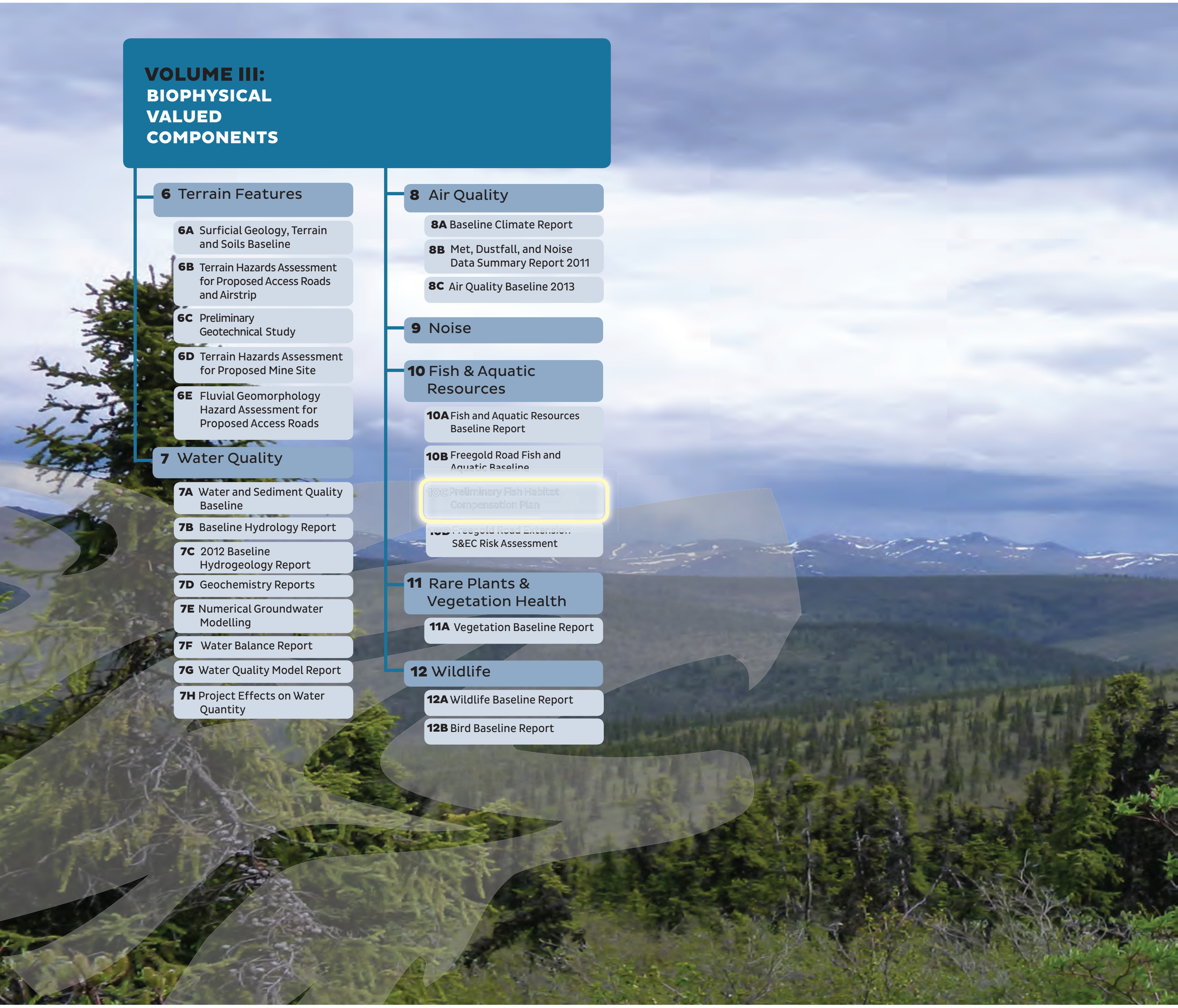
APPENDIX 10C: PRELIMINARY FISH HABITAT COMPENSATION PLAN



PALMER ENVIRONMENTAL CONSULTING GROUP INC.

Casino Project

Preliminary Fish Habitat Compensation Plan

Prepared for

Casino Mining Corporation

November 29, 2013

November 29, 2013

Jesse Duke
VP Environmental Affairs
Casino Mining Corporation
2050-1111 West Georgia Street
Vancouver, BC V6E 4M3

Dear Mr. Duke,

Re: Casino Project, Preliminary Fish Habitat Compensation Plan

Palmer Environmental Consulting Group Inc. is pleased to submit the attached Preliminary Fish Habitat Compensation Plan for the Casino Project, in support of its Environmental Assessment being submitted to the Yukon Environmental and Socio-Economic Assessment Board.

This report describes how Casino Mining Corporation proposes to compensate for residual impacts to fish habitat, in order to achieve No Net Loss in fish habitat productivity. Following summaries of existing conditions and predicted impacts, it outlines the compensation objectives and rationale, provides overviews of original candidate opportunities, and describes how the proposed compensation results in net gains in both habitat quantity and quality.

If you or technical reviewers have any questions about this report, please feel free to contact Rick Palmer at 604-629-9075 or at rick@pecg.ca.

We appreciate the opportunity to work with you on this project.

Yours truly,

Palmer Environmental Consulting Group Inc.

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Executive Summary

Casino Mining Corporation proposes to develop the Casino Project, a copper-gold-molybdenum-silver mine in west-central Yukon, approximately 300 km northwest of Whitehorse within the traditional territories of the Selkirk First Nation and Little Salmon Carmacks First Nation. The proposed mine consists of an open pit, processing facilities, a heap leach facility, a tailings management facility and an airstrip, with access provided from Carmacks along an upgraded and extended Freegold Road. It is anticipated to process 120,000 t/d or 43.8 million t/y of material over 22 years of full production. Based on comprehensive baseline and risk studies, Casino Mining Corporation has minimized predicted impacts of the project on fish and fish habitat through re-design, refinement and mitigation measures. This document presents the Casino Project Preliminary Fish Habitat Compensation Plan to address predicted residual impacts on fish habitat, pursuant to the *Yukon Environmental and Socio-economic Assessment Act* and the federal *Fisheries Act*. It has been completed in accordance with the older *Fisheries Act*, during a time of transition for environmental legislation in Canada, as the new provisions have yet to be widely implemented at the time of writing.

The Casino Project is located wholly within the Yukon River watershed. The proposed mine and associated facilities are situated in the upper watersheds of Casino Creek and Canadian Creek (a tributary to Britannia Creek), with the proposed airstrip located in the adjacent Dip Creek watershed. Slimy sculpin and Arctic grayling are the dominant species within the high-elevation mine area, where cold water temperatures, high gradients and velocities, a lack of overwintering habitat, and locally poor water quality and benthic community greatly limit productive capacity. Low numbers of burbot and round whitefish are present in the lower watersheds. Juvenile Chinook salmon have been captured in lower Britannia Creek, near its confluence with the Yukon River. Habitats mainly support rearing, with limited opportunities for spawning, and overwintering restricted to larger, downstream watercourses with sufficient base flows and deep pools. Similar species and habitat types dominate the watercourses crossed by the Freegold Road upgrade and extension, between the mine site and Carmacks. However, chum salmon and Chinook salmon spawning habitat have also been documented in some of the largest creeks and rivers.

The main impacts of the Casino Project on fish habitat are anticipated in the upper Casino Creek watershed, in association with tailings management facility construction. Smaller-scale, in-stream impacts are also expected along lower Casino Creek and Dip Creek, due to flow reductions; along a small, unnamed tributary to Dip Creek, which will be diverted around the new airstrip using natural channel design principles; along lower Canadian Creek, once surface runoff in its headwaters is allowed to drain into the open pit; along lower Britannia Creek, in association with the compensatory reinstatement of its historical, meandering channel; and within the small footprint of a single, new bridge pier in the Nordenskiold River. Impacts to riparian habitat are predicted in correspondence with these sites of in-stream impact, as well as in association with the abutments and approaches to clear-span bridges along the Freegold upgrade and extension, and the airstrip access road.

Potential impacts of the Casino Project on in-stream fish habitat were assessed using a physical habitat simulation (PHABSIM), where a partial loss of flow is predicted, and a habitat evaluation procedure

(HEP), where a complete loss of flow is anticipated. Both methods have been widely used across North America as a reliable model for quantifying habitat loss, including for recent environmental assessments for similar projects in Canada, because they provide a means of quantifying biologically-relevant habitat loss (or gain) by taking into account the habitat preferences and requirements of a species at varying life stages. Impacts to riparian habitat were determined based on the predicted areas of disturbance or loss of vegetation within stream-side buffers that reflect the type of vegetation and the suitability and sensitivities of adjacent, in-stream habitats. The assessments predict a loss of 18,956 m^2 of 'usable' in-stream habitat and a loss of 355,970 m^2 of riparian habitat alongside fish-bearing watercourses.

Casino Mining Corporation has identified and developed preliminary designs for several fish habitat compensation opportunities that address known limitations to fish habitat productivity in the affected watersheds, in order to compensate effectively for the residual impacts outlined above. An initial, systematic inventory of compensation opportunities in the project area identified ten candidate options for restoring, creating or enhancing in-stream and riparian habitat. Three of these options, plus an additional two recently identified opportunities, will ensure "No Net Loss" in the productive capacity of fish habitat through an in-stream habitat gain-to-loss ratio of 2:1. The reinstatement of the historical channel of lower Britannia Creek, within 2 km of its confluence with Yukon River, will re-establish 13,643 m^2 of pre-existing, high quality habitat that exhibits tortuous meanders, gravel and cobble substrates, deep pools separated by low-gradient riffles, undercut banks and functional in-stream large woody debris. A deep, groundwater-fed pool will be excavated alongside Britannia Creek, mimicking the form and function of a natural oxbow, in order to provide about 9,200 m^2 of off-channel rearing and overwintering habitat for Chinook salmon, Arctic grayling and other species of fish. In-stream and riparian habitat will be restored at seven abandoned fords along lower Britannia Creek, where vehicle tracking has led to bank erosion and continued sedimentation downstream, resulting in a gain of 560 m^2 of in-stream habitat plus its restored riparian buffer. The diversion of a small, unnamed tributary of Dip Creek around the proposed airstrip will provide the opportunity to re-establish a naturalized, sinuous channel with large woody debris and variable substrates, providing 4,753 m^2 of enhanced, replacement habitat. Although the combined implementation of these four compensation measures is predicted to result in greater gains than losses in habitat, Casino Mining Corporation further commits to identifying, designing, constructing and monitoring at least 9,756 m^2 of new, enhanced or restored Chinook spawning and rearing habitat, through a project developed in consultation with Selkirk First Nation, Fisheries and Oceans Canada and other interested organizations, allowing for the possibility that certain compensation elements may not function as effectively as intended.

A strategy is outlined for safely and cost-effectively implementing the proposed compensation measures, including consideration of the timing and phasing of construction, the installation and maintenance of erosion and sediment control measures, and the need for construction and effectiveness monitoring. The total cost of the fish habitat compensation plan is estimated to be approximately $3.2 million. Subsequent detailed, multi-disciplinary design, the implementation of compensation works before or in conjunction with impacts, and an allowance for adaptive management will ensure the long-term effectiveness of the proposed compensation measures.

Table of Contents

Letter
Signatures
Executive Summary

1 Introduction ... 1
1.1 Casino Project Overview ... 1
1.1.1 Principal Mine Components and Infrastructure ... 1
1.1.2 Project Phasing and Scheduling ... 5
1.2 DFO Consultation ... 6
1.3 Report Organization ... 7

2 Overview of Fish and Fish Habitat in the Project Area ... 8
2.1 Contribution to Local Fisheries ... 11
2.2 Habitat Requirements ... 11
2.3 Limitations to Habitat Productive Capacity ... 12

3 Summary of Impact Assessment ... 14
3.1 Habitat Impact Evaluation ... 14
3.1.1 Physical Habitat Simulation (PHABSIM) ... 14
3.1.2 Habitat Evaluation Procedure (HEP) ... 24
3.1.3 Riparian Habitat ... 25
3.2 Habitat Impacts ... 25
3.2.1 Airstrip and Access Road ... 27
3.2.2 Canadian Creek Diversion ... 28
3.2.3 Fish Habitat Compensation Construction ... 28
3.2.4 Freegold Road Extension ... 28
3.2.5 Freegold Road Upgrade ... 28
3.2.6 Tailings Management Facility ... 29
3.3 Habitat Impacts Mitigated by Project Re-design ... 30
3.3.1 Bridges Instead of Culverts for Fish-Bearing Crossings ... 30
3.3.2 TMF Spillway By-pass of Brynelson Creek ... 30
3.3.3 Naturalization of Airstrip Diversion Channel ... 31

4 Fish Habitat Compensation ... 32
4.1 Objectives and Rationale ... 32
4.1.1 Hierarchy of Preferred Compensation Options ... 33
4.1.2 Target Species and Fisheries Management Objectives ... 33
4.1.3 Improvement of Existing Impacts or Constraints ... 34
4.1.4 First Nations Traditional Uses and Knowledge ... 35
4.1.5 Compliance with Recovery Planning for Species at Risk ... 35
4.1.6 Type, Amount and Supply of Habitat at Impact and Compensation Sites ... 36

4.1.7 Temporal Nature of Impacts 38
4.1.8 Risk of Failure and Time Lag until Compensation Habitats Functional 38
4.2 Original Compensation Options 40
4.3 Description of Proposed Compensation 45
4.3.1 Lower Britannia Creek Compensation 47
4.3.2 Naturalized Airstrip Diversion Channel 51
4.3.3 Chinook Project Contribution 52
4.3.4 Riparian Habitat Compensation 53
4.4 Habitat Balance 55

5 Implementation Strategy 57
5.1 Timeline and Construction Phasing 57
5.2 Erosion and Sediment Control 59
5.3 Monitoring and Adaptive Management 60
5.4 Cost Estimate 61
5.5 Uncertainties and Next Steps 62

6 References 64

List of Figures

Figure 1-1. Overview Map of the Casino Project 2
Figure 1-2. Mine Site Overview 3
Figure 2-1. Placer Stream Classifications 10
Figure 3-1. Habitat Index versus Flow for All Life Stages of Arctic Grayling in Casino Creek 17
Figure 4-1. Schedule of Predicted Fish Habitat Impacts and Gains 39
Figure 4-2. Original Fish Habitat Compensation Options 41
Figure 4-3. Locations of Fish Habitat Impacts and Proposed Compensation 46
Figure 4-4. Existing and Historical Channels of Lower Britannia Creek 47
Figure 4-5. Downstream View of “Roadway” Channel of Lower Britannia Creek on Aug. 23, 2011 48
Figure 4-6. Overgrown Historical Channel of Lower Britannia Creek 49

List of Tables

Table 1-1. Casino Project Phases and Schedule 6
Table 3-1. Descriptions of Habitat Types Characterized along Casino, Dip and Canadian Creeks 15
Table 3-2. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Casino Creek (H18 and W4 Average) 18
Table 3-3. Total Adverse Impact to Usable Habitat (m^2) for Arctic Grayling Life Stages for Casino Creek (Average Values), Dip Creek and Canadian Creek under All Project Phases 19
Table 3-4. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Dip Creek, Downstream of Casino Creek 20

Table 3-5. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Canadian Creek (W3) 21
Table 3-6. Usable Habitat (m^2), Total Available Habitat (m^2) and Net Change from Baseline for Arctic Grayling Life Stages for Lower Casino Creek, Dip Creek and Canadian Creek under All Project Phases 23
Table 3-7. Results of HEP Studies on Upper Casino Creek, Britannia Creek and Meloy Creek 25
Table 3-8. Estimated In-stream Habitat Loss 26
Table 3-9. Estimated Riparian Habitat Loss 27
Table 4-1. Type and Supply of Habitat at Impact and Compensation Sites 37
Table 4-2. Risk of Failure and Time Lag for Compensation 39
Table 4-3. Summary Evaluation of Original Fish Habitat Compensation Options 42
Table 4-4. Summary of Riparian Habitat Compensation 54
Table 4-5. Habitat Balance Summary 55
Table 5-1. Estimated Habitat Compensation Costs 61

List of Appendices

Appendix A. Fish Habitat Compensation Preliminary Design Drawings

1 Introduction

Casino Mining Corporation (CMC) proposes to develop the Casino Project ("the Project"), located in west central Yukon approximately 150 km northwest of Carmacks (**Figure 1-1**). The Project is a proposed open pit copper-gold-molybdenum-silver mine that is anticipated to process 120,000 t/d or 43.8 million t/y of material over 22 years of full production. The Project is located on Crown land and is within the traditional territory of the Selkirk First Nation (SFN).

This document presents the Casino Project Preliminary Fish Habitat Compensation Plan (FHCP) to address predicted impacts on fish habitat, as described in the "Fish and Aquatic Resources Effects Assessment" (Section 10) of the Project Proposal pursuant to the *Yukon Environmental and Socio-economic Assessment Act* (YESAA). It has been completed during a time of transition for environmental legislation in Canada, including with respect to policies of Fisheries and Oceans Canada (DFO). In this FHCP, terminology relating to *Fisheries Act* policy is consistent with the older version of the *Act*, as the new provisions have yet to be widely implemented at the time of writing. New and forthcoming fisheries protection provisions relevant to this FHCP include amendments to Section 35 of the *Fisheries Act*, and to the supporting Fish Habitat Compensation Guide. The updated policy will support DFO's new focus on avoiding "Serious Harm to Fish", and the framework for offsetting any residual serious harm to fish.

