercut bank (5%). Rearing, feeding, and overwintering habitat were rated as fair due to the lack of cover and habitat complexity for fish of various life stages. Migratory habitat was rated as good due to lack of impediments to migration (e.g., beaver dams, large woody debris jams). Spawning was rated as none due to the abundance of fine substrate. Overall, fish habitat within site P-1 was rated as marginal.

Plate 6.1-11. Existing pool habitat.

Site R-1 (Riffle 1) was selected as representative existing riffle habitat at the Lion Creek site (Plate 6.1-12). Mean bankfull and wetted width was 11 m and 6 m, respectively. Mean bankfull and wetted depth was 0.38 m and 0.1 m, respectively. Substrate consisted exclusively of gravel. Cover for fish was limited to trace amounts of undercut bank (10%) and overhanging vegetation (5%). Rearing and adult feeding habitat were rated as poor due to the lack of cover and habitat complexity for fish of various life stages. Migratory habitat was rated as good due to lack of impediments to migration (e.g., beaver dams, large woody debris jams). Spawning was rated as good due to the abundance of gravel substrate. Overall, fish habitat within site R-1 was rated as marginal due to the lack of habitat complexity and cover.

Plate 6.1-12. Existing riffle habitat.

Site R/P-1 (Riffle-pool 1) was selected as representative existing riffle-pool habitat at the Lion Creek site. This site was located upstream from site R-1. Stream morphology of this site was classified as riffle-pool. Mean bankfull and wetted width was 9 m and 3 m, respectively. Mean bankfull and wetted depth was 0.2 m and 0.5 m, respectively. Substrate consisted primarily of gravel (dominant) and fines (subdominant), with trace amounts of boulder and cobble. A scour pool (habitat unit 2) exhibited a maximum and crest depth of 0.6 m and 0.1 m, respectively. Cover for fish was abundant, especially in pool habitat with accumulations of large woody debris. Spawning and rearing habitat were rated as good due to abundant cover and gravel substrate. Rearing and adult feeding habitat were rated as poor due to the lack of cover and habitat complexity for fish of various life stages. Migratory habitat was rated as fair due to the presence of large woody debris jams. Overwintering habitat was rated due to the lack of pools greater than 1 m in depth. Overall, fish habitat within site R/P-1 was rated as marginal.

Site R/P-2 (Riffle-Pool 2) was located upstream from site R/P-1, and selected as a second representative existing riffle-pool habitat at the Lion Creek site. Mean bankfull and wetted width was 9.7 m and 7.3 m, respectively. Mean bankfull and wetted depth was 0.73 m and 0.24 m, respectively. Gravel and fines were the dominant and subdominant substrate types in all habitat units. A scour pool (habitat unit 2) exhibited a maximum and crest depth of 1 m and 0.3 m, respectively. Cover for fish was primarily composed of large and small woody debris, and abundant in riffle and pool habitat units. Spawning, rearing and migration habitat were rated as good due to the presence of gravel substrate, abundance of cover, and habitat complexity for fish of various life stages. Overwintering habitat was rated as fair due to the presence of a single deep pool that may provide sufficient depth for overwintering. Overall, fish habitat within site R/P-1 was rated as important.

6.1.5.6 Fish Community

The existing fish community at the Lion Creek site was accessed on September 9 and 10, 2014. The same five sites surveyed for fish habitat were surveyed for fish community (Figure 6.1-1; Table 6.1-4). Riffle site 'R-1' and riffle/pool complex sites 'R/P-1' and 'R/P-2' were surveyed for fish community using a backpack electrofisher. Pools within riffle/pool sites were also surveyed with minnow traps. Larger pool and beaver impoundment sites (e.g., site 'P-1' and 'BI-1') were surveyed exclusively with minnow traps.

Tables 6.1-5 and 6.1-6 present summaries of effort and CPUE data for sites sampled using electrofishing and minnow trapping methods, respectively. Slimy Sculpin (*Cottus cognatus*; Plate 6.1-13) were the lone fish species captured from Lion Creek during early September. Slimy Sculpin were not categorized by life stage due the lack of external indicators of development (e.g., parr marks). Target species, including Bull Trout and Coho Salmon, were not present at the Lion Creek site during the time of the survey. The highest CPUE of Slimy Sculpin captured by electrofishing was 4.25 fish/100 s at site R/P-2. Minnow traps captured Slimy Sculpin at site BI-1 only. Thus, the preferred existing habitat of Slimy Sculpin at the Lion Creek site appears to be riffle-pool complexes.

Table 6.1-5. Electrofishing Effort and Catch Summary

Site	Date	Effort (s)	Species	No. of Fish	CPUE (fish / 100 s)
R-1	10-Sep	742	CCG	11	1.48
R/P-1	10-Sep	1,421	CCG	6	0.42
R/P-2	10-Sep	612	CCG	26	4.25

Notes:
Fish species codes: CCG = Slimy Sculpin
SD = standard deviation; SE = standard error of the mean
Dashes (—) indicate no data.

Table 6.1-6. Minnow Trapping Effort and Catch Summary

Site	Date	Effort (h)	Species	No. of Fish	CPUE (fish / trap / 24 h)		
					Mean	SD	SE
BI-1	10-Sep	130	CCG	2	0.37	0.83	0.37
P-1	10-Sep	130	no catch	—	—	—	—
R/P-1	10-Sep	127.5	no catch	—	—	—	—
R/P-2	10-Sep	127.5	no catch	—	—	—	—

Notes:
Fish species codes: CCG = Slimy Sculpin
SD = standard deviation; SE = standard error of the mean
Dashes (—) indicate no data.

Plate 6.1-13. Slimy Sculpin captured from riffle-pool habitat.

Biological data collected from sampled Slimy Sculpin are summarized and presented in Table 6.1-7. The total length, weight, and condition of sampled Slimy Sculpin from beaver impoundment, riffle, and riffle-pool sites were consistent. Total length of Slimy Sculpin ranged from 24 mm to 85 mm, with a mean of 57 mm overall. The mean condition (K) was 1.00, which is expected for Slimy Sculpin.

6.1.6 Project Design

Detailed project design plan and profile drawings are found in Appendix F. The proposed offsetting site is located on the north side of the Lion Creek valley. The site will extend down-valley parallel to Lion Creek, and flow into an existing pool that drains into the main channel upstream of the CN Rail tunnel. The preliminary design consists of a groundwater-supplied series of six ponds and interconnecting channels, with a total wetted area of 1.1 ha. The purpose of the channels and ponds is to provide off-channel rearing, refuge and overwintering habitat. Currently the area between the berm and the CN Rail alignment can become a "fish trap" after high water recedes. A key feature of this project will improve the habitat continuity of the site.

The ponds and channels presented in the technically feasible design drawings (Appendix F) are preliminary and will be further developed during the detailed design phase. Preliminary areas for each type of habitat are presented in Table 6.1-8. During the detailed design phase, additional complexity and specific habitat features will be prescribed such as pool-riffle morphology, shoal-island-deepwater complexing in ponds, LWD placement frequency and orientation, and riparian prescriptions including low-bank wetland vegetation. Figure 6.1-3 illustrates typical habitat complexing features.

Table 6.1-7. Fish Biological Data Summary

Site	Species	Method	Total Length (mm)					Weight (g)					Condition (K)				
			n	Mean	Min	Max	SE	n	Mean	Min	Max	SE	n	Mean	Min	Max	SE
BI-1	CCG	MT	2	61	57	64	4	2	1.9	1.7	2.1	0.2	2	0.86	0.80	0.92	0.06
R-1	CCG	EF	6	51	24	71	9	4	3.0	1.6	4.9	0.7	4	1.11	0.96	1.37	0.09
R/P-1	CCG	EF	6	65	41	83	6	6	3.0	0.8	6.1	0.7	6	1.01	0.78	1.16	0.05
R/P-2	CCG	EF	26	57	41	85	2	26	2.0	0.2	6.8	0.2	26	1.00	0.15	1.53	0.05

Notes:
Fish species codes: CCG = Slimy Sculpin
Method code: EF = backpack electrofishing; MT = minnow trapping
SE = standard error of the mean

Figure 6.1-3
Typical Fish Habitat Complexing Features

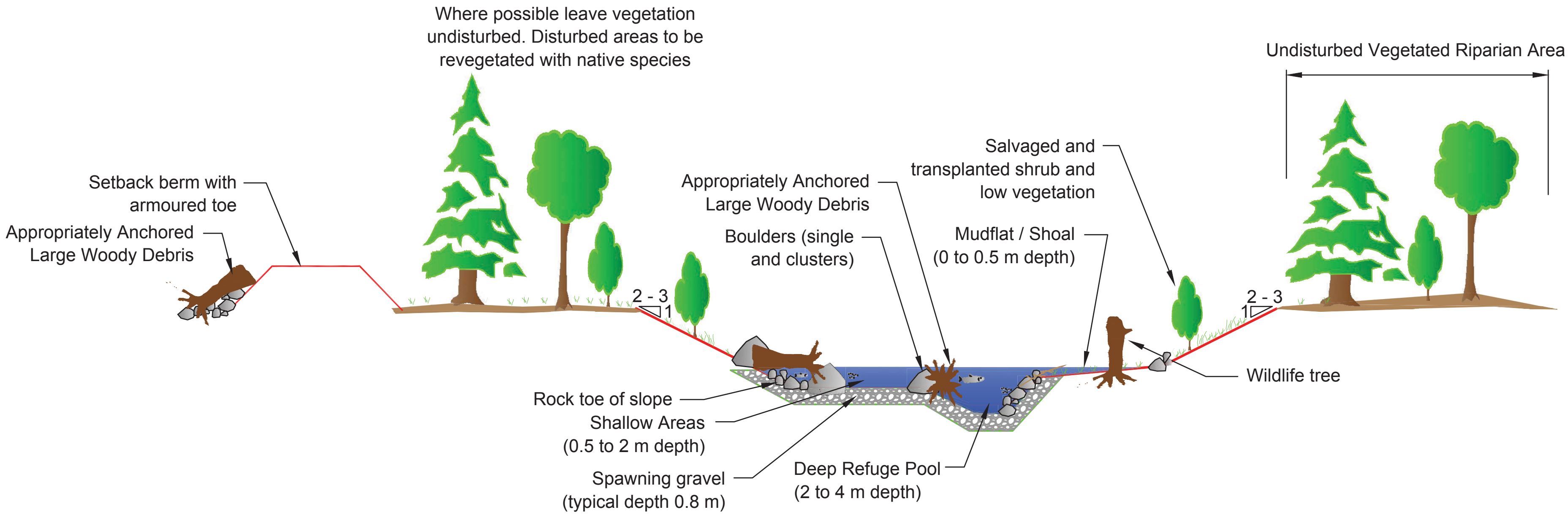


Table 6.1-8. Preliminary Area per Habitat Type

	Typical Depth (m)	Habitat Features	Preliminary Area (m^2)
Wetland	< 0.5	Instream vegetation Limited LWD Mudflat or bare shoals	0.35
Shallow Pond	0.5-1.0	Spawning gravel at inlets and outlets of pond LWD and boulder cover	0.55
Deep Pond	> 1.0	Spawning gravel at inlets and outlets of pond LWD and boulder cover Water depth for cover	0.20
Stream	0.25	Spawning gravel Noticable flowing water LWD and boulder cover	0.02
Total Area			**1.12**

The design provides approximately 200 m of linear channel habitat and approximately 1.1 ha of wetland and pond habitat.