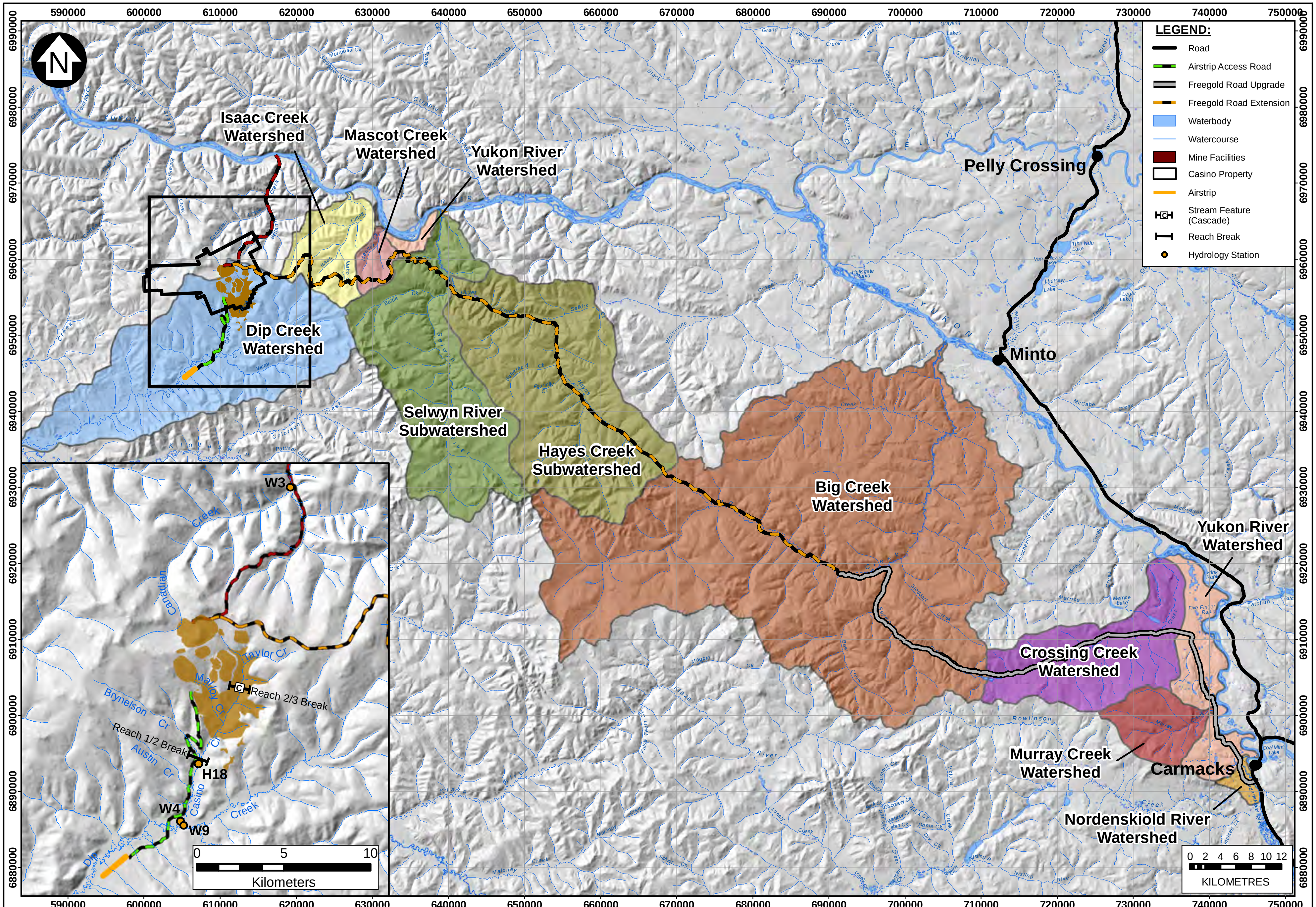
CMC has completed comprehensive baseline and risk studies to minimize predicted impacts of the Project on fish and fish habitat through re-design, refinement and mitigation measures. Compensation measures and an authorization under Section 35(2) of the *Fisheries Act* will be required, however, where it is not possible to avoid a harmful alteration, disruption or destruction of fish habitat (HADD). Accordingly, CMC anticipates that DFO will be identified by the Yukon Environmental and Socio-economic Board (YESAB) as a Decision Body under YESAA. The objective of the FHCP is to support DFO review of the Project Proposal, which will be submitted under YESAA. Detailed designs for fish habitat compensation will be provided to DFO in association with CMC's subsequent request for HADD authorization.

1.1 Casino Project Overview

1.1.1 Principal Mine Components and Infrastructure

This section provides an overview of seven principal mine components and associated infrastructure that have the potential to affect fish and fish habitat in the Project area (**Figures 1-1** and **1-2**):

- Open Pit;
- Tailings Management Facility (TMF);
- Processing Facilities;
- Heap Leach Facility;
- Freegold Road Upgrade;
- Freegold Road Extension; and
- Airstrip and Airstrip Access Road.



PREPARED BY:

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

DESIGNED	R. McKillop
DRAWN	D. Turner
CHK'D	R. McKillop
APP'D	R. McKillop
REV	R. Palmer
DATE	30Oct'13

NOTES:

1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:650,000

CASINO COPPER AND GOLD

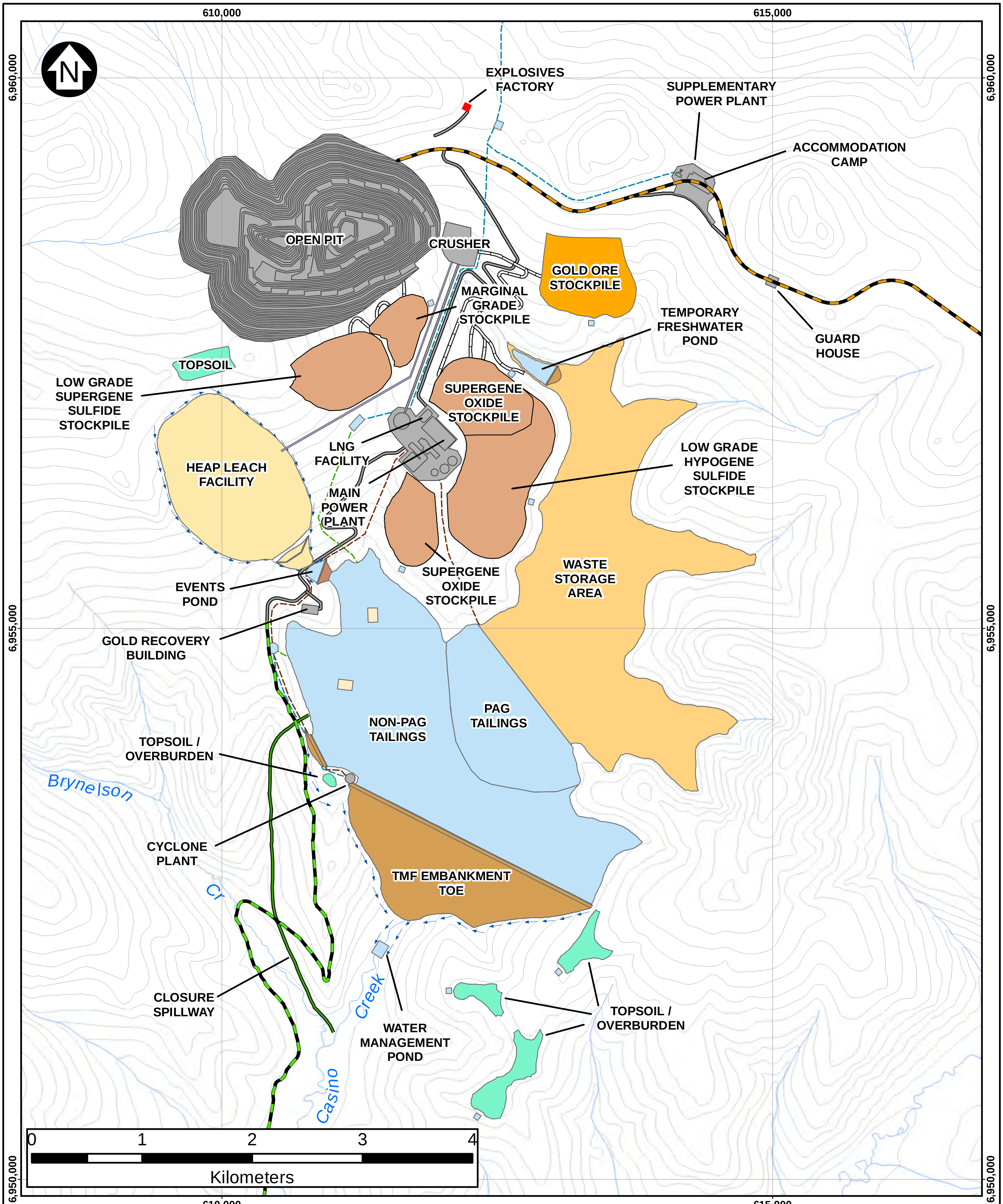
CASINO PROJECT

Overview Map of the Casino Project

FIGURE 1-1

FHCP REPORT

PN 10011



PREPARED BY:			NOTES:		
PALMER ENVIRONMENTAL CONSULTING GROUP INC.	DESIGNED	D. Turner	1. BASE MAP: 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca).	CASINO COPPER AND GOLD	MINE SITE OVERVIEW
	DRAWN	D. Turner	2. PROJECTION: NAD 1983 UTM Zone 7N		
	CHK'D	R. McKillop	3. COORDINATE GRID: METRES		
	APP'D	R. McKillop	4. SCALE: 1:45,000		
	REV	R. Palmer	5. CONTOUR INTERVAL: 100 feet	CASINO PROJECT	FIGURE 1-2 — FHCP REPORT
	DATE	30Oct2013			PN 10011

Additional details on the mine components are presented in the "Project Description" in Section 4 of the Project Proposal.

Casino Mine Open Pit

The proposed Open Pit straddles the headwaters of Casino Creek and Canadian Creek and is anticipated to produce an average 120,000 t/d of ore over 22 years of full production (**Figure 1-2**). The Open Pit will occupy an area of approximately 300 ha and will extend to a maximum depth of approximately 600 m below existing grade (Knight Piésold Ltd., 2012a). The Open Pit will contain two designated mining zones, the Main Pit and the West Pit, which will be developed concurrently during the operations phase of the Project using standard drill and blast technology.

Tailings Management Facility (TMF)

The Project TMF is located southeast of the Open Pit within the valley formed by the headwaters of Casino Creek (**Figure 1-2**). At its full extent, the TMF will cover approximately 1,120 ha of land within the Casino Creek valley. The objective of the TMF is to protect groundwater and surface waters from potentially reactive waste rock from the Open Pit, acidic supergene waste and supernatant water pond. The TMF has been designed to retain 974 Mt of tailings together with 598 Mt of potentially reactive waste rock and overburden, as well as 9 Mt of acidic supergene waste (Knight Piésold Ltd., 2012b, 2013a). The two embankments of the TMF – the Main Embankment and West Saddle Embankment – will be developed in stages throughout the duration of the Project using a combination of suitable non-reactive overburden, cyclone sand and waste rock materials from the plant site, Open Pit and local borrow sources (Knight Piésold Ltd., 2012b). The final heights of the Main Embankment and West Saddle Embankment will be 286 m (998 m elevation at crest) and 21 m (998 m elevation at crest), respectively.

Processing Facilities

The Project consists of two ore processing facilities, one for sulphide ore (i.e., molybdenum and copper) and one for oxide ore (i.e., gold, silver and copper) (**Figure 1-2**). The sulphide ore processing process involves primary crushing followed by conventional single-line semi-autogenous (SAG) mill circuit and conventional copper molybdenum floatation to produce concentrates of molybdenum and copper. Oxide ore processing involves a heap leach with a carbon adsorption facility to recover gold and silver and a Sulphidization, Acidification, Recycling and Thickening (SART) process to recover copper.

Heap Leach Facility

The proposed heap leach facility is located south of the open pit within the small tributary valley of Meloy Creek (**Figures 1-1 and 1-2**). This facility utilizes heap leach to process oxide 'gold' ore. The heap leach facility is anticipated to process approximately 157.5 million tonnes of oxide ore over the life of the Project.

Freegold Road Upgrade

Access to the proposed Casino mine site is currently limited to fixed-wing aircraft, helicopter and Yukon River barge, with some limited winter access for heavy equipment available along the old Casino Trail. To provide year-round access for heavy equipment, fuel and haulage trucks, CMC plans to construct a new all-weather resource road that connects the Casino mine site with the western limit of the existing Freegold Road, located approximately 85 km northwest of Carmacks (**Figure 1-1**). The existing Freegold Road will be upgraded to a two-lane (8.2 m-wide) gravel resource road that can accommodate the anticipated traffic from the Casino mine (hereinafter referred to as the "Freegold Road Upgrade"). Existing bridge and culvert crossings along the Freegold Road Upgrade section will be expanded to accommodate larger construction vehicles (Associated Engineering (AE), 2013). Bridge upgrades will be required over Crossing Creek and Bow Creek, and a new bridge will be constructed across the Nordenskiold River.

Freegold Road Extension

Beginning where the Freegold Road Upgrade section ends, CMC proposes to construct a new, all-weather, gravel road to the Casino mine site, referred to as the "Freegold Road Extension" (**Figure 1-1**). The Freegold Road Extension is a 120 km-long, two-lane gravel resource road designed to accommodate mine traffic. There are 18 major bridge crossings proposed along the extension, including crossings of Big Creek, Hayes Creek and Selwyn River, as well as several larger tributaries and side channels. Small, clear-span bridges are proposed across all other fish-bearing watercourses, with culverts only proposed for non-fish-bearing watercourse crossings.

Airstrip and Airstrip Access Road

The existing Casino Airstrip will be replaced with a larger facility located in the Dip Creek valley, approximately 12 km southwest of the Casino mine site (**Figure 1-1**). The airstrip will be 2,000 m long and 30 m wide, with an 80 m grade width and a run out of 60 m at each end, and will be oriented northeast to southwest (AE, 2013). A new Airstrip Access Road will be constructed between the new Airstrip and the Casino mine site. This access road will be a 14 km-long, single-lane gravel road, with two major bridge crossings and several minor crossings.

1.1.2 Project Phasing and Scheduling

The Project phases are defined as Construction, Operations, Closure and Decommissioning, and Post-Closure (**Table 1-1**). The construction phase of the Project will begin once required permits and financing are in place. This phase is anticipated to be four years in duration. Completion of the Freegold Road Upgrade, Freegold Road Extension and Airstrip and Airstrip Access Road are priorities for early in the construction phase. Soil removal and pre-stripping of the Open Pit will occur during this phase. Construction of the TMF and Processing Facilities (including the heap leach facility) will also occur during the construction phase and will be fully operational by Year 1 of the operations phase.

Table 1-1. Casino Project Phases and Schedule

Project Phase	Period	Anticipated Schedule	Project Year
Construction	4 years	2016 - 2019	Year -4 to Year -1
Operations	22 years	2020 - 2042	Year 1 to Year 22
Closure and Decommissioning	3 years	2043 - 2045	Year 23 to Year 25
Post-Closure	5 years	2046- 2050	Year 26 to Year 30

Note: From the "Project Description" (Section 4 of Project Proposal)

The operations phase of the Project will begin at the commencement of full production and is projected to last 22 years (**Table 1-1**). In Year 1, the Casino Project is projected to operate at 75% capacity, with production increasing to the nominal daily production capacity of 120,000 t/d for the remainder of this phase. Open pit mining and ore processing (including both heap leaching and sulphide ore processing) will gradually increase to meet the nominal daily production capacity. Waste rock and tailings management will be a key element of the operations phase.

The closure and decommissioning phase (hereinafter referred to simply as "closure") is projected to commence in Year 23 and last three years (**Table 1-1**). During the closure phase, the surface facilities will be removed and the Casino mine site will be fully reclaimed according to the reclamation objectives established in the "Closure and Reclamation Plan" (Section 4B of the Project Proposal).

Post-Closure phase activities include annual inspections and monitoring of the Project area over a five-year timeframe to evaluate the predicted results of reclamation and ensure that reclamation objectives have been met (**Table 1-1**).

1.2 Consultation

CMC is committed to communicating clearly and openly about the planning of the Project, and to soliciting and incorporating feedback received through its consultation process. Since conception of the Project, CMC has consulted regulatory agencies, First Nations and local communities, Renewable Resource Councils and the public through a combination of site field tours and community meetings and workshops. It has made changes to project design based on feedback received from agencies, such as DFO (as outlined below in Section 3.3).

SFN has provided considerable support in the identification, evaluation and preliminary design of fish habitat compensation opportunities for the Project. SFN Lands and Environment participated in an on-site tour to discuss compensation options, in addition to several community meetings. It prioritized compensation opportunities targeted to Chinook salmon and identified the cultural and ecological significance of lower Britannia Creek, where considerable compensation efforts are now proposed. SFN is helping CMC identify additional, off-site compensation opportunities within its traditional territory.

CMC and its consulting team engaged DFO early in its Project planning and continued regular consultation throughout Project design, recognizing the valuable input DFO is able to provide regarding priorities for fish habitat protection and compensation strategies. CMC has hosted four YESAA workshops, in which DFO staff participated, and led on-site field tours and information sharing sessions aimed at identifying critical habitats for protection and opportunities for habitat restoration and enhancement. DFO has been regularly updated on project changes and their interaction with fish and fish habitat and has had the opportunity to provide feedback on conceptual compensation strategies.

This FHCP incorporates the insight and recommendations provided by DFO, SFN and other stakeholders over the course of consultation for this project.

1.3 Report Organization

This document demonstrates how the FHCP will address DFO's requirement of "No Net Loss" of the productive capacity of fish habitat. Following this introduction (Section 1), it provides an overview of fish and fish habitat in the Project area (Section 2) and summarizes predicted habitat impacts (Section 3). Section 4 provides an overview of compensation objectives and original options, followed by a description and preliminary design drawing of each proposed compensation measure. Section 5 outlines the overall implementation strategy for the compensation measures and acknowledges next steps in compensation planning and design.

2 Overview of Fish and Fish Habitat in the Project Area

Detailed descriptions of fish and fish habitat in the Project area are provided in the *Casino Project Fish and Aquatic Resources Baseline Report* for the mine area (Appendix 10A of Section 10 of the Project Proposal) and for the Freegold Road Extension, Freegold Road Upgrade and Casino Airstrip and Airstrip Access Road (Appendix 10B of Section 10 of the Project Proposal). A summary of the pertinent watersheds, general sampling methods, species distribution and habitat characteristics is provided below.

The Project, including the proposed mine area and its access roads, is wholly located within the Yukon River watershed (**Figure 1-1**). The proposed mine and associated facilities are situated in the upper watersheds of Casino Creek and Canadian Creek (a tributary to Britannia Creek), with the proposed Airstrip and its Access Road located in the adjacent Dip Creek watershed. The Freegold Road Upgrade and Extension cross several large and small watersheds between Carmacks and the mine site, including (from east to west) those of Nordenskiold River, Yukon River minor tributaries, Murray Creek, Crossing Creek, Big Creek, Hayes Creek, Selwyn River, Yukon River minor tributaries, Mascot Creek, Isaac Creek and Dip Creek. Fish and aquatic resource studies were conducted from 2008 to 2013 in the Project study area. Fish sampling and habitat assessment efforts were concentrated in the Casino and Canadian Creek watersheds, where potential near-field effects are anticipated. Backpack electrofishing and minnow trapping were the primary fish sampling methods used, and fish habitat assessments were conducted according to pre-established methods to characterize habitat quality including site-specific potential for supporting rearing, spawning and overwintering activities. In addition, multi-year Chinook spawning surveys were completed in the Britannia and Dip Creek watersheds. To further characterize local fisheries in the mine area, benthic invertebrate and periphyton studies were conducted in the Casino, Dip and Britannia Creek watersheds to assess the primary productivity, community characteristics and overall aquatic ecosystem health. Following initial reconnaissance completed in 2010 and 2011, fish and fish habitat assessments were completed at 61 locations along the Freegold Road Upgrade, 95 locations along the Freegold Road Extension and 12 locations along the Airstrip Access Road.

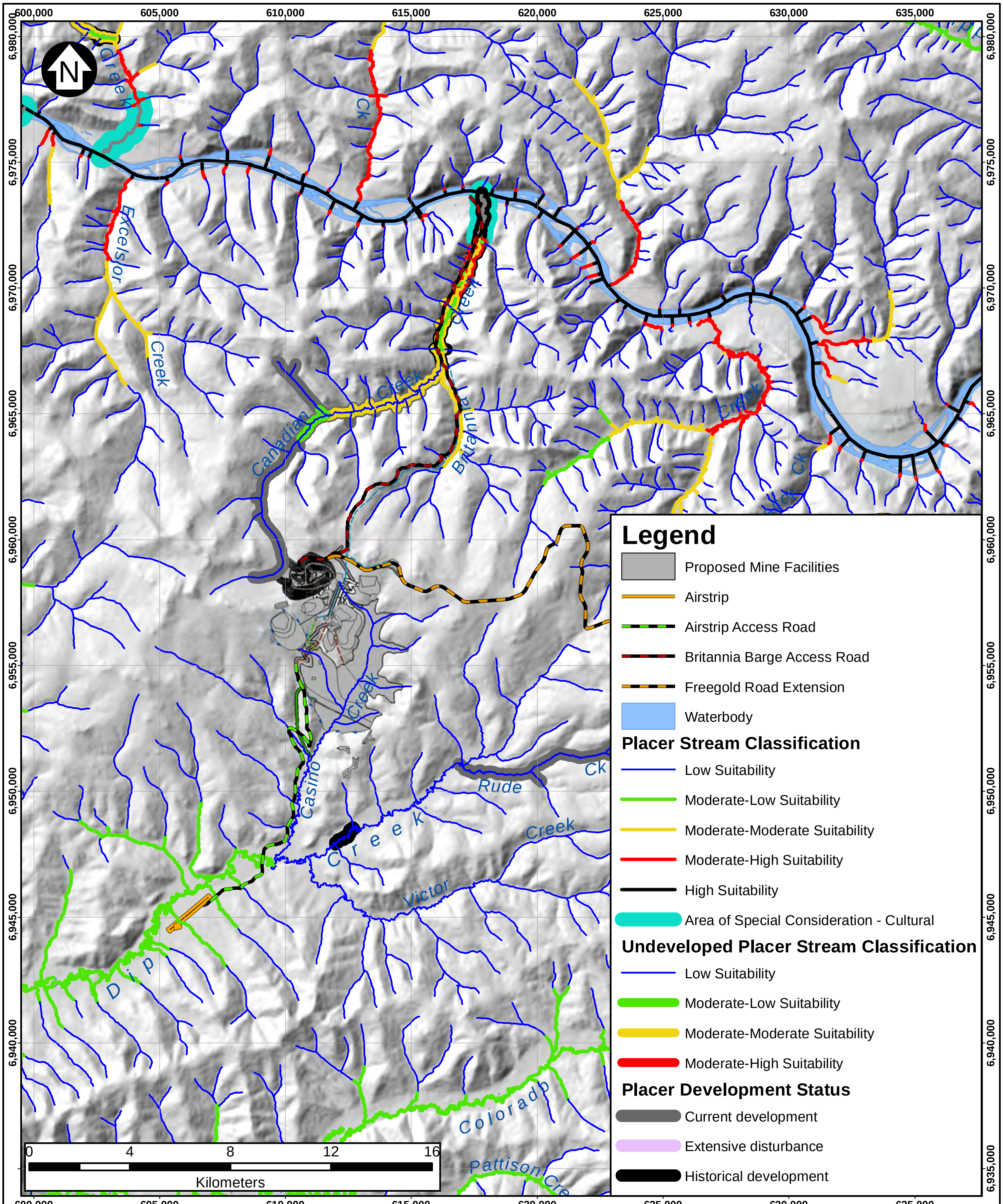
In the Casino, Britannia and Dip Creek watersheds encompassing the mine area, slimy sculpin (*Cottus cognatus)* and Arctic grayling (*Thymallus arcticus)* were the most dominant species captured, with low numbers of burbot (*Lota lota)* and round whitefish (*Prosopium cylindraceum)* also present in the lower watersheds. The greatest efforts were made to assess baseline conditions in upper Casino Creek (reaches 2 and 3, **Figure 1-1**), where most habitat loss is predicted, with an emphasis on characterizing habitat quality, fish abundance and life history usage. Cold water temperatures, high gradients and velocities, cascades (flow-dependent barriers) and poor water quality from natural and anthropogenic acid rock drainage in upper Casino Creek greatly limit its productive capacity. Despite four years of fish sampling in upper Casino Creek (Reach 3, **Figure 1-1**), only four Arctic grayling were ever captured (in 2013), during exceptionally clear and low-flow conditions (as outlined by Palmer Environmental Consulting Group Inc. (PECG) in Appendix 10A of Section 10 in the Project Proposal). The steep, headwater tributaries to Casino Creek do not directly support fish habitat, with the exception of lowermost Taylor Creek.

Fish abundance and species diversity generally increased downstream within the watersheds, particularly in close proximity to the Yukon River. Juvenile Chinook salmon (*Oncorhynchus tshawytscha*) were captured in lower Britannia Creek in 2009 and 2011, near its confluence with the Yukon River. The capture of only one juvenile Chinook salmon in Dip Creek (downstream of the confluence with Casino Creek), despite sampling from 2008 to 2013, indicates that Dip Creek may occasionally provide habitat for low abundances of juvenile Chinook salmon. No Chinook salmon spawning was observed in either the Britannia or Dip Creek watersheds despite multi-year surveying.

Rearing habitat is the most common habitat type within all watersheds, with most sites providing moderate to good opportunities for rearing. In upper Casino Creek, however, moderately steep cascades limit rearing opportunities. There is minimal overwintering habitat in the mine area, except along portions of Dip Creek, due to a lack of deep pools and the widespread formation of anchor ice during the winter. The lack of young-of-the-year rearing in the majority of the Project area suggests that Arctic grayling spawning activities are correspondingly minimal.

The potential for spawning habitat throughout the Project area was mostly rated none to poor, consistent with the Yukon Mining Secretariat's designation of the watercourses as not supporting spawning activities or providing critical migratory corridors for spawning Chinook salmon. According to the Yukon Placer Stream Classification Model (Yukon Placer Secretariat, 2012), the entire Casino Creek watershed is classified as "low" suitability habitat, whereas most middle to lower reaches of Britannia Creek have been classified as "low-moderate" to "moderate" suitability (**Figure 2-1**). The lowermost reach of Britannia Creek has been designated as an "area of special consideration", subject to the most restrictive conditions for placer mining in order to protect Chinook habitat near the mouth.

Within the watersheds crossed by the Freegold Road Extension and Upgrade, Chinook salmon, chum salmon, Arctic grayling, slimy sculpin and round whitefish are known to be present. No species at risk exist within the Project study area. Fish abundance and diversity are greatest along large, meandering creeks and rivers (>third-order), where flow and groundwater discharge is sufficient to inhibit anchor ice formation, pool-riffle morphology is well developed, and bed material is dominated by gravel/cobble substrate (as outlined by PECG in Appendix 10B of Section 10 in the Project Proposal). Big Creek, Selwyn River and Nordenskiold River are known to be utilized by adult Chinook salmon for spawning habitat (DFO 1985; Yukon River Panel, 2008a), and the tributaries of Seymour Creek, Bow Creek, Stoddart Creek, Hayes Creek and Dip Creek have all been shown to contain fry and juvenile Chinook (DFO, 1994, von Finster, 1998). Juvenile Chinook salmon have also been documented in the lower reaches of Britannia Creek, Isaac Creek, Mascot Creek, Crossing Creek and Murray Creek, near the confluence with the Yukon River (DFO, 1994; EDI, 2011).



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DESIGNED	D. Turner
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DATE	25Nov2013

NOTES:
1. BASE MAP: 1:50,000 Topographic Spatial Data and Placer Stream Classification provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca).
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:200,000

CASINO COPPER AND GOLD

CASINO PROJECT

PLACER STREAM CLASSIFICATIONS

FIGURE 2-1

FHCP REPORT

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Along most first- and second-order tributaries crossed by the Freegold Road Extension and Upgrade, flows are generally intermittent and groundwater inputs are often insufficient to maintain ice-free conditions. Stream gradients along the tributaries at the crossing locations are generally less than 5%, but steepen dramatically immediately upstream. Bed material typically comprises cobbles to boulders, which in some cases become difficult for fish to negotiate during low-flow conditions. Pools are comparatively rare and, where present, relatively shallow. The lack of pool and overwintering habitat limits productivity in many small watercourses and suggests that many creeks in the study area may not provide critical habitat required for sustaining fish populations. Thawing permafrost in the summer months maintains cold water temperatures at many of the crossing locations, which also limits habitat productive capacity.

2.1 Contribution to Local Fisheries

The remoteness and inaccessibility of the Casino and Dip Creek watersheds probably limits any recreational or aboriginal fishing in the mine site area. Also, watersheds draining directly into the Yukon River along the proposed road corridor, and north of the mine site, are generally remote waterways with limited access for fishing activities. However, watersheds in the Project area support important life history stages for subsistence, recreational and commercial species of Yukon River fish, including Arctic grayling and salmon. Adult Chinook salmon are known to spawn in Big and Selwyn Creeks, which also provide important overwintering habitat for a variety of fish species. Yukon River supports regionally significant commercial, aboriginal and recreational fisheries, with an average of 14,000 and 16,000 Chinook and Coho salmon harvested per year, respectively, during the 1992 to 2002 period (Yukon River Panel, 2008b).

2.2 Habitat Requirements

Arctic grayling and slimy sculpin are the most dominant fish species in the Project area, followed by juvenile Chinook salmon. Arctic grayling primarily occupy areas with clear, slow-moving water, typically with velocities of 20 to 110 cm/s (Hubert et al., 1985; Vehanen et al., 2003; Stewart et al., 2007). As juveniles, Arctic grayling reside in shallow pools and side channels within the lower and middle reaches of small streams (Stewart et al., 2007). Adult Arctic grayling undergo seasonal migrations upstream, where they occupy slow-moving shallows and deeper pools (Roberge et al., 2001; Stewart et al., 2007). The formation of anchor ice in shallow, lower-order tributaries within the Project area during the fall and winter forces Arctic grayling (and other species) to retreat downstream to higher-order creeks with deeper pools. Arctic grayling spawning occurs from April to mid-June around ice break-up, in streams with velocities of 30 to 80 cm/s, and over gravel substrates (Stewart et al., 2007).

The slimy sculpin is a bottom-dwelling species, residing under cobble or other in-stream habitat cover features. Slimy sculpins demonstrate very high site fidelity, generally remaining within a 50 m-radius home range throughout their lives (Gray et al., 2002). Thus, all life history stages, including overwintering and spawning, must be carried out within this limited home range. Spawning takes place in the spring when temperatures approach 5 to 10°C, in nests on the underside of rocks, submerged rocks or other available in-stream habitat (Roberge et al., 2002).

Juvenile Chinook salmon in Yukon rear in freshwater generally for 1 year before migrating to sea. During the winters in freshwater, overwintering habitat with adequate oxygen, flow and water quality is critical for juvenile survival. They generally occupy slow-moving pools and stream margins, and are often found around undercut banks and woody debris accumulations (Healey, 1991). The importance of small, non-natal streams within the Yukon River watershed as habitat for juvenile Chinook salmon has been previously documented, particularly where deeper pools and slow-moving water were available (Bradford et al., 2001). Chinook spawning in Yukon takes place in low gradient (<4-5%) streams that sustain sufficient overwinter incubation flows over gravel-cobble substrate from July to September (Healy, 1991).

2.3 Limitations to Habitat Productive Capacity

An understanding of which factors currently limit the productive capacity of habitats where project impacts are predicted is important, because it enables proposed compensation habitats to be designed specifically to address these limitations. Several important limitations to the productive capacity of Arctic grayling habitat along upper Casino Creek, where most project impacts are expected to occur, have been identified:

- **Lack of overwintering habitat in upper watersheds** – Deep pools provide an important ecological function through their provision of overwintering habitat and low-velocity refuge for juvenile rearing. Along upper Casino Creek and its tributaries, deep pools capable of providing overwintering and juvenile rearing habitat are uncommon. Winter air temperatures are too cold, and winter baseflows from groundwater are generally insufficient, to prevent the formation of anchor ice and full, frozen-to-bed conditions. Fish are forced to retreat downstream and overwinter and rear in deep pools of larger creeks that remain unfrozen at depth, such as Dip Creek. Fish tend to concentrate in the middle to lower reaches of the headwater tributaries, such as Casino Creek, where gradients and migration distances between rearing habitats and downstream overwintering habitats are lower. This natural, lack of overwintering habitat is common throughout the headwater drainages encompassing the Project area.

- **Unsuitable substrates for spawning** – Arctic grayling and other fish that utilize Casino Creek require particular sizes and areas of gravel substrates in which to spawn. Much of the substrate along upper Casino Creek has been derived from colluvial mass movements from the adjacent valley sides; it is cobbly to bouldery and unsuitable for spawning. Although spring and summer flow conditions along portions of Casino Creek are amenable to spawning activity, the rarity of appropriate gravel substrates represents a natural limitation on productive capacity.

- **Poor water quality and benthic community** – Naturally poor water quality in highly mineralized upper Casino Creek and its western tributaries in the mine site area represents an important limitation on the productive capacity of habitat within the watershed. Water quality monitoring within Casino Creek indicates that the Canadian Council of Ministers of the Environment (CCME) guidelines for the protection of aquatic life are naturally exceeded for a variety of elements, including aluminum, cadmium, copper, iron, lead and zinc (Appendix 10A of Section 10 in the Project Proposal). Metal concentrations are highest in Proctor Gulch, the most upstream headwater of Casino Creek, and gradually become more dilute downstream. Poor water quality can affect fish through its impact on their physiology, eggs and food supply. Only the most important fish foods, which are the Ephemeroptera, Plecoptera and Tricopetera (EPT) families of benthic organisms, are the most sensitive to contaminant levels. Other, more tolerant benthic invertebrates are dominant in the upper watershed.

- **Periodic, natural barriers to fish passage** – Upper Casino Creek and its tributaries are predisposed to naturally forming barriers to fish habitat, at least seasonally, due to their cobbly to bouldery substrates, moderately steep gradients and relatively low flows. Casino Creek exhibits small cascades and step-pool morphology in its upper reaches. Some of the boulder-formed steps create vertical drops of 0.5 m or more across the full width of the channel. Over time, these bedforms evolve; a boulder cascade one year may collapse into a fish-passable riffle another year. The capture of very few Arctic grayling in upper Casino Creek, only once in four years of sampling, may relate to the natural formation and collapse of in-stream barriers (Appendix 10A of Section 10 in the Project Proposal). In the long-term, this process limits the quality and reliability of habitat.