The following is a summary of the results from the completed engineering planning and assessment work that was used in the preliminary design phase:

- The design of the Project is based on the concept that open channels and ponds will be excavated below the existing ground surface to intercept groundwater and seasonal surface water runoff from the adjacent landscape.
- Design criteria for the layout and dimensions of the ponds and open channels were derived from the spatial limitations of the site, channel and pond stability, habitat features, and habitat area required for offsetting.
- The channel patterns and the configuration of the ponds were based on the existing ground contours and were designed to integrate the ponds into the surrounding landscape to minimize earthworks construction volumes.
- The trapezoidal shape and size of the open channel sections were sized to convey any intercepted ground and surface waters along the ponds and channel sections. The channel base width is 1 m, with 2H:1V side slopes excavated to depths up to 3 m below the existing ground surface.
- The site will rely on groundwater as a water source. Groundwater is generally warmer in winter and cooler in summer relative to the surface water. This temperature difference can maintain and sometimes increase productivity during seasonal extremes. Groundwater is also a relatively stable source of flow and will be able to provide connectivity between habitats and reaches for fish during periods of low water.

- It appears that some flow has a path under the rail grade in the location of the original channel alignment prior to construction of the tunnel. There are two options that were considered. One is to work with the current conditions. The second is to consolidate flow, by constructing an impermeable berm (e.g., bentonite core) near the toe of the rail grade. With the information gathered to date, a technically feasible design using the existing conditions (option one) has been used as further work would be required to pursue rail grade modifications.
- An average design flow of 0.1 m^3/s was used for planning purposes with the minimum water depth along the channel sections to be 0.25 m. This will result in an average stream velocity of 0.10 m/s.
- The outlet for the Project will be located downstream along the left bank of Lion Creek discharging into an existing natural pool that is connected to Lion Creek. The outlet will also serve as the access point for fish to enter the offsetting site.
- A variety of habitat types and features have been included in the technically feasible design. These include shallow ponds, deep ponds, stream and riparian areas for multiple species such as Bull Trout and Coho Salmon. By incorporating a variety of habitat types, habitat for other animals such as toads and birds can be supported. Table 6.1-2 summarizes the preliminary area of each habitat type that will be created.
- Deeper water sections 1 to 2 m deep will be present within each pond. The depths of these sections will be determined, in part, by the minimum elevation of the local water table at each location.
- The addition of LWD to the aquatic areas creates cover and shade and enhances hydraulic complexity, contributing to the long-term stability of habitat features such as pools.
- An access road and protection berm will be constructed along the western extent of the site. This embankment structure will be sized to withstand a 25 year flood event and will provide access during the construction and future maintenance. The structure will be constructed from materials excavated during the construction of the ponds and channels.
- A 1-m high cascade (Plate 6.1-14) immediately downstream of the CN Rail tunnel will require modification to facilitate adult Coho Salmon and adfluvial Bull Trout migration into the site.

6.1.7 Risk Assessment

As part of the feasibility assessment for the Lion Creek site, a risk assessment was undertaken to identify information gaps and to quantify potential risk. The assessment was based on the available information and included an assessment of the water supply potential, channel stability, earthworks, layout of the proposed system, and related maintenance requirements.

During the risk assessment all available information was reviewed, significant information gaps were identified, any hazards associated with the known information or with gaps were considered. Possible consequences associated with the information or information gaps were then identified and a risk rating relative to the feasibility of the project was assigned. Finally, potential mitigation for associated risks was identified.

The risk assessment results are provided in Appendix G.

Plate 6.1-14. 1 m cascade immediately downstream of the CN Rail tunnel that may limit upstream fish migration, Lion Creek, 2014.

Water Supply

- Based on site conditions and other projects in the North Thompson watershed it is expected that groundwater flow will be in the order of 0.1 m^3/s within the developed channels and ponds.
- There is the possibility of loss of flow through the CN rail grade and through the original channel alignment. Loss of flow will be mitigated through design considerations. If steps are not taken to mitigate the possible subsurface flow loss through the rail grade the project is still technically feasible.

Channel Stability

- The Lion Creek channel is somewhat mobile due to bedload deposition. To provide stable, continuous habitat the spoil material will be used to berm and protect the site from channel movement and deposition.

Earthworks

- The abundance of well-graded coarse-grained materials are suitable channel bed substrates and construction materials for the access road/protection dyke.
- There is a limited supply of fine-grained materials; however, given the intention to construct a groundwater based system, there is expected to be little need for the construction of impermeable layers.

Access

- Access to the site currently restricts machinery. Discussion with CN may allow for the use of the CN rail line to bring in equipment. If needed, a single lane, 1.5 km tote road could be constructed from the nearby Messiter Forest Service Road at the base of the hillside for access. A special use permit would be required for access road construction. This road could be deactivated after construction.

Project Layout

- The site features were laid out along contours and within other landscape features to minimize earthworks.

Maintenance Requirements

- Maintenance needs were evaluated to be at moderate risk for beaver-related impacts, low risk for sediment accumulation, and low risk for physical repairs to pond and channel sections and debris obstructions.
- Active wildlife management may be required on an annual basis to mitigate the potential effects of beaver activities within the offsetting area. Features such as beaver fencing and bafflers can be incorporated as appropriate.
- Invasive vegetation control on disturbed areas.
- The outlet location will be properly positioned and maintained to ensure continuity for fish.

6.1.8 Offset Summary

Habitat creation at the proposed Lion Creek site is estimated to provide 1.1 ha of high-quality multi-species spawning and rearing habitat. It is estimated, based on the spawning areas developed at the Lion Creek site, at 250 fry per m^2, 50,000 Bull Trout and/or Coho Salmon fry may be produced.

6.1.9 Recommendations and Conclusions

The results from the technical feasibility assessment for the proposed Lion Creek site have been presented. Site investigations and engineering planning has been completed to confirm that the development of the site is technically feasible at the proposed location. The low gradient terrain indicates that conventional excavation and construction techniques for the channels and ponds will be appropriate.

The presence of groundwater along the proposed alignment has been identified and groundwater will be the primary water supply source for the offsetting site, though there may be some loss of flow through the rail grade. The existing terrain provides suitable low gradient ground surfaces for the construction of the channels and ponds minimizing excavation requirements.

The designs presented in Appendix D show achievable habitat area that is feasible to construct. The actual areas that will be constructed will be determined based on the habitat area required for sufficient offsetting. The larger potential number is presented as optional area available as a risk mitigation measure.

The site was chosen based on many biological and geophysical criteria. However, biologically, the availability of Coho Salmon and the area available for habitat creation within Lion Creek made this site suitable. Preference was given to building one larger project as opposed to many small projects, in order to efficiently use resources and to focus maintenance activities.

The following are recommendations for consideration in the future development of the Project:

1. Installation of piezometers or standpipes with pressure transducers to confirm low ground water levels specifically in the winter and possible loss through the rail grade. There is the potential that by constructing this 'sealing' berm that Lion Creek may improve its connectivity further upstream as the water table will be maintained at a higher level.
2. Additional topographic information will be required for developing a tote road from the Messiter Forest Service Road.
3. A Construction Management Plan should be completed that will include tote road access details, borrow and spoil areas, material handling, construction sequencing, and an Environmental Management Plan for the Project area.
4. Written understanding with CN Rail regarding the habitat offsetting work adjacent to their line, and the possible fish passage modifications downstream of the tunnel.
5. Development of post-construction monitoring and maintenance plan to meet DFO authorization requirements.

6.2 Harper Creek Gravel Placement

6.2.1 Site Description

6.2.1.1 Fish Community and Habitat

As described in Chapter 14 sections 14.4.3.2 and 14.4.4.4, lower Harper Creek contains the most diverse habitat types and greatest fish diversity in the LSA. The dominant stream morphology in lower Harper Creek is cascade-pool (Plate 6.2-1), although the low gradient reaches immediately upstream of North Barrière Lake are classified as riffle-pool. Alluvial bed material consisting primarily of cobble, interspersed with boulder and some gravel, are present throughout lower Harper Creek. Functional large woody debris and log jams are important habitat features for trapping gravel and increasing habitat complexity (i.e., scour pool formation). The upper reaches of lower Harper Creek generally exhibit higher stream gradient, confined cascade-pool morphology, cobble/boulder substrate, and decreasing habitat complexity. The uppermost reach of lower Harper Creek contains several large cascades and a 2-m waterfall confined by a bedrock canyon. Overall, lower Harper Creek primarily supplies rearing habitat for Bull Trout, Coho Salmon and Rainbow Trout. Spawning and overwintering habitat for resident adults are relatively less abundant.

Plate 6.2-1. Cascade-pool morphology present in lower Harper Creek.

Coho Salmon fry were observed between mainstem km 8.0 and 9.5, and were associated with off channel habitat. Coho Salmon parr were associated with pools and woody debris in lower Harper below mainstem km 2.0. The presence of two juvenile cohorts (fry and age 1+ parr) indicated that Coho Salmon use lower Harper Creek for spawning; however, exact spawning locations for Coho Salmon have not been documented. Bull Trout were the only species observed upstream of mainstem km 9.5 to the 2-m waterfall at km 18.5. The relative abundance of fry, juveniles, and adfluvial spawning adults was highest between mainstem km 17.0 to the 2-m waterfall at km 18.5. The relatively high number of fry and spawning adfluvial Bull Trout indicates that this section of lower Harper Creek supplies important spawning and rearing habitat (Appendix 14-A, Section 5.2.1.4).

Although isolated areas of productive Bull Trout and Coho Salmon spawning and emergent fry rearing habitat are available, preferred spawning habitat (Plate 6.2-2) has been reported as a limiting habitat form throughout lower Harper Creek for these VC species. This lack of suitable spawning habitat may limit Bull Trout and Coho Salmon periodicity and productivity in lower Harper Creek. In contrast, Coho Salmon rearing habitat is relatively more abundant in the lower reaches of Harper Creek near North Barrière Lake. Bull Trout YOY and juvenile rearing habitat in the form of cascade-pool morphology with large boulder and cobble are relatively common habitat forms throughout lower Harper Creek.