An awareness of these natural limitations in the productive capacity of upper Casino Creek habitat justifies consideration of *off-site* compensation measures that do not necessarily represent *"like-for-like"* habitat (as described below in Section 4.1).

3 Summary of Impact Assessment

The assessment of impacts of the Project on fish habitat was completed using a combination of methods, depending on whether impacts were predicted to result in a partial loss of flow, complete loss of flow, or loss of riparian habitat. A *Physical Habitat Simulation* (PHABSIM) was used to predict the change in 'usable' in-stream habitat following a reduction of flow along lower Casino Creek (downstream of the TMF), Dip Creek (farther downstream of the TMF) and lower Canadian Creek (downstream of the open pit) (Section 3.1.1). A *Habitat Evaluation Procedure* (HEP) was used to quantify predicted impacts following a complete loss of flow along upper Casino Creek (within and upstream of the TMF footprint) and along lower Britannia Creek (in association with compensatory reinstatement of the historical, meandering channel) (Section 3.1.2). Both methods were originally developed by the U.S. Fish and Wildlife Service and have been widely used across North America as a reliable model for quantifying habitat loss. Recent environmental assessments for similar projects in Canada have successfully employed either PHABSIM or HEP (e.g., Mount Milligan, Kemess, Doris North). Detailed documentation of the comprehensive methods and results of the PHABSIM and HEP studies is provided by PECG and Normandeau Associates, Inc. (Normandeau) (2013a,b), following initial reporting by Normandeau and PECG (2013). Both PHABSIM and HEP are advantageous methods as they provide a means of quantifying biologically-relevant habitat loss, or gain, by taking into account the habitat preferences and requirements of a species at varying life stages. Further, the methods allow a standardized measurement of habitat loss, which facilitates an effective comparison with different potential compensation sites, regardless of habitat type.

Predicted impacts to riparian habitat were quantified with consideration for the suitability and sensitivity of adjacent in-stream habitat (Section 3.1.3). Following the overview of habitat impact evaluation (Section 3.1), a summary is provided of predicted habitat impacts corresponding to each main component of the Project (Section 3.2). Section 3.3 highlights several ways in which Project design changes were made to avoid or significantly reduce potential impacts to habitat that would otherwise have occurred.

3.1 Habitat Impact Evaluation

3.1.1 Physical Habitat Simulation (PHABSIM)

Overview

PHABSIM is designed to characterize the amount of usable habitat available for a specific fish species at different ages and life history stages including rearing, spawning and overwintering. Measuring the area (m^2) of usable habitat is done by integrating habitat suitability indices (HSI curves) derived from scientific literature that define the range of age- and stage-specific optimal flows, depths and substrate types for Arctic grayling. Arctic grayling is one dominant species with widespread distribution in the Project area, and data for flow and habitat indices are available in the literature for this species. Thus, the usable habitat index is defined as a proportion of the total usable habitat (m^2/1000 m of stream length) at a specific flow. PHABSIM can be used further to predict habitat losses under different flow scenarios, providing a range of potential responses over the Project life. Accordingly, it is possible to quantify the usable habitat index for each age and life history stage, both before and after development.

Methods and Results

Habitat type units were identified and mapped along Reach 1 of Casino Creek; along Dip Creek, from its confluence with Casino Creek downstream to its confluence with the next major tributary (beyond which effects would be undetectable); and along lower Canadian Creek (**Figure 1-1**, **Table 3-1**). Next, hydrology transect locations were chosen in different habitat type units on the basis of their relative abundance in the creek reach under investigation. Casino Creek was divided into two, 3.25 km-long sections, upper and lower, with ten transect sites in each section. Two groups of ten transects were selected in Dip Creek, starting just downstream of its confluence with Casino Creek. Twenty transects were originally selected in Canadian Creek, starting just upstream of the confluence with Britannia Creek. One transect was later removed as changes in the discharge rendered it inappropriate for the model.

Table 3-1. Descriptions of Habitat Types Characterized along Casino, Dip and Canadian Creeks

Habitat Type	Description
Pool	• Low velocity flow
	• Generally deep across the channel or scoured along one bank
	• Often contain eddies along one or both banks
	• Retains standing water as discharge approaches zero
Glide	• Shallow, uniform channel with smooth or laminar flow
	• Normally little or no exposed substrate
	• Typically do not have defined thalweg
	• May also occur in tailouts of pools or interspersed with runs
Run	• Generally deep, higher velocity flow
	• Can contain intermittent exposed boulders, bedrock or coarse substrate
	• Well-defined thalweg, often along one bank
Low Gradient Riffle	• Shallow and turbulent, white-water flow, exposed substrate at low flows
	• Usually composed of gravel/cobble substrate
	• Lacks any definitive thalweg
	• Generally act as controls for lower gradient habitat types
High Gradient Riffle	• Fast, high gradient (usually greater than 4%) habitat type
	• Substrate generally cobble or boulder dominated
	• May have interspersed steps and small pools at low flow
Cascade	• Steep, high gradient habitat type
	• May have interspersed pools at low flow
Other	• Includes any uncommon habitat type (e.g., falls, bedrock chutes, etc.)

Velocity, depth and water elevation measurements along each transect were recorded during one sampling event, and water surface elevations, along with one representative discharge measurement, were recorded during two more sampling events. Sampling events were conducted in order to obtain three distinct flow regimes (Low, Mid, High) in the creek whenever possible. Bank elevations at each transect were also measured from the water level up to the estimated high water mark to facilitate a complete creek profile. The following substrate types were documented for aiding in the habitat suitability modeling:

- Organics/Silt/Mud
- Fines (<0.2 cm)
- Gravel (0.2 – 6.4 cm)
- Rubble (6.4 – 17.0 cm)
- Cobble (17.0 – 25.6 cm)
- Boulders (>25.6 cm)
- Bedrock

Habitat suitability indices for Arctic grayling were obtained from Hubert et al. (1985), a reference commonly used in habitat compensation planning (e.g., Ruby Creek Molybdenum Project 2006, Adanac Moly Corporation). Although slimy sculpin is the most dominant fish species in Casino and Dip Creeks, the species was not used for in-stream flow modeling as it is a sedentary benthic species, and has no habitat suitability indices derived. Instead, Arctic grayling was chosen for modeling as it is also a dominant species in Casino and Dip Creeks, it has habitat suitability data available, and it has similar habitat requirements to one of the key species being targeted for compensation: Chinook salmon.

Each hydrologic cross-section was subdivided into a minimum of 20 cells, with each cell conveying approximately 0 to 10% of the total flow. The area of each cell (m^2) was derived using water depth and cross-section length interval at a specific flow. Each cross-section cell was designated a habitat score, depending on the measured habitat quality of the cell and how it compared with the habitat requirements for a specific Arctic grayling life stage (Hubert et al., 1985). The habitat score was multiplied with the total cell area to obtain the proportion of usable habitat in that cell. The usable habitat in each cross-section cell was combined to estimate the total usable habitat of the entire cross-section. The calculations were done for each Arctic grayling life stage separately, given their different habitat requirements.

Each cross-section represented a specific habitat type (e.g., run, pool, glide, riffle) found in Casino, Dip or Canadian Creek. The known proportion of each habitat type was used to extrapolate results from habitat usability calculations to the entire creek length. In Casino Creek, for example, Site 1-Transect 1 was recorded as a run. As runs in Reach 1 of Casino Creek comprised 36% of the total length, and a total of six run transects were measured, the representative contribution of Site 1-Transect 1 was 6% (0.36/6*100=6%). Thus, the calculated usable habitat at Site 1-Transect 1, for a specific flow, was used to represent 6% of the total length of Reach 1 of Casino Creek, or 0.39 km.

The usable habitat of a cross-section varies depending on the water stage. Thus, using the three sets of hydrologic measurements at each cross-section, the velocity and depth for Low, Mid and High flow conditions were calculated using the MANSQ channel conveyance method developed by Normandeau. Usable habitat for each Arctic grayling life stage was then calculated for a full range of potential flows, for example as shown below for Casino Creek (**Figure 3-1**).

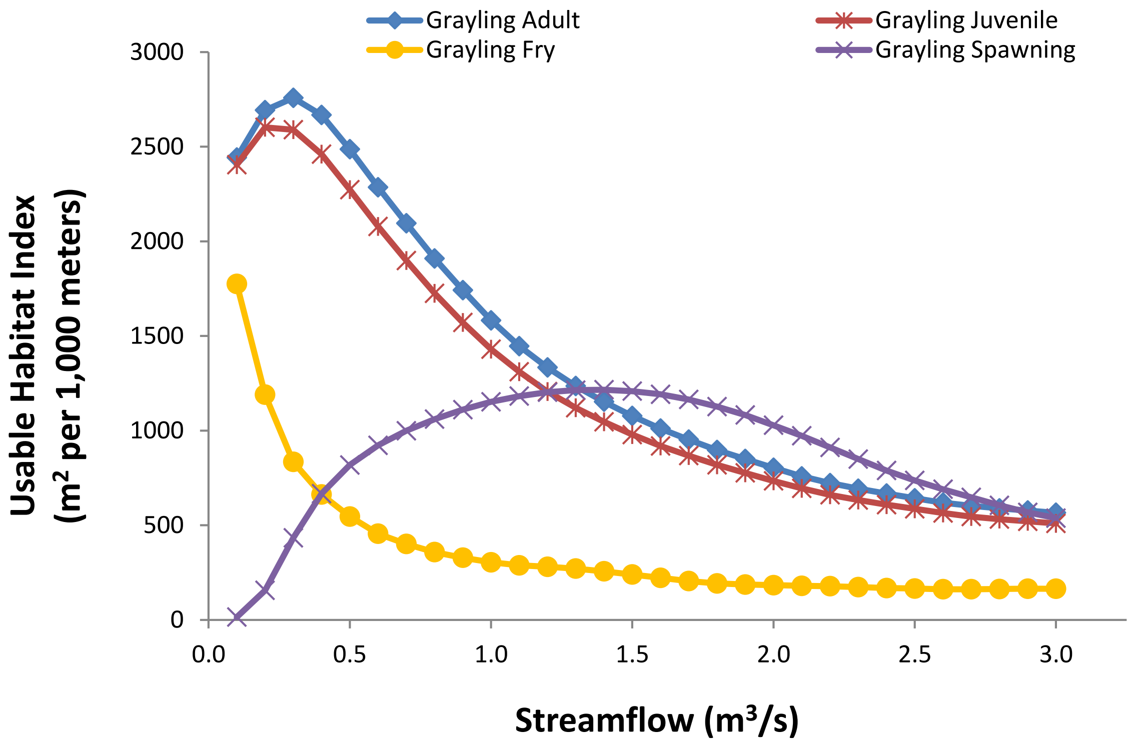


Figure 3-1. Habitat Index versus Flow for All Life Stages of Arctic Grayling in Casino Creek

As a basis for estimating the changes in usable habitat following project development, hydrological data from stream gauges recently installed in Casino, Dip and Canadian Creeks were combined with long-term flow records from nearby, permanent gauges (prorated according to watershed area) to generate long-term synthetic flow series (Knight Piésold, 2013b). To estimate the effect of each project phase on flows in Reach 1 of Casino Creek, flows from mid Casino Creek (H18) were subtracted from those in lower Casino Creek (W4). Baseline and project-phase flows were then entered into the in-stream flow model to estimate changes in usable habitat for each life stage during each project phase, averaged for the two flow stations (**Table 3-2**). As the net loss would still fluctuate depending on the time of year and thus flow chosen for the model, the amount of usable habitat available during 50% or more of the year was used in the final assessment.

In order to ensure all habitat impacts were represented in the predicted totals across all project phases, impacts to different life stages were added by project phase, and then the maximum phase-specific habitat loss was selected for the final HADD value for each affected area (**Table 3-3**). Adult and juvenile Arctic grayling usable habitat losses were not considered additive, because their HSI curves are almost identical, and it would be redundant to include both losses.

Table 3-2. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Casino Creek (H18 and W4 Average)

Duration	Usable Habitat (m^2/1000 m)					Change in Usable Habitat from Baseline (m^2/1000 m)				Percent Change in Usable Habitat from Baseline (m^2/1000 m)			
Percent	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	2732	2748	2748	2734	2726	16	16	2	-5	0.6%	0.6%	0.1%	-0.2%
25	2629	2717	2717	2672	2583	88	88	43	-46	3.3%	3.3%	1.6%	-1.7%
50	**2305**	**2606**	**2606**	**2413**	**2139**	**301**	**301**	**108**	**-167**	**13.1%**	**13.1%**	**4.7%**	**-7.2%**
75	1695	2377	2377	1822	1508	683	683	127	-187	40.3%	40.3%	7.5%	-11.0%
90	1026	1793	1786	1116	919	767	760	90	-108	74.8%	74.1%	8.8%	-10.5%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	2592	2601	2601	2594	2575	9	9	1	-17	0.3%	0.3%	0.0%	-0.7%
25	2473	2590	2590	2506	2415	118	118	34	-58	4.8%	4.8%	1.4%	-2.3%
50	**2099**	**2492**	**2492**	**2219**	**1939**	**393**	**393**	**120**	**-160**	**18.7%**	**18.7%**	**5.7%**	**-7.6%**
75	1530	2249	2249	1646	1364	719	719	116	-167	47.0%	47.0%	7.6%	-10.9%
90	934	1655	1651	1014	837	721	717	80	-97	77.2%	76.8%	8.6%	-10.4%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1040	1735	1735	1154	945	696	695	114	-94	66.9%	66.8%	11.0%	-9.0%
25	698	1476	1475	764	636	779	778	66	-62	111.6%	111.5%	9.5%	-8.9%
50	**468**	**991**	**989**	**521**	**412**	**523**	**521**	**54**	**-55**	**111.8%**	**111.3%**	**11.5%**	**-11.8%**
75	322	664	664	344	296	342	342	22	-26	106.2%	106.2%	6.8%	-8.1%
90	225	432	431	244	204	207	206	20	-21	92.0%	91.6%	8.9%	-9.3%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1170	1049	1053	1166	1157	-121	-117	-3	-13	-10.3%	-10.0%	-0.3%	-1.1%
25	990	694	702	1008	1022	-296	-288	17	31	-29.9%	-29.1%	1.7%	3.1%
50	**620**	**135**	**134**	**571**	**668**	**-485**	**-486**	**-49**	**48**	**-78.2%**	**-78.4%**	**-7.9%**	**7.7%**
75	312	15	16	229	368	-296	-296	-83	57	-94.9%	-94.9%	-26.6%	18.3%
90	133	10	10	98	163	-123	-123	-35	30	-92.5%	-92.5%	-26.3%	22.6%

Note: From Table 8 of PECG and Normandeau (2013a)

Table 3-3. Total Adverse Impact to Usable Habitat (m²) for Arctic Grayling Life Stages for Casino Creek (Average Values), Dip Creek and Canadian Creek under All Project Phases

Stream	Life Stage	Net Change in Usable Habitat from Baseline (m²)			
		Construction	Operation	Closure	Post-Closure
Casino	Arctic Grayling Combined Rearing[a]	1956 (13.1%)	1956 (13.1%)	703 (4.7%)	-1083 (-7.2%)
	Arctic Grayling Fry	3402 (111.9%)	3389 (111.5%)	349 (11.5%)	-360 (-11.8%)
	Arctic Grayling Spawning	-3155 (-78.3%)	-3157 (-78.4%)	-320 (-7.9%)	311 (7.7%)
Total Adverse Impact[b]:		-3155 (-78.3%)	**-3157 (-78.4%)**	-320 (-7.9%)	-1443 (-8.0%)
Dip	Arctic Grayling Combined Rearing[a]	2579 (7.0%)	2579 (7.0%)	562 (1.7%)	-1001 (-2.7%)
	Arctic Grayling Fry	-164 (-3.2%)	-164 (-3.2%)	-13 (-0.3%)	54 (1.0%)
	Arctic Grayling Spawning	-147 (-1.9%)	-147 (-1.9%)	-90 (-1.1%)	38 (0.5%)
Total Adverse Impact[b]:		-311 (-2.3%)	-311 (-2.3%)	-103 (-0.8%)	**-1001 (-2.7%)**
Canadian	Arctic Grayling Combined Rearing[a]	0 (0.0%)	52 (0.05%)	-59 (-0.6%)	-59 (-0.6%)
	Arctic Grayling Fry	0 (0.0%)	272 (8.8%)	882 (28.7%)	882 (28.7%)
	Arctic Grayling Spawning	0 (0.0%)	-52 (-2.5%)	-240 (-11.4%)	-240 (-11.4%)
Total Adverse Impact[b]:		0 (0.0%)	-52 (-2.5%)	**-299 (-2.4%)**	**-299 (-2.4%)**

*Based on PECG and Normandeau (2013a); bolded values are used in final HADD calculations (as shown below in **Table 3-8**)*

[a] Represents the most conservative estimate of impact from Artic Grayling Adult Rearing and Arctic Grayling Juvenile Rearing values

[b] Represents the sum of all adverse impacts to usable habitat that occur in any one project phase, excluding net gains

A long-term synthetic flow series for Dip Creek, downstream of Casino Creek, was generated by Knight Piésold (2013b) based on the sum of flows at gauges W4 (Casino Creek, near mouth) and W9 (Dip Creek, immediately upstream of the confluence with Casino Creek) (**Figure 1-1**). Baseline and project-phase flows were then entered into the in-stream flow model for Dip Creek to assess predicted changes in usable habitat (**Table 3-4**). The final HADD values are provided in **Table 3-3**.

The long-term synthetic flow series for Canadian Creek was generated by Knight Piésold (2013b) based on flow records from the gauge in lower Canadian Creek (W3). Baseline and project-phase flows were then entered into the in-stream flow model for Canadian Creek to assess predicted changes in usable habitat (**Table 3-5**). The final HADD values are provided in **Table 3-3**.

Table 3-4. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Dip Creek, Downstream of Casino Creek

Duration	Usable Habitat (m^2/1000 m)					Change in Usable Habitat from Baseline (m^2/1000 m)				Percent Change in Usable Habitat from Baseline (m^2/1000 m)			
Percent	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	6000	5978	5978	6021	6000	-22	-22	20	0	-0.4%	-0.4%	0.3%	0.0%
25	5248	5419	5419	5246	5188	171	171	-1	-59	3.3%	3.3%	0.0%	-1.1%
50	**4323**	**4626**	**4626**	**4394**	**4205**	**303**	**303**	**71**	**-118**	**7.0%**	**7.0%**	**1.6%**	**-2.7%**
75	2806	3047	3047	2818	2796	240	240	11	-10	8.6%	8.6%	0.4%	-0.4%
90	2562	2562	2562	2562	2562	0	0	0	0	0.0%	0.0%	0.0%	0.0%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	5475	5457	5457	5487	5494	-18	-18	12	18	-0.3%	-0.3%	0.2%	0.3%
25	4752	4912	4912	4782	4679	161	161	30	-73	3.4%	3.4%	0.6%	-1.5%
50	**3879**	**4191**	**4191**	**3946**	**3780**	**312**	**312**	**66**	**-100**	**8.0%**	**8.0%**	**1.7%**	**-2.6%**
75	2557	2778	2778	2570	2552	221	221	12	-5	8.6%	8.6%	0.5%	-0.2%
90	2406	2406	2406	2407	2406	0	0	0	-1	0.0%	0.0%	0.0%	0.0%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	716	716	716	719	714	0	0	3	-1	0.0%	0.0%	0.4%	-0.1%
25	692	686	686	692	694	-6	-6	-1	1	-0.9%	-0.9%	-0.1%	0.1%
50	**611**	**591**	**591**	**609**	**617**	**-19**	**-19**	**-2**	**6**	**-3.1%**	**-3.1%**	**-0.3%**	**1.0%**
75	560	555	555	561	559	-5	-5	1	-1	-0.9%	-0.9%	0.2%	-0.2%
90	536	534	534	536	538	-2	-2	1	2	-0.4%	-0.4%	0.2%	0.4%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	1223	1232	1232	1234	1236	9	9	11	12	0.7%	0.7%	0.9%	1.0%
25	1128	1095	1095	1129	1138	-33	-33	2	10	-2.9%	-2.9%	0.2%	0.9%
50	**933**	**916**	**916**	**922**	**937**	**-17**	**-17**	**-11**	**4**	**-1.8%**	**-1.8%**	**-1.2%**	**0.4%**
75	686	671	671	673	691	-15	-15	-13	5	-2.2%	-2.2%	-1.9%	0.7%
90	216	186	186	215	220	-31	-31	-2	3	-14.4%	-14.4%	-0.9%	1.4%

Note: From Table 9 of PECG and Normandeau (2013a)

Table 3-5. Habitat Index Value (m^2/1000 m) for Arctic Grayling Life Stages at Selected Habitat Duration Percentages under Baseline and Project Phases for Canadian Creek (W3)

Duration	Usable Habitat (m^2/1000 m)					Change in Usable Habitat from Baseline (m^2/1000 m)				Percent Change in Usable Habitat from Baseline (m^2/1000 m)			
Percent	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult				Arctic Grayling Adult			
10	1831	1831	1830	1814	1814	0	-1	-17	-17	0.0%	-0.1%	-0.9%	-0.9%
25	1756	1756	1751	1724	1724	0	-5	-32	-32	0.0%	-0.3%	-1.8%	-1.8%
50	**1454**	**1454**	**1468**	**1446**	**1446**	**0**	**13**	**-8**	**-8**	**0.0%**	**0.9%**	**-0.6%**	**-0.6%**
75	959	959	977	1004	1004	0	18	45	45	0.0%	1.9%	4.7%	4.7%
90	478	478	507	589	589	0	29	111	111	0.0%	6.1%	23.2%	23.2%
	Arctic Grayling Juvenile					Arctic Grayling Juvenile				Arctic Grayling Juvenile			
10	1609	1609	1608	1593	1593	0	0	-16	-16	0.0%	0.0%	-1.0%	-1.0%
25	1547	1547	1544	1535	1535	0	-4	-12	-12	0.0%	-0.3%	-0.8%	-0.8%
50	**1299**	**1299**	**1307**	**1313**	**1313**	**0**	**7**	**13**	**13**	**0.0%**	**0.5%**	**1.0%**	**1.0%**
75	916	916	918	940	940	0	2	24	24	0.0%	0.2%	2.6%	2.6%
90	420	420	444	513	513	0	24	93	93	0.0%	5.7%	22.1%	22.1%
	Arctic Grayling Fry					Arctic Grayling Fry				Arctic Grayling Fry			
10	1714	1714	1752	1847	1847	0	37	133	133	0.0%	2.2%	7.8%	7.8%
25	915	915	1004	1188	1188	0	88	273	273	0.0%	9.6%	29.8%	29.8%
50	**439**	**439**	**478**	**565**	**565**	**0**	**39**	**126**	**126**	**0.0%**	**8.9%**	**28.7%**	**28.7%**
75	277	277	289	317	317	0	12	39	39	0.0%	4.3%	14.1%	14.1%
90	203	203	201	207	207	0	-2	4	4	0.0%	-1.0%	2.0%	2.0%
	Arctic Grayling Spawning					Arctic Grayling Spawning				Arctic Grayling Spawning			
10	522	522	526	526	526	0	4	4	4	0.0%	0.8%	0.8%	0.8%
25	471	471	469	451	451	0	-2	-20	-20	0.0%	-0.4%	-4.2%	-4.2%
50	**300**	**300**	**293**	**266**	**266**	**0**	**-7**	**-34**	**-34**	**0.0%**	**-2.3%**	**-11.3%**	**-11.3%**
75	208	208	181	135	135	0	-27	-73	-73	0.0%	-13.0%	-35.1%	-35.1%
90	108	108	92	72	72	0	-16	-36	-36	0.0%	-14.8%	-33.3%	-33.3%

Note: From Table 10 of PECG and Normandeau (2013a)

Results from PHABSIM for Reach 1 of Casino Creek demonstrate that the usable habitat area for most life history stages will increase during the construction and operational phases of the project, with the exception of spawning habitat (**Table 3-6**). A small additional increase in usable habitat is noted for adult, juvenile and fry rearing during the closure phase. The increases in habitat can be mainly attributed to the lower flows predicted following TMF construction, which will facilitate a larger area of the creek being usable for Arctic grayling during both adult and juvenile rearing, with a higher net change in usable habitat predicted for the latter. As higher velocities are optimal for spawning, estimated reductions in flow are predicted to reduce the volume of usable habitat for this life stage during construction (3,155 m^2, or 78.3%), operation (3,157 m^2, or 78.4%) and closure (320 m^2, or 7.9%). As there is no evidence for spawning activities in Casino Creek, the net loss of spawning habitat is likely to have minimal impact on Arctic grayling production. However, the reduction in spawning habitat is noted as a conservative measure and included in the total calculation for habitat loss. During the post-closure phase, the largest habitat losses in lower Casino Creek are predicted for adult rearing (1,083 m^2, or 7.2%) and juvenile rearing (1,038 m^2, or 7.6%), followed by fry rearing (360 m^2, or 11.8%). A small increase in spawning habitat is predicted.

In Dip Creek, the amount of usable habitat is predicted to increase for adult and juvenile Arctic grayling during the construction, operation and closure phases of the project, reflecting slight reductions in velocity in association with reduced flow contributions from Casino Creek (**Table 3-6**). During the post-closure phase, small reductions in usable habitat of 1,001 m^2 (2.7%) and 847 m^2 (2.6%) are predicted for adult and juvenile rearing habitat, respectively, due to periodic increased discharges from the reclaimed TMF upstream. Fry rearing habitat is predicted to decrease by 164 m^2 (3.2%) during construction and operations, but by only 13 m^2 (0.3%) during closure. Spawning habitat is predicted to decrease by only 147 m^2 (1.9%) during construction and operations, and by only 90 m^2 (1.1%) during closure. Fry and spawning life stages are expected to return to baseline values during the post-closure phase.

In Canadian Creek, small increases in usable habitat are predicted for Arctic grayling adults, juveniles and fry during the operation phase of the project (**Table 3-6**). Spawning habitat is expected to decrease by 52 m^2 (2.5%) during operations. During closure and post-closure phases, a 59 m^2 (0.6%) decrease in adult rearing habitat is expected, while a slight increase in juvenile rearing and fry habitat is predicted. Usable spawning habitat is predicted to be reduced by 240 m^2 (11.4%).

Table 3-6. Usable Habitat (m^2), Total Available Habitat (m^2) and Net Change from Baseline for Arctic Grayling Life Stages for Lower Casino Creek, Dip Creek and Canadian Creek under All Project Phases

Stream	Usable Habitat (m^2)					Net Change in Usable Habitat from Baseline (m^2)			
	Baseline	Construction	Operation	Closure	Post-Closure	Construction	Operation	Closure	Post-Closure
	Arctic Grayling Adult					Arctic Grayling Adult			
Casino	14984	16940	16940	15687	13901	1956 (13.1%)	1956 (13.1%)	703 (4.7%)	-1083 (-7.2%)
Dip	36741	39321	39321	37346	35740	2579 (7.0%)	2579 (7.0%)	605 (1.6%)	**-1001 (-2.7%)**
Canadian	10179	10179	10273	10120	10120	0 (0.0%)	94 (0.9%)	-59 (-0.6%)	-59 (-0.6%)
	Arctic Grayling Juvenile					Arctic Grayling Juvenile			
Casino	13643	16197	16197	14423	12605	2555 (18.7%)	2555 (18.7%)	780 (5.7%)	-1038 (-7.6%)
Dip	32975	35623	35623	33537	32128	2648 (8.0%)	2648 (8.0%)	562 (1.7%)	-847 (-2.6%)
Canadian	9096	9096	9148	9189	9189	0 (0.0%)	52 (0.6%)	93 (1.0%)	93 (1.0%)
	Arctic Grayling Fry					Arctic Grayling Fry			
Casino	3040	6442	6428	3389	2679	3402 (111.9%)	3389 (111.5%)	349 (11.5%)	-360 (-11.8%)
Dip	5190	5027	5027	5178	5245	-164 (-3.2%)	-164 (-3.2%)	-13 (-0.3%)	54 (1.0%)
Canadian	3075	3075	3348	3957	3957	0 (0.0%)	272 (8.8%)	882 (28.7%)	882 (28.7%)
	Arctic Grayling Spawning					Arctic Grayling Spawning			
Casino	4029	874	872	3709	4340	-3155 (-78.3%)	**-3157 (-78.4%)**	-320 (-7.9%)	311 (7.7%)
Dip	7929	7783	7783	7839	7967	-147 (-1.9%)	-147 (-1.9%)	-90 (-1.1%)	38 (0.5%)
Canadian	2103	2103	2051	1863	1863	0 (0.0%)	-52 (-2.5%)	**-240 (-11.4%)**	**-240 (-11.4%)**
	Available Habitat (m^2)					**Net Change in Available Habitat from Baseline (m^2)**			
	Rearing (May 15 to Sept 30)					Rearing (May 15 to Sept 30)			
Casino	29959	28521	28523	29778	30203	-1438 (-4.8%)	-1437 (-4.8%)	-181 (-0.6%)	244 (0.8%)
Dip	90268	87926	87926	90022	90558	-2342 (-2.6%)	-2342 (-2.6%)	-245 (-0.3%)	291 (0.3%)
Canadian	35040	35040	34786	34239	34239	0 (0.0%)	-254 (-0.7%)	-801 (-2.3%)	-801 (-2.3%)
	Spawning (May 15 to June 30)					Spawning (May 15 to June 30)			
Casino	29426	27955	27985	29515	29662	-1472 (-5.0%)	-1441 (-4.9%)	89 (0.3%)	236 (0.8%)
Dip	87110	85139	85139	87283	87759	-1971 (-2.3%)	-1971 (-2.3%)	172 (0.2%)	648 (0.7%)
Canadian	36901	36901	36625	36123	36123	0 (0.0%)	-276 (-0.7%)	-778 (-2.1%)	-778 (-2.1%)

*Notes: From Table 11 of PECG and Normandeau (2013a); bolded values used in final HADD calculation (as shown below in **Table 3-8**)*

3.1.2 Habitat Evaluation Procedure (HEP)

Overview

HEP is based on the rationale that the most limited but important habitat characteristic in a waterbody is restricting and therefore regulating fisheries capacity. The total amount of habitat lost calculated using stream measurements is then adjusted to the predicted area of habitat being used, which varies depending on the estimated magnitude of limitation.

Methods and Results

Habitat in reaches 2 and 3 of Casino Creek was mapped over its entire 7.5 km length by habitat unit type and length (**Table 3-1**). Habitat mapping was also completed along lower Taylor Creek, downstream of a fish barrier. Within each habitat unit, several parameters were measured including mean depth, mean width, substrate, cover type and percentage, and maximum pool depth. In areas deemed suitable for Arctic grayling spawning, additional information was collected including the percentage of spawning substrate (e.g., gravel and rubble), the percentage of fine substrate (<0.2 cm diameter), area (m^2) of spawning habitat available, and estimated velocity. Additionally, HEP surveys were carried out on the lower reach of Britannia Creek and on Meloy Creek, in order to capture any changes to fish habitat in association with reinstatement of the lower historical channel of Britannia Creek and loss of Meloy Creek due to the TMF, respectively.

Habitat data were analyzed to determine habitat features that may be limiting Arctic grayling productive capacity. From this analysis, five habitat variables were chosen as being potentially limiting: % spawning substrate, % fines in spawning areas, % total fines, overwintering habitat, and % pools and backwaters. Using habitat suitability indices (Hubert et al., 1985), a score was assigned to each habitat variable ranging from 0 to 1, with 1 representing the most optimal conditions for Arctic grayling and indicating that 100% of the available habitat is usable, and 0 indicating that no habitat is usable.

Results of all completed HEP studies in the Project area are summarized below in **Table 3-7**. HSI results were derived in Casino and Britannia Creeks from the lack of appropriate pool habitat, which is required for Arctic grayling rearing and is likely the greatest constraint to their production in these watersheds. The Meloy Creek HSI score of 0.0 reflects both the lack of available pool habitat in the creek and the predominance of fine sediment substrates.

Table 3-7. Results of HEP Studies on Upper Casino Creek, Britannia Creek and Meloy Creek

Stream	Total Available Habitat (m^2)	HSI Score Applied	Net Habitat Loss[a] (m^2)
Casino Creek – Brynelson Creek to TMF Main Embankment	5,979	0.41	2,451
Casino Creek – TMF embankment to Reach 2/3 break	13,520	0.18	2,434
Casino Creek – Upstream of Reach 2/3 break	19,707	0.29	5715
SUBTOTAL – Casino Creek (Brynelson Creek to headwaters)	**39,206**		**10,600**
Meloy Creek	4,222	0.0	0
Lower Britannia Creek Existing “Roadway” Channel[b]	9,535	0.25	2,384
TOTAL	**52,963**		**12,984**

[a] *Based on Normandeau and PECG (2013) and PECG and Normandeau (2013b); used in final HADD calculation (as shown below in* ***Table 3-8****)*

[b] *In support of compensatory reinstatement of historical meandering channel*

3.1.3 Riparian Habitat

Impacts to riparian habitat were calculated for the mine site area and along the access roads, wherever a project facility footprint or road crossing is predicted to result in a loss of riparian vegetation. Impacts were quantified by multiplying the length of stream alongside which the riparian habitat impacts are anticipated by one of three buffer widths, based on the suitability and sensitivity of fish habitat:

- 30 m riparian habitat buffer alongside stream sections that support Chinook salmon;
- 15 m riparian habitat buffer alongside stream sections that support fish other than Chinook salmon; and
- 5 m riparian habitat buffer alongside stream sections that do not support fish habitat, and along Meloy Creek and uppermost Casino Creek (upstream of Reach 2/3 break), where fish utilization is rare.

Riparian habitat impacts may occur in association with corresponding in-stream habitat impacts, such as along upper Casino Creek within the TMF footprint, or they may occur independently, such as along watercourses proposed to be crossed by clear-span bridges along the access roads. Total riparian impacts were determined for both fish-bearing and non-fish bearing streams.

3.2 Habitat Impacts

Predicted impacts of the main Project components on in-stream and riparian habitat are summarized below in **Tables 3-8** and **3-9**, respectively, and described succinctly in Sections 3.2.1 to 3.2.6. The component-specific impacts are presented alphabetically for consistency with the detailed accounts of impacts provided in Section 10 of the Project Proposal.