Appendix 14-A, Section 4.2, Table 4.2-2 shows electrofishing effort, catch, and CPUE of various fish species captured during baseline studies in lower and upper Harper Creek. Catches and CPUE of juvenile and resident Bull Trout in upper Harper Creek were consistently greater than two-times that of lower Harper Creek. Further, catches of Coho Salmon, Rainbow Trout, and Mountain Whitefish, were consistently less than half that of Bull Trout catches in lower Harper Creek. Based upon extensive electrofishing effort conducted during baseline studies, the relative abundance of all fish species in lower Harper Creek is very low. These data suggest that fisheries productivity in lower Harper Creek may be constrained by an apparent lack of suitable spawning and emergent fry rearing habitat.

Plate 6.2-2. Preferred Bull Trout spawning habitat with coarse gravel substrate and overhanging vegetation.

6.2.2 Objective and Techniques

As explained above, spawning and emergent fry habitat has been documented as a limiting habitat form throughout Harper Creek, and especially in lower Harper Creek. In order to provide additional spawning and emergent fry habitat, gravel placement within upper and lower Harper Creek is suggested. The objective of this offsetting project is to increase the number and quality of spawning habitat sites, and augment Coho Salmon and Bull Trout productivity within Harper Creek.

Gravel placement has been successfully used in other areas of British Columbia to improve habitat value and spawning success. For example, in 1997 DFO used gravel placement to increase the availability of Chinook Salmon and Coho Salmon spawning habitat within the Campbell River (Sheng et.al. 1998), and in 2004 as part of the Greater Georgia Basin Steelhead Recovery Plan (McCulloch 2005).

6.2.3 Project Design

Preferred gravel deposition locations were determined by reviewing:

- historical and Project-specific baseline fish and fish habitat studies (e.g., Appendix 14-A) to identify preferred Bull Trout and Coho Salmon spawning habitat;
- predicted changes in water quantity due to Project development throughout Harper Creek; and
- areas where ground equipment could easily access points along Harper Creek.

A total of four gravel placement locations within Harper Creek were identified, including upstream of the 2-m waterfall at km 18.5 (Figure 6.2-1).

Estimates include: 18 dump truck loads of gravel, representing 1 truck load per river km. Each truck load is equivalent to 10 m^3. Gravel is predicted to displace downstream at a depth of 0.25 to 0.5 m. Thus, gravel placement is estimated to enhance 400 m^2 (0.04 ha) of new, high quality Bull Trout and Coho Salmon spawning habitat.

Gravel placement is anticipated to increase Bull Trout and/or Coho Salmon fry production by 250 fry per m^2. Thus, gravel placement in Harper Creek is expected to increase by 100,000 Bull Trout and/or Coho Salmon fry.

Gravel could be added to Harper Creek by using a combination of methods presented below:

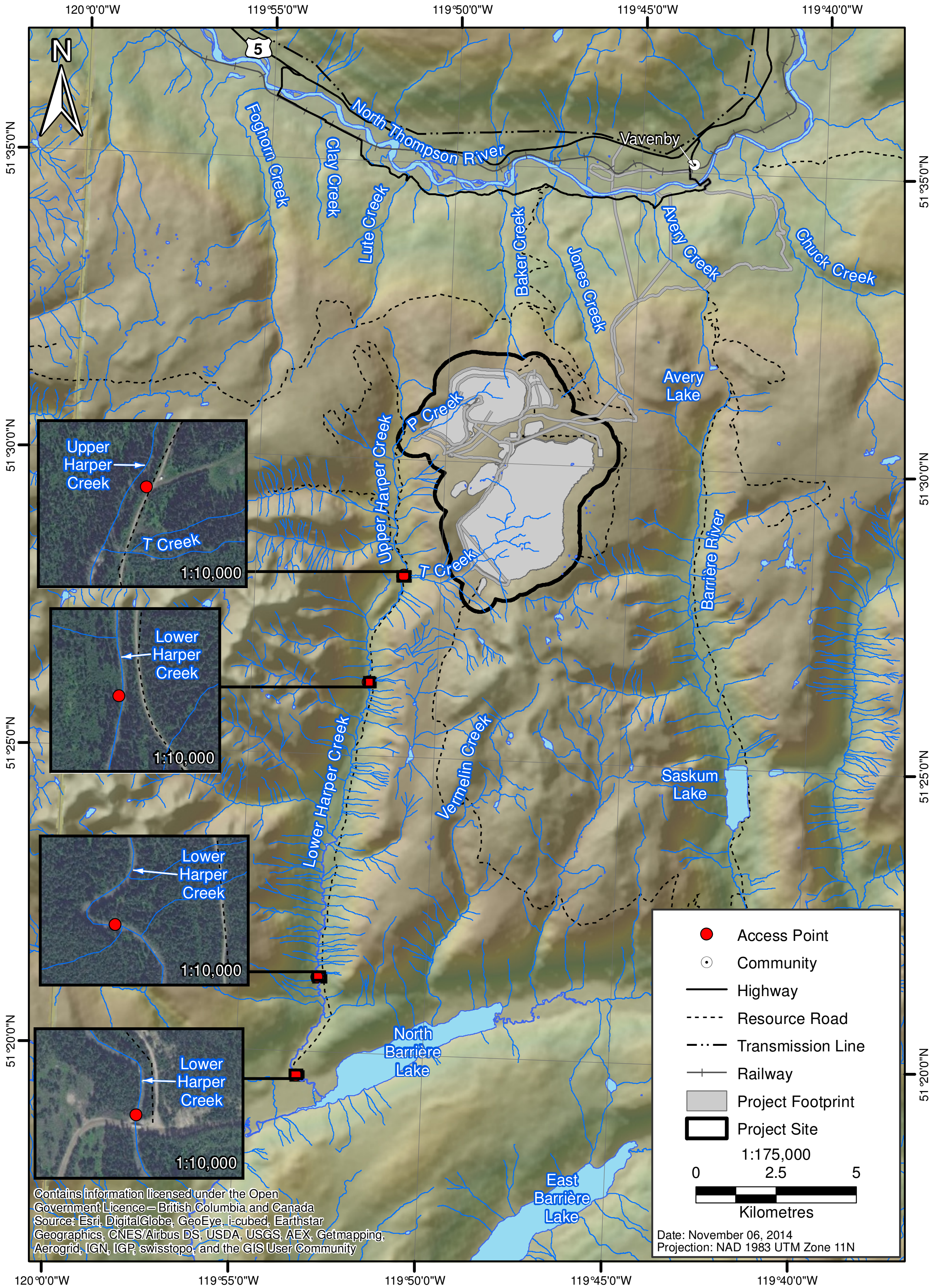
- Use small loaders or stone slingers to place gravel at a large scour location such as in a pool downstream of a large cascade or drop. At high flows, gravel would be moved by the creek to stable deposition points.
- Use wheelbarrows to place gravel in specific locations in the stream channel; and/or
- Use helicopters to place gravel at specific locations in the stream channel.

Locations have been selected based on a preference to have sites access by ground versus air. Access to the creek itself is limited. As a result only four locations have been identified to be able to add gravel without creation of significant roads. Suggested access locations are:

- near the T-creek and Harper Creek Road Junction (UTM 302065 E 5705695 N);
- approximately 300 m downstream of the 18.5 km barrier (UTM 300957 E 5702353 N);
- upstream of the North Barriere FSR bridge (UTM 298688 E 5690111 N); and
- from the FSR on the river right of Harper Creek through historic cut block access roads (UTM 299357 E 5693170 N).

Figure 6.2-1

Potential Spawning Gravel Placement Access Point Locations



A stone slinger should be able to access these sites and spread gravel over a wider area. The approximate range of a stone slinger is 40 m. It is to be expected that gravel would be transported downstream to stable locations. Approximately 40 to 50 m^3 of gravel would be placed at each location.

6.2.4 Offset Summary

Gravel placement is estimated to provide a total of 0.04 (400 m^2) of highly productive adfluvial Bull Trout and Coho Salmon spawning habitat. Productivity estimates indicate that approximately 250 fry per m^2 or a total of 100,000 Bull Trout and/or Coho Salmon fry may be produced as a result of gravel placement in Harper Creek.

6.2.5 Recommendations and Conclusions

To complete the design process, further work will be required, which include the following activities:

- field verify locations for access routes;
- topographic survey of existing spawning gravel for pre-placement area and volumes;
- sieve tests of gravel from preferred Bull Trout spawning sites; and
- velocity and depth criteria to develop Froude number relationship for Bull Trout to confirm hydraulics at confirmed locations prior to placement and for follow up monitoring purposes.

7. CONSTRUCTION PLANNING AND TECHNIQUES

The selected offsetting projects will undergo final design development in preparation for the construction stage, which will be after the EA process has concluded and during permitting. The proposed offsetting sites are adjacent to or within fish bearing streams and wetlands, consequently the construction must be implemented in a safe and effective manner to avoid adverse effects. Implementation of the final offsetting project designs will involve construction planning, site preparation, design layout, mobilization of equipment and materials, onsite construction, and demobilization. Critical to the success will be management and mitigation of risks and potential adverse effects to existing fish and fish habitat. These potential effects include:

- increased sedimentation or dewatering of fish habitat;
- contamination as the result of hazardous substance spills;
- loss or alteration of fish habitat;
- alteration of water and/or sediment quality; and
- alteration of the productive capacity of aquatic habitat.

The Fish and Aquatic Effects Monitoring and Management Plan developed for the Application/EIS will also guide similar activities carried out during the construction of offsetting sites to prevent impacts.

The implementation and construction stages of the fish habitat offsetting plan are summarized below, including the type of activity and the risks they present to fish habitat. The construction process will include the following components and mitigation:

- Layout and site marking will include minor brush clearing and staking of the excavation boundaries for channel and pond arrangements. Crews will undertake a danger tree assessment, identify fuel handling and fish salvage locations, flag access routes, laydown areas, no disturbance and machine-free zones, temporary stockpile locations, etc. This step poses no risk to fish habitat as no heavy equipment is involved.
- Heavy equipment will either be trucked to access points along existing roads or rail.
- Temporary access (i.e., tote roads or trails) will be developed at offsetting sites with minimal effect on riparian vegetation and fish habitat. Streams will be crossed with temporary structures (e.g., log box) built with onsite materials. Temporary fording of some channels may be required for initial access but only across stable channels with competent banks. Generally, excavated materials from channels and ponds will be spoiled into berms for use as temporary roads. Berms and temporary access roads will be kept narrow (5 to 7 m wide) and avoid sensitive features. Risks to fish habitat along roads will be minimized by avoiding aquatic features as much as possible and preventing sedimentation. Temporary access routes will be re-vegetated upon completion to prevent erosion and sedimentation of aquatic habitat.