Table 3-8. Estimated In-stream Habitat Loss

Watercourse or Project Component Area	Impacted Stream Length (m)		Impacted Stream Area (m^2)[a]		Impacted Modeled Area (m^2)[b]	
	Fish-bearing	Non-fish-bearing	Fish-bearing	Non-fish-bearing	Fish-bearing	Non-fish-bearing
Total Habitat Loss within project footprint						
Lower Britannia	1,405	0	9,535	0	2,384[e]	n/a
Upper Canadian	0	3,483	0	17,415	n/a	n/a
Upper Casino[c]	15,819	11,012	43,428	14,377	10,600[e]	n/a
Freegold Extension	0	1,031	0	787	n/a	n/a
Freegold Upgrade	0	30	6[d]	24	6[f]	n/a
Airstrip	1,006	0	1,509	0	1,509[f]	n/a
Airstrip Access Road	0	91	0	54	n/a	n/a
Wetted Habitat Loss due to stream flow reductions						
Lower Canadian	7,000	0	801	0	299[h]	n/a
Lower Casino[g]	6,500	0	1,438	0	3,157[h]	n/a
Dip	8,500	0	2,342	0	1,001[h]	n/a
Total	**40,230**	**15,647**	**59,059**	**32,657**	**18,956***	**n/a**

[a] Areas experiencing total habitat loss were obtained from a combination of field and 1:50,000 GIS base mapping measurements. Areas experiencing wetted habitat loss were obtained from in-stream flow modelling results, where the total change in rearing habitat was used as it represented the median loss of habitat for the entire ice-free season (May 15 – September 30).

[b] All Modeled values are obtained from analyses using PHABSIM (PECG and Normandeau, 2013a) and HEP (PECG and Normandeau, 2013b), originally described in Normandeau and PECG (2013).

[c] Upper Casino Creek encompasses all reaches and tributaries upstream of its confluence with Brynelson Creek, including Meloy Creek, three unnamed tributaries, Taylor Creek and Proctor Gulch.

[d] Habitat loss from the Nordenskiold River bridge pier.

[e] HEP modelling used to calculate total habitat loss (Normandeau and PECG 2013; PECG and Normandeau 2013b).

[f] No modeled value available as there were no habitat limitation criteria identified.

[g] Lower Casino Creek refers to Reach 1 (i.e., from the confluence with Dip Creek upstream to the confluence with Brynelson Creek).

[h] PHABSIM used to calculate the change in usable Arctic grayling wetted habitat. Habitat loss was divided by project phase, with the maximum values by phase reported here (Normandeau and PECG, 2013; PECG and Normandeau, 2013a).

* Denotes final HADD value

Table 3-9. Estimated Riparian Habitat Loss

Watercourse or Project Component Area	Impacted Stream Length (m)		Impacted Riparian Area (m^2)		
	Fish-bearing	Non-fish-bearing	Fish-bearing	Non-fish-bearing	Total Area
Britannia	1,405	0	52,860	0	52,860
Upper Canadian	0	3,483	0	34,830	34,830
Upper Casino	15,819	11,012	233,030	110,120	393,150
Freegold Extension	1,077*	1,031	32,310	10,310	42,620
Freegold Upgrade	180*	30	5,400	300	5,700
Airstrip	1,006	0	30,180	0	30,180
Airstrip Access Road	73*	91	2,190	455	2,645
Total			**355,970**	**156,015**	**511,985**

Note: Riparian habitat setbacks were 30 m for Chinook salmon fish-bearing stream sections, 15 m for non-Chinook salmon fish-bearing streams, and 5 m for non-fish-bearing streams, Meloy Creek and Casino Creek upstream of the Reach 2/3 break (**Figure 1-1**). Asterisks (*) denote that only riparian habitat was impacted due to the installation of clear-span bridges on fish-bearing crossings.

3.2.1 Airstrip and Access Road

Construction of the airstrip and access road will require the clearing and grubbing of vegetation, the installation of culverts and bridges along the 14 km-long access road, and the construction of the airstrip and associated facilities. The 2000 m-long airstrip will be located in the Dip Creek valley approximately 12 km southwest of the mine site. Within the single fish-bearing drainage intersecting the airstrip, there will be a permanent loss of 1,509 m^2 of fish-bearing habitat (conservatively assuming the existing habitat is 100% usable, because it was not modeled using HEP due to a lack of identified habitat limitation criteria) from the airstrip downstream to its confluence with Dip Creek and upstream to the entrance to the proposed diversion channel (**Table 3-8**). The proposed naturalized airstrip diversion channel will provide connectivity to habitat upstream of the airstrip, and will provide new, enhanced habitat offsetting the local habitat loss.

The airstrip access road will require the construction of six clear-span bridges over Dip Creek, Brynelson Creek and four unnamed fish-bearing creeks, and four major culverts along non-fish-bearing watercourses. As clear-span bridges will be installed on all fish-bearing creeks, only non-fish-bearing habitat will be lost along the access road due to culvert installations. In addition, riparian habitat loss and alteration will occur adjacent to both fish-bearing and non-fish-bearing crossings (**Table 3-9**).

3.2.2 Canadian Creek Diversion

The Canadian Creek diversion around the Open Pit will be constructed in year 10 of operations. The upper section of Canadian Creek is non-fish bearing, with an identified high-gradient (>20%), cascade barrier located approximately 1.2 km downstream of the proposed diversion. Thus, there will be no fish-bearing habitat loss due to the diversion of Canadian Creek.

During closure, the Canadian Creek diversion will be decommissioned, allowing headwaters to drain directly into the Open Pit. Non-fish-bearing in-stream and riparian habitat will be permanently lost within the footprint of the Open Pit and upstream to the creek headwaters (17,415 m^2 of in-stream habitat (**Table 3-8)** and 34,830 m^2 of riparian habitat (**Table 3-9**)).

The predicted change in usable fish habitat was assessed under closure conditions using a PHABSIM model (PECG and Normandeau, 2013a). In lower Canadian Creek, usable habitat for Arctic grayling juvenile and fry rearing is predicted to increase under the new flow regime, while small decreases are predicted for adult rearing (59 m^2, or 0.6%) and spawning habitat (240 m^2, or 11.4%).

3.2.3 Fish Habitat Compensation Construction

The reinstatement of the historical, meandering channel of lower Britannia Creek, an integral part of this FHCP, will result in habitat loss within the lowermost 1.4 km-long section of the existing, mostly straight channel of Britannia Creek (as described below in Section 4.3.1.1). A HEP analysis predicts a 2,384 m^2 loss of usable fish-bearing habitat in lower Britannia Creek, which represents approximately 25% of the total habitat area based on the lack of pool habitat (**Table 3-8**).

3.2.4 Freegold Road Extension

Construction of the Freegold Road extension will include 120 km of new road, including the installation of 39 culverts and 56 bridges at 95 stream crossings (**Figure 1-1**). As clear-span bridges will be installed on all fish-bearing creeks, only non-fish-bearing aquatic habitat will be lost along the access road due to culvert installations (**Table 3-8**). In addition, riparian habitat loss and alteration will occur adjacent to both fish-bearing and non-fish-bearing crossings (**Table 3-9**).

3.2.5 Freegold Road Upgrade

The existing Freegold Road originates in Carmacks and extends approximately 85 km in a northwest direction towards the Casino mine site (**Figure 1-1**). The road crosses a total of 37 watercourses, 22 of which are fish-bearing. To accommodate Casino mine traffic, upgrades will include widening the road to two lanes with a design speed of 70 km/h; a 5 km by-pass around Carmacks; major new bridges over Nordenskiold River, Seymour Creek, Bow Creek and Crossing Creek; and nine short-span bridges to replace culverts requiring upgrading or relocation. All bridges will be single-lane, clear-span structures with the exception of the Nordenskiold River bridge, which will be two-span with a single pier located in the river.

As clear-span bridges will be installed on all fish-bearing creeks, only non-fish-bearing aquatic habitat will be lost along the access road due to culvert installations, with the sole exception of a 6 m^2 loss of in-stream habitat from the Nordenskiold River bridge pier (**Table 3-8**). Riparian habitat loss and alteration will occur adjacent to both fish-bearing and non-fish-bearing crossings (**Table 3-9**).

3.2.6 Tailings Management Facility

Construction of the TMF will cause direct habitat loss of the upper Casino Creek watershed, including main-stem Casino Creek from its headwaters to its confluence with Brynelson Creek, Proctor Gulch, Taylor Creek, Meloy Creek, and three unnamed tributaries that drain westward into Casino Creek (**Tables 3-8** and **3-9**). The majority of the upper watershed is considered fish-bearing with the exception of the three unnamed tributaries, which are too small to permit fish passage. In addition, a fish barrier on Taylor Creek approximately 275 m above its confluence with Casino Creek (1 m vertical drop within an 18% gradient segment) prohibits fish from accessing habitat farther upstream. While approximately 750 m of habitat will technically remain between the water management pond and the confluence of Casino and Brynelson Creeks (**Figure 1-1**), this section is included as lost habitat as the predicted flows are too low to support viable aquatic communities. A HEP analysis predicts a 10,600 m^2 loss of usable fish-bearing habitat in the upper watershed, which represents approximately 30% of the total habitat area (**Table 3-8**).

The reduction in stream flows in Casino Creek due to the construction of the TMF will alter downstream fish-bearing habitat. The reduction in flow will result in a net reduction of 1,438 m^2 (4.8%) of wetted area in lower Casino Creek compared to existing area (**Table 3-8**). Farther downstream, Dip Creek will experience flow reductions from baseline values during the summer and winter months, resulting in predicted reductions in wetted area (3%), width (2%) and depth (3%) (as described in Section 10 of the Project Proposal). During the construction, operations and closure phases, in-stream flow modeling predicts an increase in usable habitat for all life stages of Arctic grayling in lower Casino Creek, with the exception of spawning habitat, which will be reduced by 3,157 m^2 (78.4%) (**Table 3-6**). PHABSIM models predict total adverse areal impacts of no more than 3% in Dip Creek due to reduced flows in Casino Creek (**Table 3-3**).

Following project closure, a spillway will periodically drain excess water from the reclaimed TMF to lower Casino Creek (**Figure 1-2**). Spillway discharge is predicted to produce modest increases in flow from baseline conditions in both lower Casino Creek and Dip Creek during the April-May period. During post-closure, the greatest habitat losses in lower Casino are predicted for adult rearing (1,083 m^2, or 7.2%) and juvenile rearing (1,038 m^2, or 7.6%), followed by fry rearing (360 m^2, or 11.8%) (**Table 3-6**).

In Dip Creek, small changes are predicted in Arctic grayling usable habitat during closure and post-closure (**Table 3-6**). During closure, adult and juvenile rearing usable habitat is predicted to increase relative to baseline conditions, whereas negligible decreases of 13 m^2 (0.3%) and 90 m^2 (1.1%) are predicted for fry rearing and spawning habitat, respectively. During post-closure, reductions in adult and juvenile rearing habitat are predicted to be 1,001 m^2 (2.7%) and 847 m^2 (2.6%), respectively, whereas minor increases are predicted for fry rearing and spawning.

3.3 Habitat Impacts Mitigated by Project Re-design

CMC made several significant changes to the project design primarily to reduce or eliminate impacts to fish habitat that would otherwise have occurred. As suggested by DFO, these changes are briefly described below.

3.3.1 Bridges Instead of Culverts for Fish-Bearing Crossings

Large watercourses along the Freegold Road Upgrade, Freegold Road Extension and Airstrip Access Road, such as Hayes Creek, Big Creek and Dip Creek, have always been proposed to be crossed using clear-span bridges, both for technical reasons and to minimize impacts to aquatic habitat. This original plan has been carried through preliminary design, in association with this submission to YESAB.

Culverts (embedded or not) were originally proposed to convey all small watercourses beneath new or upgraded road crossings. During the late stages of preliminary design, however, CMC proposed to accommodate in its design and construction plan the crossing of all *fish-bearing* watercourses with short-span, precast concrete slab bridges (“short-span bridges”). In addition to the reduction in environmental impact, other rationale cited by AE (2013) for using short-span bridges instead of culverts, particularly in areas of permafrost, includes “simple construction methods, faster construction schedule, robustness, and low maintenance requirements”. Non-fish bearing watercourses may still be crossed using conventional corrugated steel pipe culverts designed to convey water and bed material.

The crossing of fish-bearing watercourses with short-span bridges instead of new or replacement culverts along all access roads avoids impacts to approximately 7,300 m^2 of in-stream fish habitat, which would otherwise have required authorization (and compensation). Furthermore, the bridge crossings have been designed to minimize risk to in-stream habitat. All bridge abutments will be set back from the tops of banks, in order to avoid projections into the channel and changes in flow or habitat area. Stone will be placed on the bank beneath the bridge deck, flush with adjacent bank sections, to inhibit irregular and potentially severe erosion that might otherwise occur when riparian vegetation is lost due to year-round shading, especially in areas of permafrost. Impacts to riparian vegetation cannot reasonably be avoided, but the need for any riparian habitat compensation will be minimized by bank stabilization and re-vegetation to mitigate local erosion and sedimentation.

3.3.2 TMF Spillway By-pass of Brynelson Creek

In association with project closure (Years 23 to 25, **Table 1-1**), an overflow spillway is proposed to be constructed to the west of the main embankment of the TMF (**Figure 1-2**). Its purpose is to facilitate control and discharge of excess water accumulation within the TMF and to provide safe passage of storm water volumes from the TMF (Knight Piésold, 2012b). This spillway, which has been situated to follow a natural draw on the north side of Brynelson Creek, was originally proposed to discharge to Brynelson Creek, just upstream of its crossing by the Airstrip Access Road. An integrated hydraulic, fluvial geomorphological and fish habitat assessment of the capacity of lower Brynelson Creek to convey the additional flow from the spillway was completed. The results indicated that both the hydraulic capacity and erosion threshold of Brynelson Creek would be exceeded, potentially resulting in adverse effects on local and downstream fish habitat. In light of these findings, CMC approved the realignment of the spillway such that it is now proposed to by-pass Brynelson Creek altogether (**Figure 1-2**). This spillway re-design avoids direct impacts to approximately 8,500 m^2 of fish habitat and considerable indirect impacts through increased sedimentation downstream in lower Casino Creek. The period during which excess water will be drained from the TMF has also now been extended from just two months (April-May) to the full spring-summer period, in order to reduce the magnitude of flows and avoid potentially adverse effects on fish habitat in lower Casino Creek (Section 10 of Project Proposal).

3.3.3 Naturalization of Airstrip Diversion Channel

The proposed airstrip for the Project requires considerable length on level ground, with good approaches in either direction. One of the few locations where these criteria are met is within the Dip Creek valley. The airstrip is proposed to extend onto a gentle alluvial fan across which a small, unnamed tributary of Dip Creek flows (**Figure 1-1**). In order to ensure stability and safety of the airstrip, the small tributary must be diverted around it, rather than being conveyed beneath it through a culvert. The tributary and local surface runoff were originally going to directed around the airstrip along a straight, gravel-filled interceptor drain along the toe of a berm, built about 120 m upslope from the airstrip. This local filling of fish habitat and disconnection of the watercourse upstream of the airstrip would have resulted in a substantial amount of lost fish habitat.

In order to avoid as much as 9,000 m^2 in lost fish habitat, CMC has changed its surface water diversion strategy to create a naturalized airstrip diversion channel to by-pass the airstrip and drain into an existing, natural drainage path (another distributary channel on the alluvial fan). The diversion channel will be constructed using natural channel design principles in order to accommodate fish passage and re-create the habitat features to which fish have adapted. This decision will reduce the amount of lost habitat to 1,509 m^2, for which the 4,753 m^2 of new fish habitat within the diversion channel will fully compensate (as described below in Section 4.3.2).

4 Fish Habitat Compensation

This section begins by outlining the objectives and rationale of the FHCP (Section 4.1). It provides the necessary context for the overviews of each original candidate compensation opportunity (Section 4.2) and the more detailed descriptions of each proposed compensation measure, including riparian plantings (Section 4.3). The overall habitat balance is outlined in Section 4.4.

4.1 Objectives and Rationale

CMC has designed the Project to avoid HADDs, to the greatest extent possible, through project redesign, refinement and impact mitigation. Despite these efforts, certain HADDs (as described above in Section 3.2) are unavoidable and require authorization from DFO, pursuant to Section 35(2) of the *Fisheries Act*. Additionally, compensation measures are necessary in order to achieve the guiding principle of "No Net Loss", as outlined in DFO's *Policy for the Management of Fish Habitat* (DFO, 1986), wherein compensation is defined as follows:

> "The replacement of natural habitat, increase in the productive capacity of existing habitat, or maintenance of fish production by artificial means in circumstances dictated by social and economic conditions, where mitigation techniques and other measures are not adequate to maintain habitats for Canada's fisheries resources".

CMC has identified several project-specific guiding principles on which its proposed compensation measures are based:

- Habitat restoration and creation are prioritized over enhancement, owing to their lower risks to existing, functional fish habitat;
- Compensation measures should be self-sustaining, requiring little to no maintenance in the long-term;
- Preference should be given to compensating for impacts to low suitability and sensitivity habitats with measures that benefit high suitability and sensitivity habitats, in order to better address limitations to the productive capacity of the watershed;
- Compensation should minimize disturbance to existing natural aquatic and terrestrial habitats; and
- Compensation measures should provide opportunities for meaningful First Nations engagement.

The following sections demonstrate how the compensation measures proposed by CMC address each of the factors DFO (2013a,b) indicates should be considered in compensation planning, prior to describing each compensation opportunity in detail (Section 4.3).

4.1.1 Hierarchy of Preferred Compensation Options

DFO (1986) outlines a hierarchy of preferred compensation options, with preference given to on-site rather than off-site compensation, that should generally be followed in order to maximize the likelihood of meeting the objective of No Net Loss:

1. Create or increase the productive capacity of **like-for-like** habitat in the same ecological unit;
2. Create or increase the productive capacity of **unlike** habitat in the same ecological unit;
3. Create or increase the productive capacity of habitat in a **different** ecological unit;
4. As a last resort, use artificial production techniques to maintain a stock of fish, deferred compensation or restoration of chemically contaminated sites.

DFO (2013b) also makes two important statements that form the basis for CMC's decision to incorporate off-site and lower-level compensation measures into its proposed compensation plan. First, DFO acknowledges, "While the Hierarchy of Compensation Options should normally be followed, there are circumstances under which exceptions may be required…where limitations to productive capacity are known." Section 2.3 identified several known limitations to the productive capacity of fish habitat, including the rarity of deep pools for overwintering. CMC proposes to reinstate the historical meandering channel of lower Britannia Creek, in part due to its locally deep pool habitat (off-site, Level 3) (Section 4.3.1.1), and to create a large, groundwater-fed pool near the mouth of Britannia Creek (off-site, Level 3) (Section 4.3.1.2). Both measures are specifically designed to address this known limitation to productive capacity.

Second, DFO (2013b) emphasizes that "…moving down the hierarchy may present a better opportunity for maximizing the amount of habitat gained…." Accordingly, CMC proposes to compensate for impacts within the Casino Creek watershed off-site in the adjacent Britannia Creek watershed. The proposed compensation measures along lower Britannia Creek, a wider, higher-order reach in direct connection to the Yukon River, will benefit a much more diverse fish community, including Chinook – a priority species for protection and restoration in Yukon. In comparison, Casino Creek and its tributaries are relatively isolated, occurring at high elevation far from the more productive reaches of Yukon River and its major tributaries. The impacted reaches also support only a few species (not Chinook) or indirect, non-fish-bearing habitat (tributaries), in part due to poor water quality, steep gradients and a lack of suitable substrate materials. Compensation along lower Britannia Creek, instead of within the Casino Creek watershed, is expected to yield far greater gains in the productive capacity of habitat that will benefit more species and life history stages of these species.

4.1.2 Target Species and Fisheries Management Objectives

The high ecological, cultural and economic value of Chinook salmon makes it an ideal target species for habitat compensation works. Although Chinook salmon do not reside in the primary impacted area of Casino Creek, they are found in nearby watercourses such as Dip Creek and lower Britannia Creek. Also, habitat compensation that is designed to benefit Chinook salmon will also be advantageous to Arctic grayling and slimy sculpin, which are the dominant fish species residing in the proposed impacted area of

Casino Creek. Both Arctic grayling and slimy sculpin have habitat requirements in common with Chinook salmon, such as deep pools for juvenile rearing and overwintering.

Yukon freshwater fishery management is under the jurisdiction of the Fish and Wildlife branch of the Yukon Government. It has several principal objectives:

- To maintain and enhance the quality and integrity, including the biological diversity, of the aquatic environment for present and future generations;
- To ensure the sustainable use of fisheries resources through a balanced and integrated management of fish and their habitats;
- To manage resources in a manner that is collaborative and promotes environmental and socially responsible awareness, participation, and stewardship; and
- To provide sustainable fish harvesting and viewing opportunities for social, cultural, recreational and, where appropriate, commercial purposes.

In addition, Status of Yukon Fisheries (Environment Yukon, 2010) outlined the need to focus on managing over-harvested species, such as potentially vulnerable populations of Arctic grayling, lake trout, northern pike and burbot. Furthermore, recommendations were made to shift towards ecosystem or watershed-based management.

Anadromous fishes in the Yukon are managed and regulated by DFO. Additionally, the management of Yukon River salmon in the Yukon involves several coordinating and advisory agencies: the international Yukon River Panel, established under the USA/Canada Yukon River Salmon Agreement; and the Yukon Salmon Sub-Committee, established under the Yukon land claims' Umbrella Final Agreement. Both agencies provide recommendations to DFO regarding salmon harvest management, stock and habitat conservation, and the enhancement of renewable resource economies. The great emphasis on Yukon River salmon management reflects the species' ecological, cultural and economic values to Yukon communities and ecosystems. As Yukon River Chinook salmon populations are in decline, and well below historical levels, the protection and enhancement of freshwater habitats that support spawning and critical early life stages for Chinook salmon are increasingly important.

4.1.3 Improvement of Existing Impacts or Constraints

DFO (2013b) emphasizes that "…the restoration of degraded habitats for compensation purposes is considered to be a useful practice and is encouraged." The first of CMC's four guiding principles for compensation in this project, prioritizing habitat restoration over creation or enhancement, is consistent with this acknowledgment. Indeed, a key early focus of compensation planning for this project was to identify orphaned and unrestored placer mining sites, and abandoned road crossings, that may be candidates for restoration. It was through this extensive search that it was discovered that a historical avulsion (change of channel course) at a ford along lower Britannia Creek had redirected flow along a road that predates the earliest available aerial photography in the area (i.e., 1948) (as described in more detail in Section 4.3.1). Detailed geomorphological and ecological investigations were conducted to better understand the nature and implications of this avulsion and the constraints on existing fish habitat.

A key component of this compensation plan is to reinstate flow through the historical, meandering channel of lower Britannia Creek by re-diverting it from the existing, straight, “roadway” channel at the abandoned ford where the avulsion originally occurred (Section 4.3.1.1). Several other abandoned road crossings along lower Britannia Creek have also been identified for restoration – not so much because their restoration provides opportunities for significant gains in habitat area, but because their restoration will reduce downstream sedimentation and support the overall objective of restoring the lower Britannia Creek valley to its pre-existing, natural condition (Section 4.3.1.3).

Following from the discussion above (Section 2.3), the rarity of deeper pools and sufficient flows for overwintering represents a significant, natural constraint on productive capacity. A large, groundwater-fed pool is proposed near the mouth of Britannia Creek (Section 4.3.1.2), for the benefit of all species seeking opportunities for off-channel rearing including overwintering.

4.1.4 First Nations Traditional Uses and Knowledge

CMC has engaged the local First Nation communities with traditional territories encompassing the areas of predicted impacts early and regularly through the planning and development of the FHCP. The project is of greatest interest to SFN, whose traditional territory encompasses the mine site area where greatest impacts are anticipated. Negligible impacts to fish habitat are expected within the traditional territory of Little Salmon Carmacks First Nation, which encompasses the eastern end of the Freegold Road. CMC has hosted presentations and workshops within the communities and on-site to communicate the plans for the overall project and its environmental supporting studies. Specific input has been solicited from SFN on fish habitat compensation objectives, strategies, sites and design priorities. Chinook salmon has consistently been identified as a priority species for compensation. SFN identified the lower reach of Britannia Creek as an area of cultural and ecological significance based mainly on historical and potential Chinook spawning suitability. As a result, this reach was classified as an area of special consideration in the placer habitat suitability mapping process (**Figure 2-1**), with the most restrictive requirements and standards (Yukon Placer Secretariat, 2012).

CMC has had initial discussions regarding the concept of a potential partnership with SFN for identifying candidate sites for additional compensation outside the Project area but within the SFN traditional territory. The intention would be to collaboratively develop the plans for design, implementation and monitoring, with the ownership of the compensation works ultimately transferred to SFN. Section 4.3.3 outlines a proposal for making significant improvements to Chinook salmon habitat, in consultation with DFO and other organizations, within the traditional territory of SFN.

4.1.5 Compliance with Recovery Planning for Species at Risk

The public registry database for the federal *Species at Risk Act* indicates that no freshwater fish species listed in Schedules 1 or 2 of the *Act* occur within the project area or within the entire Yukon. Therefore, no species at risk will be affected by the project.

4.1.6 Type, Amount and Supply of Habitat at Impact and Compensation Sites

This FHCP aims to achieve a net increase in the productive capacity of habitat for Chinook salmon, as well as for Arctic grayling and slimy sculpin, based on greater gains than losses in habitat. A quantitative comparison of habitats at impact and compensation sites is provided below in Section 4.4, following the descriptions of proposed compensation measures (Section 4.3). In addition to comparing the amount of gains and losses in habitat, DFO (2013b) emphasizes the need to consider three factors that influence compensation requirements: (1) uncertainty in success; (2) variance in the quality of habitat being replaced; and (3) recognition of a time lag before the habitat becomes functional. Each of these factors is addressed below in relation to the principal component of compensation in this project, reinstatement of the historical meandering channel of lower Britannia Creek (Section 4.3.1.1):

1. *Uncertainty in success* – The reinstatement of the historical channel has a high certainty of success, given that it is relatively intact and was dynamically stable and provided high quality aquatic habitat for decades to centuries (based on analysis and extrapolation from historical aerial photographs), before the unnatural avulsion occurred along the historical access road right-of-way. Re-introduction of flow into the historical channel, once selectively 'cleaned' of woody obstructions, is expected to restore pre-existing, natural channel substrates and morphology, dynamic fluvial processes and complex micro-habitat features within one year of flow diversion. Riparian vegetation already consists of mature mixed forest of spruce and deciduous trees, which will immediately provide cover and important allocthonous inputs.
2. *Variance in quality of habitat being replaced* – Reinstatement of the historical meandering channel of lower Britannia Creek represents a significant improvement in the quality of habitat from both the existing, roadway channel of lower Britannia Creek and the upper reaches of Casino Creek, along which habitat will be lost. This restored channel will represent the highest suitability juvenile Chinook rearing habitat in the Project area, based on the placer stream classification (Yukon Placer Secretariat, 2012), and has some potential for Chinook spawning. Pre-existing complex habitat features include sharp meanders; deep, asymmetric pools; undercut banks with overhanging trees; and diverse gravel bed material. The existing lower Britannia Creek channel follows a former road right-of-way; its pattern is straight, its gradient is uniform and relatively steep, its flow is relatively fast with low variability bed, and its bed is dominated by cobbles and boulders with little gravel.
3. *Recognition of time lag* – DFO (2013b) specifies that "Lower [compensation] ratios would be needed if the compensation works are completed and functional before the HADD occurs." The historical meandering channel already exists in mature form, from both a geomorphological and ecological perspective. Its reinstatement is proposed to occur before or in conjunction with the occurrence of the HADD in Casino Creek, during the waning stages of a freshet. Habitat is expected to be fully functional in less than one year, before the next freshet.

Table 4-1 compares the types and supplies of different habitats at both the impact and compensation sites, demonstrating that all proposed compensation habitats are less common and more productive than those at impact sites.

Table 4-1. Type and Supply of Habitat at Impact and Compensation Sites

Habitat	Site	Type	Supply
IMPACTED	Lower Britannia Creek "Roadway" Channel (diversion of flow into historical channel)	Riffle-dominated, moderately steep, straight 4th-order channel (only 8% pools), with minimal functional large woody debris	N/A (Unnatural)
	Upper Casino Creek (TMF)	2nd order straight to sinuous channel with cobble-boulder bed and pool-riffle morphology; low seasonal usage based on high gradient, unsuitable substrates and lack of, and downstream distance to, overwintering habitats	Abundant in region
	Unnamed Tributary of Dip Creek (Airstrip)	1st order straight to sinuous channel with irregular pool-riffle morphology	Abundant in watershed and region
	Lower Canadian Creek (flow reduction downstream of open pit)	3rd order meandering to braided channel (in areas of placer disturbance) with pool-riffle morphology	Abundant in region
	Lower Casino Creek (flow reduction downstream of TMF)	2nd order sinuous to meandering channel with gravel-cobble bed and pool-riffle morphology	Abundant in region
	Dip Creek (flow reduction downstream of TMF)	4th order tortuously meandering channel with gravel bed and pool-riffle morphology	Common in region
COMPENSATION	Reinstatement of Historical Lower Britannia Creek	Low-gradient, tortuously meandering, pool-riffle channel adjacent to Yukon River, with gravel-cobble substrate (30-35% pools) and abundant functional large woody debris	Limited in watershed and region
	Groundwater-fed Pool near Britannia Creek Mouth	Deep, long groundwater-fed pool connected to mouth of 4th order tributary to Yukon River	Limited in watershed and region
	Naturalized Airstrip Diversion Channel	1st order sinuous channel with pool-riffle morphology, in-stream boulder groups and large woody debris	Moderately limited in watershed (enhanced habitat)
	Britannia Creek Ford Restoration	Riffles along 3rd to 4th order, irregularly meandering channel with gravel-cobble substrates	Common in watershed and region
	Chinook Project Contribution	TBD	TBD

Note: Proposed compensation habitats offset impacts holistically and do not necessarily correspond to particular, predicted impacted habitats.

4.1.7 Temporal Nature of Impacts

As outlined in Section 10 of the Project Proposal, the following impacts to fish habitat are permanent:

- Loss of habitat along upper Casino Creek, within and upstream of TMF footprint, and along lower Casino Creek during post-closure due to periodic increased runoff from the reclaimed TMF;
- Loss of habitat along the existing roadway channel of lower Britannia Creek, in support of reinstatement of the historical channel (i.e., compensation);
- Minor loss of habitat during post-closure along Dip Creek, downstream of Casino Creek, due to periodic increased runoff from the reclaimed TMF;
- Loss of habitat along the portion of the unnamed tributary of Dip Creek that will be diverted (and enhanced) around the airstrip; and
- Minor loss of habitat area due to flow reduction along lower Canadian Creek;

Two project impacts are temporary, but long-term (~29 years) and considered permanent for the purposes of habitat loss calculations:

- Loss of habitat area along lower Casino Creek due to flow reduction (during construction and operations project phases); and
- Minor loss of habitat area due to flow reduction along Dip Creek.

4.1.8 Risk of Failure and Time Lag until Compensation Habitats Functional

The proposed compensation measures have been developed by a multi-disciplinary team with experience in fish habitat restoration and enhancement projects. All compensation components have been designed with consideration of local hydrology and hydraulics, geomorphology and fluvial processes, and ecological sensitivities and priorities. Therefore, the risk of failure is generally considered low. **Table 4-2** provides specific rationale for the interpreted risk of failure of each compensation component. This compensation plan proposes more gains than losses and allows for the possibility that some habitat may not fully function as anticipated. Focused monitoring and an allowance and expectation for adaptive management will ensure the long-term effectiveness of compensation works.

Compensation works have also been designed to minimize the time lag between implementation and full function. All habitat restoration and enhancement measures will be completed at the start of construction of the Project, either before or in conjunction with the occurrence of authorized HADDs (**Figure 4-1**). Compensation will greatly precede the minor impacts along lower Canadian Creek. **Table 4-2** anticipates the time lag associated with each compensation component.

Table 4-2. Risk of Failure and Time Lag for Compensation

Compensation Measure	Risk of Failure	Rationale	Lag Time	Rationale
Reinstatement of Historical Britannia Creek	Low	Channel dynamically stable for decades to centuries	Negligible (<1 yr)	Complex in-stream and riparian habitat features already exist
Britannia Creek Ford Restoration	Low	Restoring natural (pre-existing) channel morphology	Short (<3 yrs)	Already surrounded by dense riparian vegetation and stable banks
Groundwater-fed Pool near Britannia Creek Mouth	Low-moderate	Mimics natural form and function of oxbow, but potential for minor sedimentation in connector channel; monitoring and adaptive management to detect early and address any issues	Short (<5 yrs)	Pool will be excavated, stabilized and re-vegetated prior to connection to creek
Naturalized Airstrip Diversion Channel	Low	Channel to partly follow existing, natural drainage path and have morphology and features to increase productivity based on standard natural channel design principles	Short (<5 yrs)	Existing, mature vegetation will maintain bank stability and provide important riparian cover
Chinook Project Contribution	TBD	TBD	TBD	TBD