- Vegetation clearing and tree falling will conducted by hand in sensitive areas or with heavy equipment in non-sensitive areas (e.g., dry areas). It will involve minimal falling into or over existing fish habitat as most can be felled away. Clearing of trunks and root wads will be done with an excavator, and woody debris will be used in ponds and channels for habitat complexing.
- Ponds and channels will be dug by medium to large excavators and a bulldozer will assist with creating berms at backwatered ponds. Dump trucks will be used at road accessible sites. Equipment will be leak-free, well-maintained and, if being used for extensive direct instream work, will use biodegradable hydraulic fluids. Sedimentation risks to existing fish habitat from excavation will be managed by isolating work sites, constructing temporary diversions for clean stream flow through sites or installation of sediment control features (e.g., sumps and pumps).
- Logs and boulders will be salvaged from pond and channel footprints or trucked into sites. Materials sourced from outside the footprint of ponds and channels will come from other areas not situated near aquatic habitat or established sources (e.g. highways pits).
- Some existing beaver ponds and channels containing fish and fish habitat will be drained or modified to fit much larger offsetting features at the same location. Fish will be salvaged from ponds. Fish will be released in the nearest similar habitat type while vegetation will be stockpiled for re-introduction to compensatory habitat. Water levels will be drained slowly to prevent downstream impacts and ensure a complete fish salvage.
- Environmental monitoring and continuous supervision will be essential for the successful completion of the offsetting sites.
- A re-vegetation plan be developed as part of the final design phase and will be implemented as soon as construction activity is completed. The re-vegetation plan will include seeding and planting with approved plants and grasses to restore ground cover, stabilize soils, minimize sedimentation and promote riparian function at all offsetting sites.

8. MITIGATION MEASURES

8.1 Standard Operating Procedures (SOPs)

Relevant standard operating procedures (SOPs) will be followed in all habitat offsetting projects. Pertinent legislation includes the *Water Act*, the *Fisheries Act*, and the *Species at Risk Act*. The principles outlined in these and all other relevant federal and provincial enactments will be incorporated in the planning and implementation of all offsetting activities. Appropriate permits and approvals will be acquired prior to beginning construction.

Qualified individuals will direct and plan the work in order to meet the objectives of the SOPs.

8.1.1 Best Management Practises (BMPs) for Instream Works

When practical, best management practices (BMPs) will be followed during the construction and maintenance of the offsetting projects. Offsetting activities will be planned to avoid or minimize the adverse effects of these activities and to prevent long term deleterious effects. Qualified individuals will manage the design, implementation, and monitoring of these activities to ensure the protection of habitat and the implementation of BMPs. The general techniques, based on Standards and Best Practices for Instream Work (BCWLAP 2004) and Fish Stream Crossing Guidebook (BCMOF 2002), to be used during construction include:

- keeping machinery clean and preventing fuel leaks or spills;
- delineating work site boundaries and confining disruptive work to within those boundaries;
- designing access routes to minimize disturbance to existing habitat and vegetation;
- performing any in-water work to periods of least risk to fish;
- installing sediment control mechanisms where earth works are to take place; and
- minimizing disturbance to riparian vegetation and seeding and/or replanting riparian areas where vegetation is disturbed.

Additional mitigation measures that may be used during offsetting works are detailed below. During the detailed planning stage, site-specific management plans will be created based on the specific construction plan and features of each site.

8.1.2 Site Access

Offsetting sites will be accessed via constructed temporary tote roads or rail as needed. Access plans will be made with consideration for individual site characteristics, minimization of environmental impact, and feasibility.

Routes for temporary tote roads will be planned to minimize environmental disturbance. Where possible, crossing fish-bearing streams will be avoided. Where stream crossings are necessary, riparian disturbance will be minimized and fish passage will be provided (BCMOF 2002).

8.1.3 Vegetation Clearing

Trees and vegetation may be cleared during the construction of temporary tote roads, stream access points, and refueling and construction zones. Additional clearing may take place during the excavation of new ponds or channels. Grubbing will be minimized, but is likely to occur in excavation projects. In compliance with WorkSafeBC policies, a dangerous tree assessment will take place in the construction area prior to beginning work. The dangerous tree assessment may require the removal of additional trees in the construction area. The impact of these activities on the environment will be mitigated with the following measures:

- trees to be removed, by permits, will be identified individually and will only be removed if it is deemed necessary;
- trees will be felled so that they do not enter the stream channel;
- trees and rootwads removed during construction will be used to build habitat complexity in the enhancement projects;
- work in offsetting areas will use the minimum number of access points necessary, and locate them such as to avoid particularly sensitive areas of vegetation or areas where bank stability would be significantly affected (BCWLAP 2004);
- where practical, machinery that must move down the stream may move along dry portions of the creek bed to avoid damaging vegetation; and
- impacted areas will be revegetated using vegetation salvaged from excavation areas whenever possible, or otherwise replanted and/or seeded with approved vegetation from other sources.

8.1.4 Sediment and Erosion Control Measures

Sediment mobilization and increased erosion are possible risks of construction in stream areas. Construction plans will be designed to maintain bank stability and mitigate or repair any damage caused by offsetting work. To control and minimize the sediment mobilization and bank erosion, control measures that may be taken include:

- using water diversion structures to divert dirty water from the work zone to a sediment control area;
- installing silt fencing, geotextile cloth, hay bales, berms, or other sediment control structures;
- conducting instream work from the point farthest away from the access point and working backwards;
- allowing constructed ponds to settle before connecting to the stream;
- ensuring that all rock materials used in the stream are inert;

- storing soil, substrate, removed vegetation and building materials in stable areas away from the ensuring that all rock materials used in the stream are inert;
- ensuring constructed banks are graded at a stable slope; and
- stabilizing excavated materials and areas denuded of vegetation using temporary erosion control blankets, biodegradable mats, planted vegetation, or other erosion control techniques.

A response plan will be created to detail sediment and erosion control measures to be implemented in the event of an unexpected increase in overland runoff or saturation of the work area due to precipitation. Additional measures will also be taken in the event that construction monitoring identifies a failure or potential failure of existing sediment control structures.

8.1.5 Fuel Management

The input of fuel or other deleterious substances to the stream will be prevented. Steps to be taken to prevent the occurrence of a spill include:

- inspection of all equipment and machinery prior to and during all work to ensure that it is clean and free of leaks;
- the use of environmentally-friendly hydraulic fluid in heavy machinery to be used for extensive direct in-stream works;
- placement of drip pans and spill pads underneath pumps or other stationary machinery; and
- provision of readily-accessible spill kits in all areas where machinery or fuel tanks will be used, stored, or refueled, and training of personnel in their use prior to beginning construction.

A Spill Response Plan that builds off of that in Section 24.15 will be created that will detail the steps to be taken to properly contain, clean up, and report any spills that may take place. To ensure a rapid response to leaks and spills all construction personnel will be trained in the procedures outlined in the Spill Response Plan.

8.1.6 Waste Management

All waste and excess material created or imported for the offsetting project will be stored and treated or removed to avoid causing environmental harm. Examples of potential waste management include:

- developing protocols for waste reduction, reuse, and recycling during construction;
- storing soil excavated during construction on a stable surface outside of the stream channel and covered or contained by erosion control measures or replanted vegetation;
- managing vegetation removed from the work zone by either storing for salvage and replanting or piling away from the stream banks for storage or burning; and
- removing non-biodegradable materials brought into the site including sediment control structures, equipment, and supplies (BCWLAP 2002).

8.1.7 Water Management

Should water diversion be required, coffer dams, pumps, or other approved water-diversion methods may be used to temporarily divert water around the construction zone while still maintaining flow downstream. Sediment-laden water will be pumped to a sediment control area where the sediment can settle or be removed before returning to the stream (BCWLAP 2002). Backup pumps may be kept on site in case of mechanical failure.

As a part of enhancement activities, beaver ponds and other areas of standing water may be drained. Where draining of wetted areas occurs, measures will be taken to ensure that the process will not cause erosion of stream banks or terrestrial areas.

8.1.8 Fish Salvage

Prior to dewatering small ponds or streams, fish will be salvaged and removed from the site. As part of the fish salvage and exclusion process, the following steps will be taken to minimize disturbance:

- the pond or stream will be isolated using seine nets;
- passive or active capture techniques, or a combination of the two, will be chosen based on characteristics of the site and used to capture fish;
- fish will be immediately removed to recovery buckets; and
- post-recovery fish will be moved to the suitable habitat nearest the salvage site.

In larger mainstem areas where isolation and salvage would be prohibitively time-consuming or difficult, the site will not be sectioned with nets. Instead, electrofishing will be used to encourage fish to move from the immediate area immediately prior to any instream works.

8.1.9 Construction Monitoring and Inspections

Throughout the access development and construction processes, a qualified environmental monitor familiar with BMPs will be present full-time (BCMWLAP 2004). As part of his or her onsite activities, he or she will:

- oversee all work;
- inspect structures and activities;
- be provided with the authority to modify or halt any activity if he or she deems it necessary to protect fish, habitat, wildlife, or safety; and
- consult with the construction manager to ensure that all activities are undertaken following BMP.

Following the completion of the construction phase, the offsetting works will be monitored according to a monitoring plan (described below in Section 13).

9. PROPOSED SCHEDULE

The offsetting project planning and completion will be composed of six phases: detailed design assessment, detailed design planning, permitting, second year baseline fisheries assessment, pre-construction planning, and construction (Table 9.1-1). The schedule has been developed to allow for offsetting areas to be constructed and established in a logical manner that can fit within the overall Project construction schedule to offset residual impacts on habitat and flow.

The baseline fisheries assessment will gather additional fish and fish habitat data to complement the existing baseline data. Fish and fish habitat information will be collected at the proposed offsetting sites as needed.

During the detailed design assessment phase, the soils, hydrology, water quality, and groundwater influence in the proposed offsetting sites will be assessed. Detailed physical surveys will be conducted to further characterize the site.

The detailed design assessment phase will provide the necessary data for detailed design planning. During the detailed design planning phase, the physical site information will be used to develop construction plans for the selected sites. The detailed designs will expand on previous plans to include more specific project features and design drawings.

The permitting phase will involve identifying and applying for any necessary government tenures, permits and approvals. A permit under the Section 35(2) *Fisheries Act* will be required. The pre-construction and construction phases will only be initiated once all permits and approvals are secured.

Logistical planning and organization for construction activities will take place during the pre-construction phase. Site access routes, construction schedules, and the organization of equipment, supplies and activities will be addressed during this phase which will occur prior to and concurrently with the construction itself.

The construction phase will be composed of multiple components and activities and will be ongoing. Offsetting sites will be created to the specifications outlined in the constructions plans created during the physical design assessment phase, which will be modified where necessary to ensure proper site function. At the completion of this phase all offsetting habitat will have been constructed and the full offsetting area created.

After site construction is completed, post-construction monitoring will be carried out.

Table 9.1-1. Proposed Offsetting Schedule

	Year -2				Year -1				Year 0				~ 1 Year of Offsetting Project Construction			
Phase	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Detailed Design Assessment		■	■	■	■	■	■									
Detailed Design Plan				■	■	■	■									
Permitting				■	■	■	■	■								
2nd Year Fish Monitoring Assessment											■	■				
Pre-construction Planning												■	■	■	■	■
Construction															■	■

Q' represents quarter of a year

10. TENURE AND ACCESS

All proposed offsetting sites are on Crown Land (ILRR 2014), and will not require permission from private landowners.

The Lion Creek site though is adjacent to the site are lands owned by CN Rail on the east side of the wetland and in the area of the water tunnel. There is also a BC Hydro ROW upstream to the west of the area proposed to be developed.

It is advised that written notification be given to CN Rail and BC Hydro, in the detailed design stage, describing the proposed habitat works as they are adjacent to the site.

11. PERMITS

Permits and authorizations required for this project will include:

- *Fisheries Act* Authorization to modify fish habitat;
- *Water Act* Sec 9 application for Works in and About a Stream;
- Ministry of Forests, Land and Natural Resource Operations Special Use Permit for construction of access roads;
- *Wildlife Act* Permit for projects requiring the disturbance of beavers and/or beaver dams;
- Fish Collection Permits from the Ministry of Environment and Department of Fisheries and Oceans Canada for salvage of freshwater and anadromous fish species respectively; and
- Licence to Cut for the removal of trees in the construction of access roads and new fish habitat.

Other necessary permits or approvals may be identified during future offsetting planning. All pertinent permits and authorizations will be acquired prior to beginning work.

12. COSTS

Preliminary ranges of cost estimates for construction were developed for the site described in this habitat offsetting plan (Table 12.1-1). The primary factors affecting cost of building the proposed fish habitat offsetting site are:

- the location of the sites (i.e., presence of roads);
- overall extent and total area of habitat to build;
- extent of excavation;
- complexity of the proposed features;
- heavy equipment requirements; and
- personnel requirements.

Offsetting site is located near proposed roads. A range of estimates for the duration of construction is provided (i.e., weeks, months, etc.). The preliminary onsite construction costs for the Lion Creek and Harper Creek offsetting options are approximately $300,000 and $100,000, respectively, for a total of $400,000.

Table 12.1-1. Preliminary Costs and Planning for Proposed Offsetting Sites

Watershed	Compensation Project Type	Area to Build (ha)	Minimum Heavy Equipment Required	Existing Road Access	Access Cost	Construction Complexity and Duration	Preliminary Onsite Construction Cost *
Lion Creek	Off-channel pond and side channel	1.12	2 excavators, bulldozer	No	Low-Moderate	Complex, 1-2 months	$ 0.3 M
Harper Creek	Stream spawning habitat creation	0.04	1 - stone throwing truck	Yes	Low	Simple, 1 months	$ 0.1 M

** excluding access construction, living out expenses, and professional fees.*

13. MONITORING

Monitoring activities associated with Project effects on fisheries will consist of two monitoring programs. The first program (Offsetting Monitoring) evaluates if offsetting programs are successful in achieving the predicted gains in habitat and population parameters to fully offset Project losses to fish habitat. The second program (Fisheries Loss Monitoring) is required to evaluate if losses in fish habitat (here and in Chapter 14) are equivalent to those predicted in the fish offsetting plan.

13.1 OFFSETTING MONITORING

Monitoring and reporting activities are critical to assessing the effectiveness of the proposed offset measures, and to ensure that the objectives of the Fisheries Protection Policy Statement are being met. When developing and implementing offsetting measures, sources of uncertainty may affect the success of the overall outcomes. Uncertainties related to error in the initial prediction of residual "serious harm" to fish, in the offsetting measures themselves through design or implementation failure, from the overestimation of the benefits of a particular offsetting strategy, and from natural variability of fish populations and stochastic conditions (e.g., changing climate conditions; invasive species) may influence the progress and benefits of the offset projects. In the event offset projects are not successful at mitigating serious harm effects, contingency measures may be needed.

The fisheries offsetting monitoring program will involve the following four components:

1. Monitoring of fish habitat and fish density/abundance at Lion Creek;
2. Baseline Bull Trout spawning and red surveys throughout lower and upper Harper Creek;
3. Monitoring Bull Trout spawning and redd surveys at gravel placement locations in lower Harper Creek; and
4. Fry and YOY density/abundance estimates in lower Harper Creek.

The study design will incorporate a before/after comparison to statistically evaluated the success of offsetting projects. This will require a minimum of one year of baseline data collected prior to Project construction for each of the above four components. The length and frequency of sampling for each monitoring component will be determined and agreed upon in coordination with DFO.

In addition to biological and population level data collection, monitoring and reporting activities will also focus on providing:

- photographs of works relating to mitigation measure and of completed offsetting measures;
- provision of records to facilitate monitoring and inspection purposes; and
- details of any mitigation changes or corrective actions in the event the mitigation or offsetting measures did not function as described.

13.2 FISHERIES LOSS MONITORING

Fisheries loss monitoring will consist of two separate studies with the following two objectives:

1. Evaluating the loss of habitat in upper Harper Creek; and
2. Evaluating Bull Trout passage at the 2 m waterfall located at mainstem km 18.5 on Harper Creek.

13.2.1 Instream Flow Study

The loss to Bull Trout Habitat predicted to occur in upper Harper Creek between P and T Creek were based on an estimate of lower and upper bounds to habitat loss derived from the relationship between WUA and discharge. These estimates were required as an Instream Flow Study (IFS) was not completed within this section of stream. To provide a more robust prediction of the habitat losses within upper Harper Creek, an IFS will be conducted prior to Project construction. This study will follow BC Instream Flow Guidelines (Hatfield et al. 2003; Lewis et al. 2004). The study area will include the area from the 2-m waterfall at km 18.5 to the boundary of fish presence at km 24.2 of upper Harper Creek. The IFS will take place over one year and scheduled prior to Project construction.

13.2.2 Bull Trout Passage Study

Based upon baseline observations and professional judgment, only larger adfluvial Bull Trout are able to ascend the 2-m waterfall, and only when freshet flows have declined during mid-summer and into the summer low flow period. As such, predicted reductions in flow may further reduce the ability of adfluvial Bull Trout to move upstream of these falls should water levels change. Gathered information will thus serve to estimate the probability of successful fish passage at the falls. Should it be determined that changes in flow prevent adfluvial Bull Trout from ascending the falls, it may be necessary to consider the use of additional mitigation measures.

Several approaches may be adopted to evaluate upstream movement by adfluvial Bull Trout at this waterfall. Although successful fish passage seems limited to the larger adfluvial Bull Trout, it is still poorly understood what sizes of fish and under what conditions are favorable to successful passage at the falls. A better link between current unaltered flow regimes over varying natural hydrological conditions and species-specific limits (i.e., physiological differences including size, swimming capabilities, jump heights, etc.) will need to be determined. A combination of direct capture (trapping and tagging) or indirect methods (underwater or above water cameras) may be considered once more detailed site-specific information is collected to determine the most suitable methods to adopt. The passage study will be required prior to prior to Project construction and monitored in successive years after Project construction begins. The length and frequency of sampling will be determined and agreed upon in coordination with DFO.

14. CONSULTATION

Consultation activities as part of the EA process have been undertaken with potentially affected Aboriginal groups, including Simpcw First Nation (SFN), the Adams Lake Indian Band (ALIB), the Neskonlith Indian Band (NIB), the Little Shuswap Indian Band, and the Métis Nation of British Columbia (MNBC).

In their Traditional Land Use and Ecological Knowledge Study (TLU & TKS; 2012; Appendix 22-A), the Simpcw First Nation identified fishing in Harper Creek as an area of interest although no site-specific information on where fishing activities have historically, or are currently occurring, has been provided.

In discussion with HCMC, the ALIB and the NIB have both requested additional information on fisheries offsetting options and indicated interest in being involved in the planning of the offset strategy. Although no specific fishing places in Harper Creek have been identified by the LSIB, the LSIB have raised concerns related to maintenance of sufficient water flows to creeks below the Project Site (see Appendix 3-F of Chapter 3 in the Application/EIS).

HCMC will continue to engage the SFN, ALIB, NIB, LSIB and the MNBC with respect to the Project and the Fisheries Offsetting Plan. Consultation with the SFN, ALIB, NIB, and LSIB specific to the Fisheries Offsetting plan will be undertaken as directed by the Canadian Environmental Assessment Agency (CEA Agency) and DFO. First Nations will have the opportunity to review and comment on the FOP during the formal review of the Application/EIS. HCMC will take these comments into consideration as appropriate.

15. CONCLUSIONS

Based on the office and field assessment of the Lion Creek and Harper Creek options, both are considered technically feasible options to offset fish habitat loss incurred by the proposed Harper Creek Project.

For the Lion Creek site the low gradient terrain indicates that conventional excavation and construction techniques for the channels and ponds will be appropriate. The presence of groundwater along the proposed alignment indicates a high potential for groundwater to be the primary water supply source. The existing terrain provides suitable low gradient ground surfaces for the construction of the channels and ponds.

The designs presented in Appendix F show potential habitat area that is feasible to construct. The actual areas that will be constructed will be less than these potential areas and will be determined based on the habitat area required for sufficient offsetting. The larger potential number is presented as optional area available as a risk mitigation measure.

The Lion Creek project was chosen based on many biological and geophysical criteria. Preference was given to building fewer larger projects as opposed to many small projects in order to more efficiently use resources and to focus maintenance activities.

The following are recommendations for consideration in the future development of the Lion Creek Off-Channel Project:

- Based on engineering surveys, detailed design work is required to determine the final configuration of the channels, ponds, and access road/protection dyke;
- The construction-related earthwork volumes will need to be determined in conjunction with related cost estimate for constructing the Project; and
- A Construction Management Plan should be completed that will include road access details, borrow and spoil areas, material handling, construction sequencing, and an Environmental Management Plan for the Project area.

The Harper Creek Spawning Gravel Placement option was selected due to its proximity to the proximity to the mine site and the focus on adfluvial Bull Trout.

For the Harper Creek Spawning Gravel Placement the following are recommendations for consideration in the future development:

- field verify locations for access routes;
- topographic survey of existing spawning gravel for pre-placement areas and volumes;
- sieve tests of gravel from preferred Bull Trout spawning sites; and
- velocity and depth criteria to develop Froude number relationship for Bull Trout to confirm hydraulics at confirm locations prior to placement and for follow up monitoring purposes.

After fisheries offsetting has been completed it is predicted that the gain in habitat will be approximately equal to the predicted losses resulting from Project activity (Table 15-1).

Table 15-1. Habitat Budget

	Location	Area (m^2)	Area (ha)
Losses	upper Harper Creek	9,643 to 13,651	0.96 to 1.37 *
	P Creek	324	0.03
	T Creek	514	0.05
	Total	10,482 to 14,490	1.04 to 1.45*
Gains	Lion Creek	11,000	1.1
	lower Harper Creek	400	0.04
	Total	11,400	1.14

*Notes: * predicted losses will be confirmed in an instream flow study prior to Project construction.*

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Definitions of the acronyms and abbreviations used in this reference list can be found in the Glossary and Abbreviations section.

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Appendix A

Summary of Watershed Model Predicted Discharge at Node 5 (P Creek at Harper Creek Confluence)

Appendix A. Summary of Watershed Model Predicted Discharge at Node 5 (P Creek at Harper Creek Confluence)

Mine Stage			Mean Monthly Discharge												Average Annual
Year	Description	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
-	Pre-Mine	m³/s	0.01	0.01	0.01	0.11	0.62	0.60	0.19	0.07	0.04	0.03	0.02	0.02	0.15
		%MAD	10%	9%	10%	78%	427%	413%	130%	45%	26%	23%	14%	10%	100%
		%Pre-Mine	-	-	-	-	-	-	-	-	-	-	-	-	-
-1	End of Construction	m³/s	0.02	0.02	0.02	0.09	0.65	0.63	0.12	0.04	0.02	0.02	0.01	0.02	0.14
		% Pre-Mine MAD	12%	11%	12%	61%	445%	435%	86%	25%	12%	13%	8%	11%	95%
		%Pre-Mine	121%	121%	121%	78%	104%	105%	66%	56%	45%	58%	57%	109%	87%
10	Operations I	m³/s	0.00	0.00	0.01	0.02	0.25	0.20	0.04	0.01	0.00	0.01	0.04	0.02	0.05
		% Pre-Mine MAD	2%	0%	6%	13%	171%	137%	28%	9%	3%	7%	27%	11%	35%
		%Pre-Mine	17%	3%	59%	16%	40%	33%	22%	21%	10%	29%	188%	102%	45%
22	Operations I	m³/s	0.00	0.00	0.01	0.02	0.24	0.19	0.04	0.01	0.00	0.01	0.04	0.02	0.05
		% Pre-Mine MAD	2%	0%	6%	13%	167%	129%	26%	9%	3%	7%	27%	11%	34%
		%Pre-Mine	19%	3%	65%	16%	39%	31%	20%	20%	10%	29%	195%	106%	46%
27	Operations II	m³/s	0.00	0.00	0.01	0.02	0.26	0.22	0.04	0.02	0.00	0.01	0.03	0.01	0.05
		% Pre-Mine MAD	1%	0%	5%	13%	180%	150%	31%	12%	3%	8%	21%	8%	36%
		%Pre-Mine	15%	3%	53%	16%	42%	36%	24%	26%	12%	33%	149%	81%	41%
30	Closure	m³/s	0.00	0.00	0.01	0.02	0.27	0.23	0.05	0.02	0.00	0.01	0.03	0.01	0.05
		% Pre-Mine MAD	1%	0%	4%	13%	186%	159%	33%	12%	3%	9%	21%	9%	38%
		%Pre-Mine	14%	2%	47%	17%	44%	38%	26%	27%	13%	38%	150%	82%	41%
50	Post-Closure	m³/s	0.00	0.00	0.01	0.02	0.27	0.23	0.05	0.02	0.00	0.02	0.03	0.01	0.05
		% Pre-Mine MAD	1%	0%	4%	13%	186%	159%	33%	12%	3%	11%	21%	9%	38%
		%Pre-Mine	14%	2%	47%	17%	44%	38%	25%	27%	13%	47%	151%	82%	42%

MAD = mean annual discharge

Appendix B

Summary of Watershed Model Predicted Discharge at Node 3 (T Creek at Harper Creek Confluence)

Appendix B. Summary of Watershed Model Predicted Discharge at Node 3 (T Creek at Harper Creek Confluence)

Mine Stage			Mean Monthly Discharge												Average Annual
Year	Description	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
-	Pre-Mine	m^3/s	0.02	0.02	0.01	0.27	1.75	2.32	1.04	0.34	0.23	0.10	0.05	0.03	0.52
		%MAD	5%	4%	3%	52%	339%	449%	201%	66%	44%	20%	9%	6%	100%
		%Pre-Mine	-	-	-	-	-	-	-	-	-	-	-	-	-
-1	End of Construction	m^3/s	0.03	0.00	0.00	0.09	0.59	0.78	0.34	0.10	0.08	0.03	0.00	0.00	0.17
		% Pre-Mine MAD	5%	0%	0%	18%	114%	151%	65%	19%	16%	6%	1%	0%	33%
		%Pre-Mine	116%	9%	3%	34%	34%	34%	32%	29%	37%	31%	9%	0%	31%
10	Operations I	m^3/s	0.00	0.00	0.00	0.08	0.57	0.73	0.27	0.05	0.02	0.02	0.00	0.00	0.14
		% Pre-Mine MAD	0%	0%	0%	15%	110%	141%	51%	9%	4%	4%	1%	0%	28%
		%Pre-Mine	0%	0%	0%	29%	32%	31%	26%	14%	10%	18%	9%	0%	14%
22	Operations I	m^3/s	0.00	0.00	0.00	0.08	0.55	0.70	0.24	0.04	0.02	0.02	0.00	0.00	0.14
		% Pre-Mine MAD	0%	0%	0%	15%	106%	135%	47%	8%	4%	3%	1%	0%	27%
		%Pre-Mine	0%	0%	0%	29%	31%	30%	24%	12%	9%	17%	9%	0%	13%
27	Operations II	m^3/s	0.00	0.00	0.00	0.08	0.55	0.70	0.25	0.04	0.02	0.02	0.00	0.00	0.14
		% Pre-Mine MAD	0%	0%	0%	15%	106%	135%	48%	8%	4%	3%	1%	0%	27%
		%Pre-Mine	0%	0%	0%	28%	31%	30%	24%	13%	9%	16%	9%	0%	13%
30	Closure	m^3/s	0.03	0.03	0.03	0.24	1.15	1.57	0.52	0.11	0.10	0.14	0.06	0.05	0.34
		% Pre-Mine MAD	6%	6%	6%	46%	223%	304%	101%	22%	20%	27%	12%	10%	65%
		%Pre-Mine	135%	163%	224%	88%	66%	68%	51%	34%	45%	136%	129%	173%	109%
50	Post-Closure	m^3/s	0.07	0.13	0.19	0.54	2.01	2.60	0.83	0.21	0.16	0.21	0.08	0.07	0.59
		% Pre-Mine MAD	13%	26%	36%	104%	389%	503%	160%	41%	31%	42%	16%	14%	115%
		%Pre-Mine	286%	696%	1258%	199%	115%	112%	80%	62%	70%	208%	173%	234%	291%

Note:
MAD = mean annual discharge

Appendix C

Biological Criteria for Fish Habitat Offsetting Designs

Appendix C. Observed Habitat Use and Selected Biological Characteristics by Life Stage for Bull Trout

Eggs	
Temperature tolerance range	0°C to 8°C
Optimum incubation temperature	2°C to 4°C
Recommended oxygen concentration	9.5 mg/L
Lower lethal oxygen concentration	NA
Range of incubation time	34 to 125 days
Incubation at optimum temperature days	95 to 125 days
Lower lethal pH	NA
Recommended current velocity	below level causing gravel scour
Juveniles	
Temperature tolerance range	0°C to 8°C
Optimum temperature for growth	< 12°C
Recommended oxygen concentration	7.75 mg/L
Lower lethal oxygen concentration	NA
Habitat type preference	pools
Preferred current velocity	to 1.0 m
Substrate	<0.5 m/s
Cover	cobble and boulder
Turbidity tolerance	cobble and fine debris
Primary food category	NA
Secondary food taxa	benthic insects drift
Adults	
Temperature tolerance range	0°C to 12.8°C
Optimum temperature for growth	NA
Recommended oxygen concentration	NA
Lower lethal oxygen concentration	NA
Habitat type preference	lake or large river
Observed depth preference	varies, up to at least 18 m
Preferred current velocity	none
Substrate	NA (primarily in lakes)
Cover	depth
Turbidity tolerance	NA
Primary food type	fish
Secondary food type	benthic insects
Form of reproduction	iteroparous
Nest construction	yes
Spawning habitat type	small streams
Preferred spawning temperature	< 9°C
Preferred spawning depth	0.15 m to 0.84 m
Preferred spawning substrate	cobble / gravel
Preferred spawning current velocity	25 cm/s to 65 cm/s
Range of first age-at-maturity	(precocious males age 3) age 5
Range of fecundity	660 to 6,750 eggs/female or 920 eggs/kg @ 600 mm FL

NOTES:

1. Source: Ford et al. (1995)

Appendix C. Observed Habitat Use and Selected Biological Characteristics by Life Stage for Rainbow Trout

Eggs -	-
Temperature tolerance range	2°C - 20°C
Optimum incubation temperature	11°C
Recommended oxygen concentration	>5.35 mg/L
Lower lethal oxygen concentration	4.3 mg/L
Range of incubation time	18 - 102 days
Incubation time at optimum temperature	28 - 49 days
Lower lethal pH	5.3
Recommended intergravel current velocity (yields 50% mort @ 5.3 mg/L DO)	2 cm/s
Optimal depth	NA
Substrate	gravel with < 5% fine
Juveniles -	-
Temperature tolerance range	0°C to 24°C
Optimum temperature for growth	10°C - 14°C
Recommended oxygen concentration	> 7 mg/L
Lower lethal oxygen concentration	3 mg/L
Habitat type preference	margins of lakes or streams
Depth preference	3 m to 6 m in lakes, 0.3 - 1.2 m in streams
Preferred current velocity	8 cm/s - 20 cm/s
Substrate	cobble/boulder and rubble
Cover	cobble, woody debris
Turbidity tolerance	NA
Primary food category	benthic invertebrates and terrestrial insect larvae
Secondary food taxa	zooplankton, adult insects
Adults -	-
Temperature tolerance range	0 - 28°C
Optimum temperature for growth	10°C - 14°C
Recommended oxygen concentration	> 7mg/L if < 15°C, > 9 mg/L if > 15°C
Lower lethal oxygen concentration	3 mg/L
Habitat type preference	lakes and streams
Depth preference	variable, based on water temperature
Preferred current velocity	20 - 30 cm/s
Substrate	cobble to boulder
Cover	light intensity, debris, boulders
Turbidity tolerance	NA
Primary food type	terrestrial insect larvae, benthic invertebrates
Secondary food type	fish
Form of reproduction	iteroparous
Nest construction	yes
Spawning habitat type	small streams
Preferred spawning temperature	7.2°C - 13.3°C
Preferred spawning depth	0.15 m - 2.5 m
Preferred spawning substrate	typically 4 mm - 100 mm
Preferred spawning current velocity	30 cm/s - 90 cm/s
Range of first age-at-maturity	1 - 4 yrs
Range of fecundity	200 - 13,000 eggs/kg

NOTES:

1. Source: Ford et al. (1995)

Appendix D

Discharge Measurements from Lion Creek

Appendix D. Discharge Measurements from Lion Creek

Site Information					
Project Name	Harper Carrk				
Station Identification	Flow into tunnel at Lion Creek				
Stream Name	Lion Creek				
Date Monitored	26-Aug-14				
Time at Site (24 hr)	**Start Time:**		**End Time:**	11:17:00 AM	
Personnel					
Station Cordinates	**Easting**	**Northing**	**Elevation**		
Weather Conditions					

Transducer Information			
DL Model		**PT Serial #**	
Gain		**Offset**	
Status		**Battery**	
# of Records		**Memory Free**	
Date Serviced		**Crest Gauges**	

Hydrometric Leveling Survey

Stn	BS	HI	FS	Elevation	Notes
BM 1		0.000			
BM 2				0.000	
BM 3				0.000	
WL				0.000	
PT				0.000	
TBM				0.000	
TBM		0.000		0.000	
BM 1				0.000	
BM 2				0.000	
BM 3				0.000	
WL				0.000	
PT				0.000	

BM#	Established Elevation (m)	Mean Elevation (this date) (m)	Difference (m)	Notes
BM 1		0.000	0.000	
BM 2		0.000	0.000	
BM 3		0.000	0.000	

Summary	
Staff Gauge Reading (m)	0.000
Stage from WL Survey (m)	0.000
Pressure Transducer Reading (m)	At Time of Stage Measurement)
Pressure Transducer Elevation (m)	#VALUE!
Discharge (m^3/s)	**0.232**
Cross Sectional Area	2.295
Average Velocity	0.101

Discharge Measurement - Mid-Section Method

Measurement Time	**Start**		**End**		**Location**	
Method	Velocity-area (Mid-section)			**Instrument Model**		
Flow Meter Type				**Instrument Serial #**		
Real Time Reading (m)	**Start**	**Reading**		**Time**		**Staff Gauge (m)**
	End	**Reading**		**Time**		**Time of SG Reading**

No.	Notes	Station (m)	Depth (m)	Distance (m)	Area (m^2)	Velocity (m/s) 60%	20%	80%	Q (m3/s)	% of Total Q %
1		4.75	0.00	0.0	0.00	0			0.000	0.0
2		4.70	0.07	0.0	0.02	0.06			0.001	0.5
3		4.20	0.50	0.5	0.23	0.32			0.072	31.1
4		3.80	0.59	0.4	0.24	0.32			0.076	32.6
5		3.40	0.68	0.4	0.31	0.22			0.067	29.0
6		2.90	0.64	0.5	0.32	0.11			0.035	15.2
7		2.40	0.69	0.5	0.41	0			0.000	0.0
8		1.70	0.66	0.7	0.40	-0.03			-0.012	-5.1
9		1.20	0.58	0.5	0.38	-0.02			-0.008	-3.3
10		0.40	0.00	0.8	0.00	0			0.000	0.0
11				0.4	0.00				0.000	0.0
12				0.0	0.00				0.000	0.0
13				0.0	0.00				0.000	0.0
14				0.0	0.00				0.000	0.0
15				0.0	0.00				0.000	0.0
16				0.0	0.00				0.000	0.0
17				0.0	0.00				0.000	0.0
18				0.0	0.00				0.000	0.0
19				0.0	0.00				0.000	0.0
20				0.0	0.00				0.000	0.0
21				0.0	0.00				0.000	0.0
22				0.0	0.00				0.000	0.0
23				0.0	0.00				0.000	0.0
24				0.0	0.00				0.000	0.0
25				0.0	0.00				0.000	0.0
26				0.0	0.00				0.000	0.0
27				0.0	0.00				0.000	0.0
28				0.0	0.00				0.000	0.0
29				0.0	0.00				0.000	0.0
30				0.0	0.00				0.000	0.0
31				0.0	0.00				0.000	0.0
32				0.0	0.00				0.000	0.0
33				0.0	0.00				0.000	0.0
Total Q									**0.232**	**100.0**

General Notes

Appendix D. Discharge Measurements from Lion Creek

Site Information					
Project Name	Harper Carrk				
Station Identification	25 m dnst hillside seepage Lion Creek				
Stream Name	Lion Creek				
Date Monitored	26-Aug-14				
Time at Site (24 hr)	Start Time:		End Time:	10:46:00 AM	
Personnel					
Station Cordinates	Easting	Northing	Elevation		
	0339977	5750186			
Weather Conditions					

Transducer Information			
DL Model		PT Serial #	
Gain		Offset	
Status		Battery	
# of Records		Memory Free	
Date Serviced		Crest Gauges	

Hydrometric Leveling Survey					
Stn	BS	HI	FS	Elevation	Notes
BM 1		0.000			
BM 2				0.000	
BM 3				0.000	
WL				0.000	
PT				0.000	
TBM				0.000	
TBM		0.000		0.000	
BM 1				0.000	
BM 2				0.000	
BM 3				0.000	
WL				0.000	
PT				0.000	

BM#	Established Elevation (m)	Mean Elevation (this date) (m)	Difference (m)	Notes
BM 1		0.000	0.000	
BM 2		0.000	0.000	
BM 3		0.000	0.000	

Summary	
Staff Gauge Reading (m)	0.000
Stage from WL Survey (m)	0.000
Pressure Transducer Reading (m)	At Time of Stage Measurement)
Pressure Transducer Elevation (m)	#VALUE!
Discharge (m^3/s)	**0.096**
Cross Sectional Area	0.828
Average Velocity	0.116

Discharge Measurement - Mid-Section Method									
Measurement Time	Start		End		Location				
Method	Velocity-area (Mid-section)			Instrument Model					
Flow Meter Type				Instrument Serial #					
Real Time Reading (m)	Start	Reading		Time		Staff Gauge (m)			
	End	Reading		Time		Time of SG Reading			

No.	Notes	Station (m)	Depth (m)	Distance (m)	Area (m^2)	Velocity (m/s) 60%	20%	80%	Q (m3/s)	% of Total Q %
1		0.40	0.00	0.0	0.04	0			0.000	0.0
2		1.00	0.12	0.6	0.07	0.06			0.004	4.5
3		1.60	0.25	0.6	0.15	0.32			0.048	49.9
4		2.20	0.14	0.6	0.08	0.32			0.027	27.9
5		2.80	0.09	0.6	0.05	0.22			0.012	12.4
6		3.40	0.11	0.6	0.07	0.11			0.007	7.5
7		4.00	0.10	0.6	0.06	0			0.000	0.0
8		4.60	0.04	0.6	0.02	-0.03			-0.001	-0.7
9		5.20	0.12	0.6	0.07	-0.02			-0.001	-1.5
10		5.80	0.20	0.6	0.12	0			0.000	0.0
11		6.40	0.14	0.6	0.09				0.000	0.0
12		7.08	0.00	0.7	0.00				0.000	0.0
13				7.1	0.00				0.000	0.0
14				0.0	0.00				0.000	0.0
15				0.0	0.00				0.000	0.0
16				0.0	0.00				0.000	0.0
17				0.0	0.00				0.000	0.0
18				0.0	0.00				0.000	0.0
19				0.0	0.00				0.000	0.0
20				0.0	0.00				0.000	0.0
21				0.0	0.00				0.000	0.0
22				0.0	0.00				0.000	0.0
23				0.0	0.00				0.000	0.0
24				0.0	0.00				0.000	0.0
25				0.0	0.00				0.000	0.0
26				0.0	0.00				0.000	0.0
27				0.0	0.00				0.000	0.0
28				0.0	0.00				0.000	0.0
29				0.0	0.00				0.000	0.0
30				0.0	0.00				0.000	0.0
31				0.0	0.00				0.000	0.0
32				0.0	0.00				0.000	0.0
33				0.0	0.00				0.000	0.0
Total Q									**0.096**	**100.0**

General Notes

Appendix E

Existing Lion Creek Water License

WATER MANAGEMENT BRANCH

MINISTRY OF ENVIRONMENT

THE PROVINCE OF BRITISH COLUMBIA—WATER ACT

CONDITIONAL WATER LICENCE

Department of Fisheries and Oceans, Canada, 1090 West Pender Street, Vancouver, B.C. V6E 2P1

is hereby authorized to divert and use water as follows:

(a) The source of the water-supply is Lion Creek.

(b) The point of diversion is located as shown on the attached plan.

(c) The date from which this licence shall have precedence is 16th February, 1981.

(d) The purpose for which the water is to be used is conservation.

(e) The maximum quantity of water which may be diverted is 10.0 cubic feet per second, and such additional quantity as the Engineer may from time to time determine should be allowed for losses.

(f) The period of the year during which the water may be used is the whole year.

(g) This licence is appurtenant to the conservation project of the licensee within Lot 3072, Kamloops Division of Yale District.

(h) The works authorized to be constructed are diversion structure, pipe and hatchery, which shall be located approximately as shown on the attached plan.

(i) The construction of the said works have been commenced and shall be completed and the water beneficially used on or before the 31st day of December, 1986.

ENTERED ON

Map No. _____

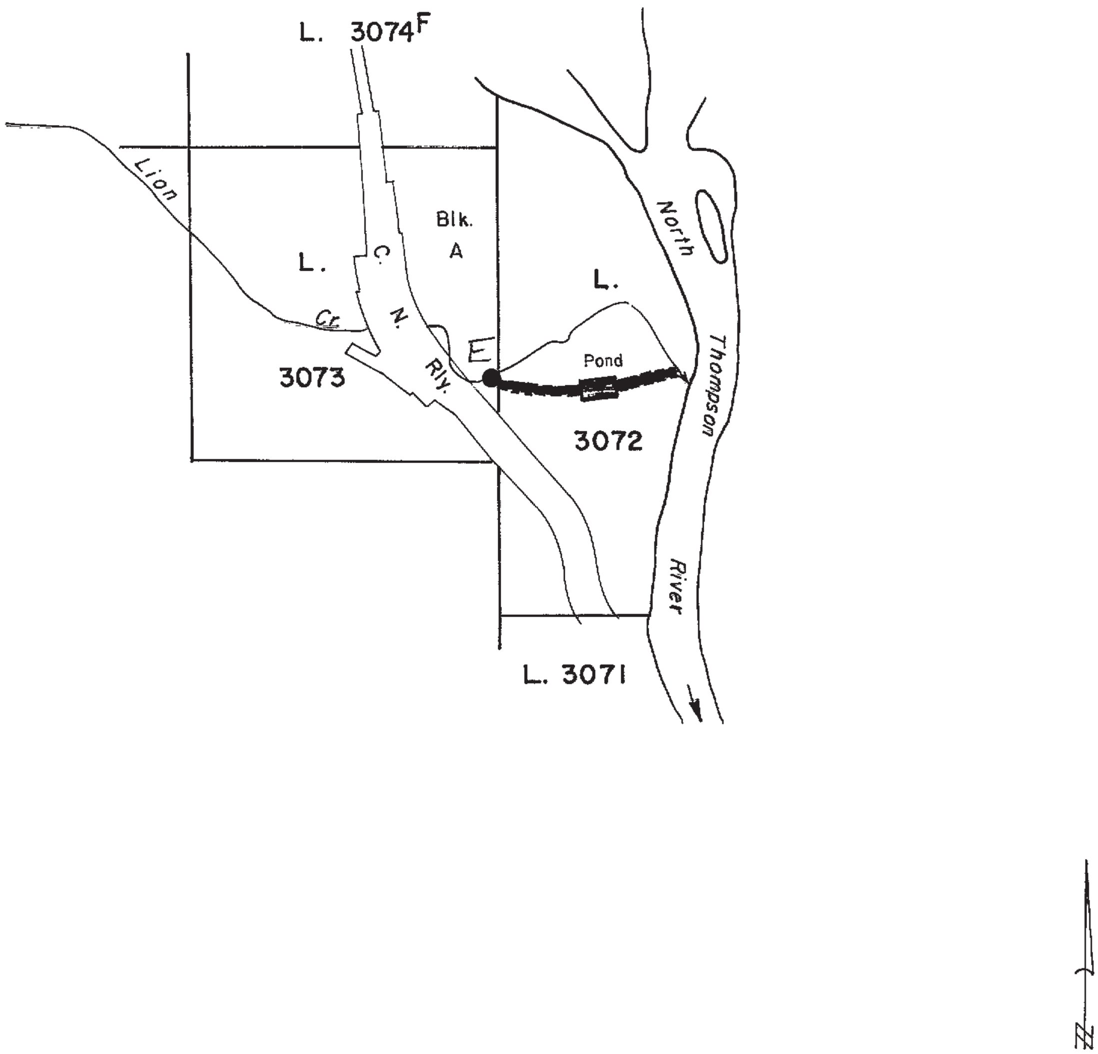
By LK

J. E. Farrell
Deputy Comptroller of Water Rights

File No. 0367926 Date issued: OCT 1 - 1984 Conditional Licence 60981

W-183

Province of British Columbia



WATER DISTRICT :KAMLOOPS
PRECINCT :NORTH BRANCH
LAND DISTRICT :KAMLOOPS DIVISION OF YALE

Signature ....
Date OCT 1 - 1984

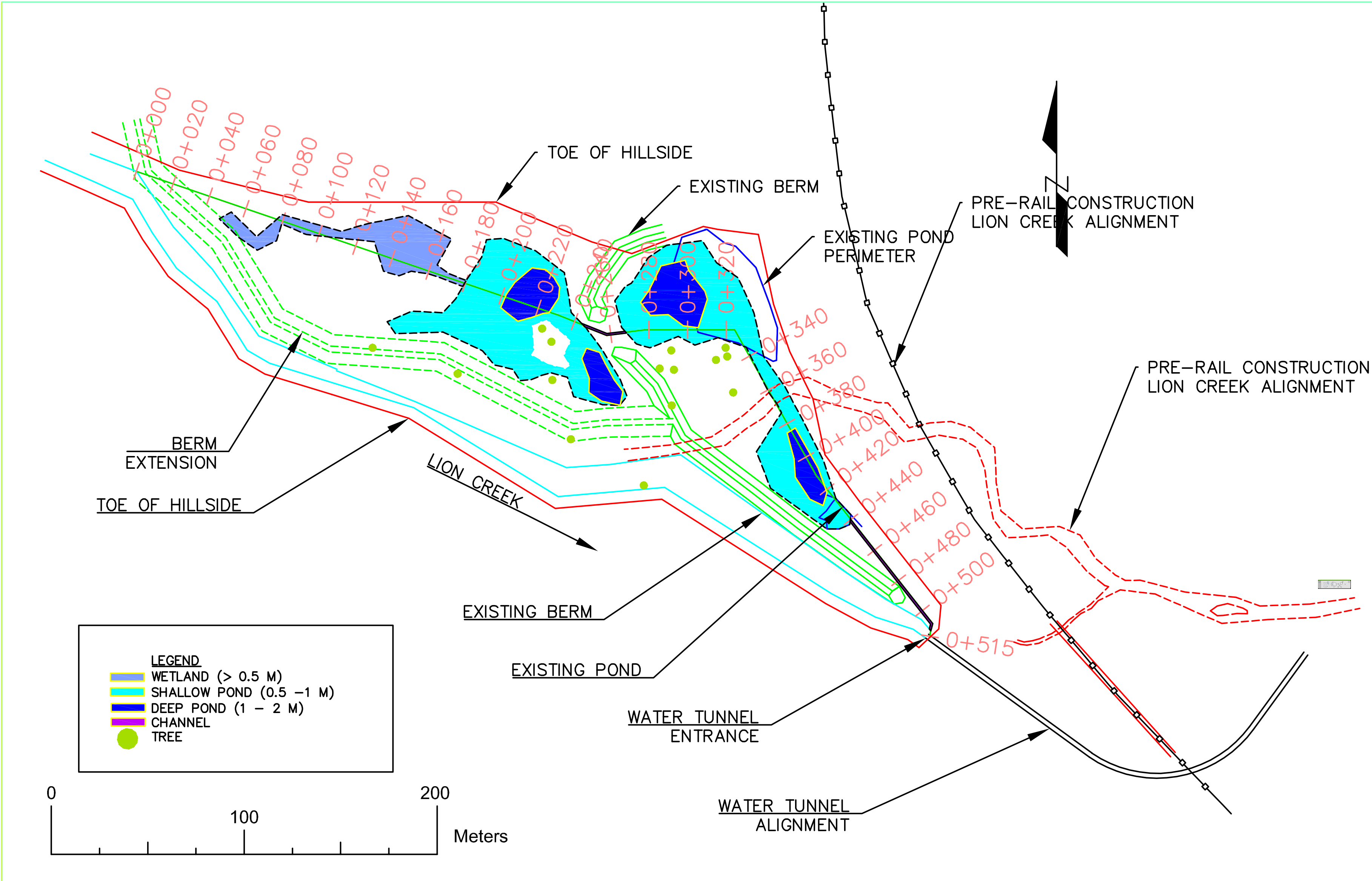
LEGEND

Scale : 20 Chains to 1 Inch
Point of Diversion : ●
Map Number : WR 82 M/NW(14-f)
Pipe : ——— - ———
Permit over Crown Land:

C.L. 60981
File 0367926
P.C.L. 14518

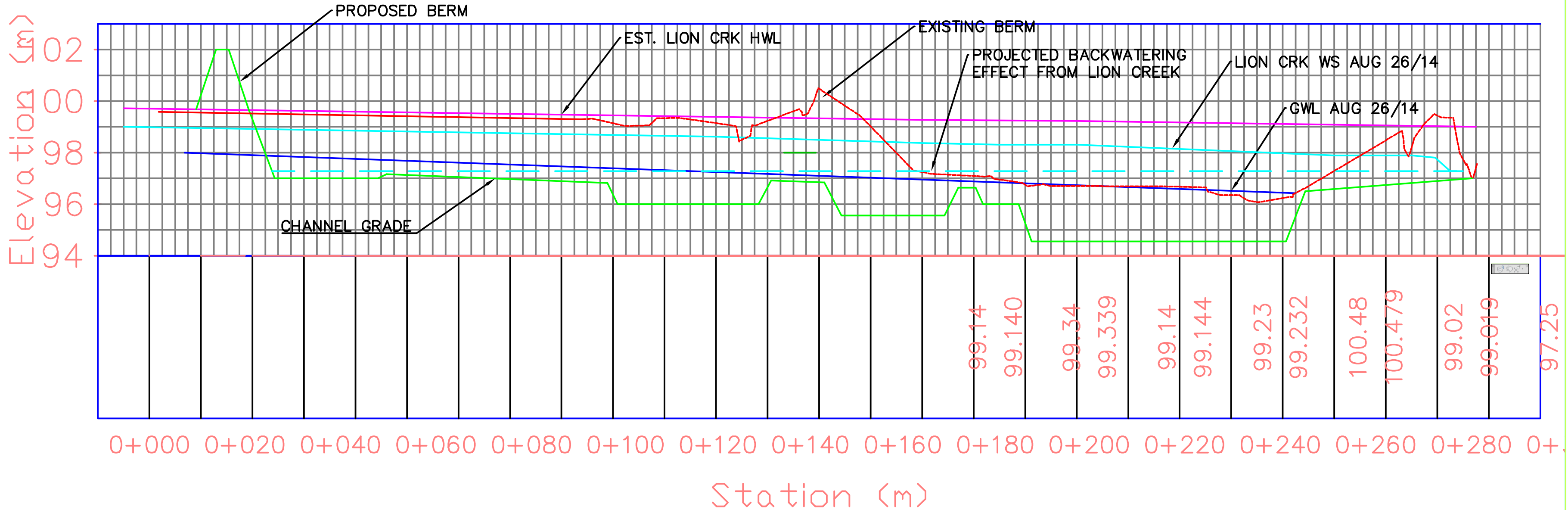
Appendix F

Lion Creek Technically Feasible Design Drawings



Drawn By P. House	ERM®	PRELIMINARY SITE LAYOUT	CHK'D
CADD Review			
Date Drawn/Rev'd Oct 10, 2014		Environmental Resources Management	

CENTRELINE PROFILE OF PROPOSED CHANNELS AND PONDS



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CADD Review			
Date Drawn/Rev'd Oct 10, 2014		Environmental Resources Management	