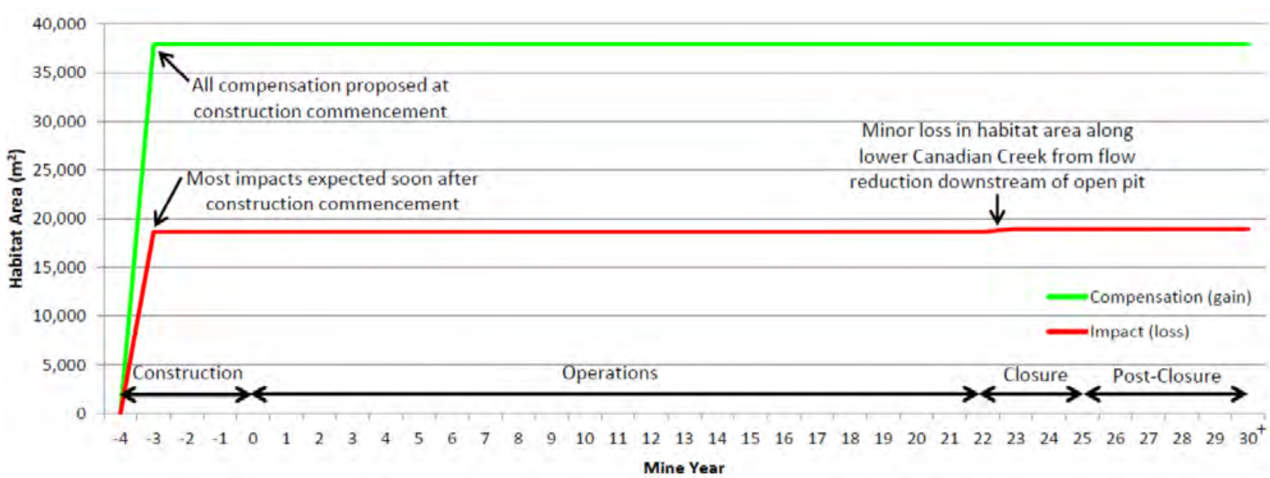


Figure 4-1. Schedule of Predicted Fish Habitat Impacts and Gains

4.2 Original Compensation Options

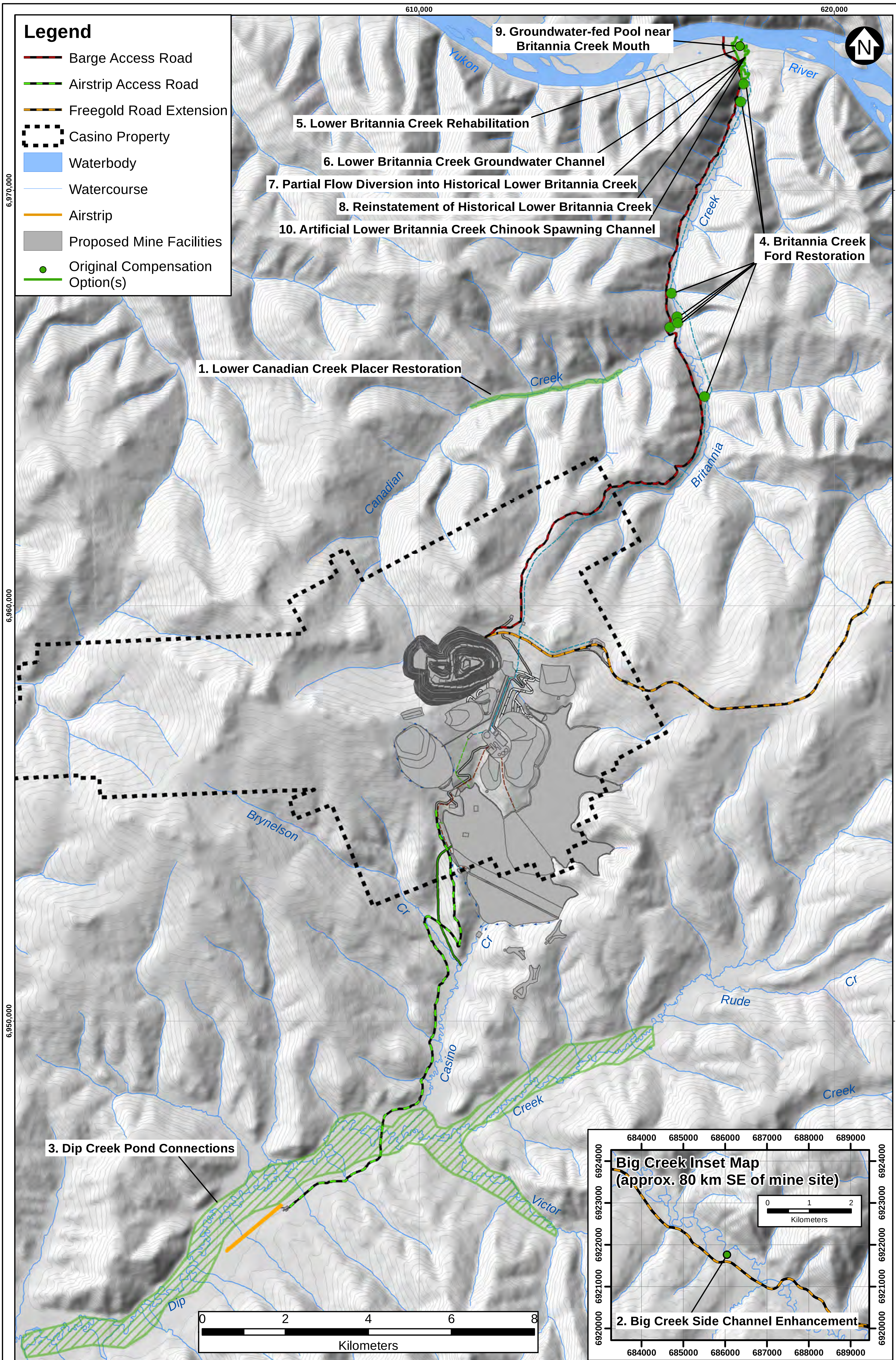
Since the initiation of baseline aquatic studies for the Project in 2008, ten potential opportunities for fish habitat compensation have been identified through a comprehensive and systematic review of undisturbed and previously impacted aquatic ecosystems in the vicinity of the Project, giving priority to opportunities closest to the Project (**Figure 4-2**). Two additional options, the naturalized airstrip diversion channel (described below in Section 4.3.2) and the Chinook project contribution (described below in Section 4.3.3), are excluded from this summary because of their recent inclusion as a form of impact mitigation and to complement other compensation totals, respectively.

Each opportunity was assessed relative to DFO's eight key factors for consideration in compensation planning (as outlined above in Section 4.1), in consultation with DFO and other stakeholders during the planning stages of the FHCP (**Table 4-3**). Construction cost, in comparison to potential long-term benefits to productivity, was also considered. The screening process facilitated a consistent and transparent evaluation of each compensation option, and provided a mechanism for assessing and comparing the potential of each option to address the various compensation objectives. The selection of preferred options that have now been advanced to preliminary design, in support of the submission to YESAB, incorporates valuable input from First Nations and local communities, regulatory agencies and the multi-disciplinary project team.

Each of the ten, original options considered for fish habitat compensation is briefly described below, with reference to key screening criteria, as appropriate:

1. <u>Lower Canadian Creek Placer Restoration</u>

Placer mining has occurred intermittently along Canadian Creek since 1911 (MacDonald, 2012). Its long-lasting and locally significant impacts on aquatic habitat along the lower 3-4 km of Canadian Creek are primarily the result of haphazard channel realignment, dredging of the channel bed and floodplain, and widespread removal of riparian vegetation. The extent of impact to fish habitat along lower Canadian Creek is unlike any other within the Project area watersheds. Consideration was given to reconstructing natural channel morphology or at least re-vegetating riparian and floodplain vegetation, in order to help restore channel stability and reduce sediment loading along the creek (**Figure 4-2**). Such restoration would benefit Arctic grayling and may result in long-terms benefits in productivity, although it may have little effect on Chinook salmon farther downstream. A significant deterrent to further consideration of this compensation is the potential for future placer mining to disrupt or destroy any restoration works, given its dominant classification by the Yukon Placer Secretariat (2012) as "low suitability" habitat and a lack of adequate measures to ensure future protection; active placer mining licenses currently cover all of lower Canadian Creek.



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NOTES:
1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:85,000

CASINO COPPER AND GOLD

CASINO PROJECT

Original Fish Habitat Compensation Options

FIGURE 4-2

FHCP REPORT

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Table 4-3. Summary Evaluation of Original Fish Habitat Compensation Options

Screening Criteria	1. Lower Canadian Creek Placer Restoration	2. Big Creek Side Channel Enhancement	3. Dip Creek Pond Connections	4. Britannia Creek Ford Restoration	5. Lower Britannia Creek Rehabilitation	6. Lower Britannia Creek Groundwater Channel	7. Partial Flow Diversion into Historical Lower Britannia Creek	8. Reinstatement of Historical Lower Britannia Creek	9. Groundwater-Fed Pool near Britannia Creek Mouth	10. Artificial Chinook Spawning Channel alongside Lower Britannia Creek
1 - Hierarchy of preferred compenstion options	Option 3 - habitat in a different ecological unit.	Option 3 - habitat in a different ecological unit, located far (80 km) from Casino Creek.	Option 3 - habitat in a different ecological unit, although closest option to Casino Creek.	Option 3 - habitat in a different ecological unit.	Option 3 - habitat in a different ecological unit.	Option 3 - habitat in a different ecological unit.	Option 3 - habitat in a different ecological unit.	Option 3 - habitat in a different ecological unit.	Option 3 - habitat in a different ecological unit.	Options 3/4 - habitat in a different ecological unit, requiring active pumping.
2 - Target species and fisheries management objectives	Low-Moderate relevance - would likely increase local productive capacity of Arctic grayling, but may have little impact on Chinook samon further downstream	Moderate relevance – creation of year-round Chinook rearing habitat	Moderate-High relevance – creation of rearing and potentially overwintering habitat for Arctic grayling, maybe also juvenile Chinook salmon	Low-Moderate relevance - improvements to local and downstream Arctic grayling habitat	Moderate-High relevance – may enhance existing Chinook rearing or overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon rearing and overwintering habitat	High relevance – creation of Chinook salmon spawning habitat, in addition to rearing and overwintering benefits
3 - Improvement of Existing Impacts or Constraints	High - opportunity to restore severely impacted habitat	Low - minor increase in off-channel refuge	Moderate - address lack of overwintering habitat	High - address site-specific and downstream impacts	High - opportunity to diversify habitat types	Moderate-High - address lack of overwintering habitat	Moderate - restore some of historical habitat value	High - restore full historical habitat value	High - provide overwintering habitat near Yukon River	High - create spawning and overwintering habitat
4 - First Nations traditional uses and knowledge	Low (Chinook priority)	Moderate-High	Moderate (difficult access)	Moderate	Moderate	Moderate-High	High	Very High	High	Very High
5 - Compliance with recovery planning for species at risk	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
6 - Type, amount and supply of habitat at impact and compensation sites	25,000 m^2 potential compensation area	5,000 m^2 potential compensation area	1,000 - 17,000 m^2 potential compensation area	560 m^2 potential compensation area	10,000 m^2 potential compensation area	12,000 m^2 potential compensation area	13,643 m^2 potential compensation area	13,643 m^2 potential compensation area	9,200 m^2 potential compensation area	2,500 - 10,000 m^2 potential compensation area
7 - Temporal nature of impacts	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses	Off-site compensation proposed for permanent habitat losses
8 - Risk of failure and time lag until compensation habitats functional	Moderate risk of failure (potential for re-activation of placer mining, which could destroy restoration efforts), <5 yr time lag	High risk of failure (potential for main stem of Big Creek to re-occupy side channel and destroy habitat enhancement efforts, given its lateral instability), <1 yr time lag	High risk of failure (potential for ponds to become disconnected through lateral channel migration, degradation of ice-rich permafrost beneath connector, or sedimentation into connector), <1 yr time lag	Low risk of failure (potential for placer miners to re-activate road in future), <3 yr time lag	Moderate risk of failure (potential for long-term channel instability in response to constructed meander pattern and in-stream structures), <5 yr time lag	High risk of failure (potential for groundwater to drop below bottom of excavations, or for flowing water to exacerbate permafrost degradation and collapse banks), <3 yr time lag	High risk of failure (potential for impediments to fish passage due to shallow depths from flow split, and long-term monitoring and maintenance required to address potential sedimentation at channel divergence), <1 yr time lag	Low risk of failure (long-term stability anticipated, given historical function, although monitoring will determine need for any localized adjustments through adaptive management), <1 yr time lag	Low risk of failure (pool outlet designed to avoid bedload sedimentation and flush fines, although initial monitoring and adaptive management recommended), <5 yr time lag	Moderate risk of failure (requirement for monitoring and periodic maintenance, in perpetuity, and potential for equipment failures during critical periods (e.g., winter)), <3 yr time lag
9 - Construction Cost (approx. dollars)	Several million	Few hundred thousand	Few hundred thousand	Several tens of thousands	Million+	Few million	Hundred thousand	Several hundreds of thousands	Million+	Hundreds of thousands+ (perpetuity)
Overall relative rank	**Moderate**	**Very low**	**Moderate**	**High (in support of watershed restoration)**	**Low**	**Moderate**	**Moderate**	**Very High**	**High**	**Moderate**

2. Big Creek Side Channel Enhancement

An existing side channel (meander scar) of Big Creek, which is flooded only during peak flow conditions, would be modified to allow year-round accessibility (**Figure 4-2**). The development of a permanent side channel would create good quality rearing habitat for both Arctic grayling and Chinook salmon. The off-channel position would facilitate a habitat with lower flows during peak flow events, as well as good protective cover and feeding opportunities for juvenile fish. In-stream habitat features such as boulders and cobble substrate could be added to enhance protective cover and the colonization of species on which fish feed (e.g., benthic invertebrates, periphyton). The key constraints to this option are the potential for the main stem of Big Creek to re-occupy the side channel, given its lateral instability, and the relatively small area of habitat gained.

3. Dip Creek Pond Connections

Numerous ponds exist within the Dip Creek valley, mainly in the form of oxbows and thermokarst (thaw) lakes (**Figure 4-2**). Consideration was given to establishing permanent connections between one or more of these ponds and Dip Creek or its tributaries, via constructed channels, to provide off-line pond rearing and/or overwintering habitat for fish species. Pond habitat would provide low-flow refuge areas outside Dip Creek itself, and would increase riparian habitat and feeding opportunities. The potential addition of overwintering habitat would be critical, as deep pools required for overwintering in the Casino Creek watershed are very limited. The primary obstacle to this option is the extent of ice-rich permafrost along the valley bottom. The establishment of permanent pond-creek connections would require costly, engineered structures and mobilization of heavy equipment to remote sites, with a high likelihood to fill in with flood sediment, become abandoned following channel migration, or collapse through permafrost degradation.

4. Britannia Creek Ford Restoration (detailed below in Section 4.3.1.3)

The original placer mining access road along the Britannia Creek valley, which was established prior to the earliest available aerial photography in the area (1948), crosses Britannia Creek and lowermost Canadian Creek at a total of seven locations (**Figure 4-2**). At each of the fords, vehicle tracking has caused the banks to collapse, erode and retreat. Channels have become over-widened, promoting local sedimentation and further widening, in turn. Fine sediments continue to be eroded from the unvegetated banks during moderate to high flows and transported downstream. With relatively minimal effort, channel morphology at the now-abandoned fords can be restored, and riparian vegetation can be re-established. Although the areal gain in habitat is small, the reductions to local and downstream sediment loading and corresponding extended downstream fish habitat benefits warrant such compensation efforts.

5. Lower Britannia Creek Rehabilitation

The existing, mostly straight channel through which lower Britannia Creek flows follows a former road right-of-way (**Figure 4-2**). The roadway channel has responded to the unnaturally straight course and steep gradient, since the avulsion from its natural, meandering channel sometime in the 1970s, by altering its channel morphology. Long, cobble-substrate riffle and run sections dominate its straight length, with few deep pools for velocity refuge or cover. Undercut banks are limited in extent and size, given the relatively uniform flow pattern along the straight channel. Log jams derived from previously eroded mature trees continue to form and create sudden, sometimes dramatic changes in channel morphology and aquatic habitat. Consideration was given to rehabilitating habitat along this unnaturally straight section of lower Britannia Creek, by reconstructing meanders with variable channel dimensions and incorporating in-stream habitat features such as boulders and appropriately situated root wads. Channel naturalization, in this manner, has significant uncertainty and potential for failure. Additionally, the time frame before natural stability would be restored in a creek of this size may be considerable.

6. Lower Britannia Creek Groundwater Channel

Consideration was given to constructing a groundwater-fed channel east of the existing lower Britannia Creek channel, either within or alongside the historical channel of Britannia Creek (**Figure 4-2**). The channel would consist of a series of deep ponds, excavated below the groundwater table, connected by short segments of channel. It would drain into Yukon River and therefore provide rearing and/or overwintering habitat for Arctic grayling and Chinook salmon. However, an integrated field and desktop assessment of groundwater levels and gradients within the valley bottom determined that the groundwater table is at least 2-3 m below the bed of the historical channel along most of its length. The depth and area of excavation required to maintain hydraulic connections between the ponds and channel segments would be impractical and result in a significant corridor of disturbance to mature floodplain habitat.

7. Partial Flow Diversion into Historical Lower Britannia Creek

For decades to centuries before its unnatural avulsion onto the former road right-of-way, lower Britannia Creek exhibited a tortuously meandering channel in its lower 2 km before entering Yukon River (**Figure 4-2**). This historical, meandering channel had much higher quality habitat than exists along the current roadway channel followed by Britannia Creek. Consideration was given to diverting part (e.g., 50%) of the flow within existing Britannia Creek into its historical channel, following restoration of its overgrown channel, at the point of divergence between the two channels. The objective would be to maintain existing fish habitat along lower Britannia Creek, while at the same time restoring habitat along the historical, meandering channel. The primary obstacle to the success of this option, however, is the relatively low stream flows that occur in this semi-arid environment, particularly during the late summer to winter months. Halving the flow to each channel may result in net gains in wetted area, but the associated reductions in flow depth would reduce the usable habitat and prolong periods of flow discontinuity across riffles.

8. Reinstatement of Historical Lower Britannia Creek (detailed below in Section 4.3.1.1)

Full reinstatement of the historical, meandering channel of lower Britannia Creek would result in substantial, immediate improvements in the quality of lower creek habitat available to Chinook salmon, Arctic grayling and other species that currently use the existing lower reach and mouth of Britannia Creek (**Figure 4-2**). It is anticipated that this restoration would lead to measurable increases in productive capacity based on the creation of high suitability habitat that is naturally limited and in low abundance in the watershed. The historical channel provides flow and gravel substrate diversity through meanders, dense cover of overhanging vegetation and undercut banks, and micro-habitats on and around in-stream large woody debris and large cobbles. Its naturally deep pools would provide velocity refuge and improved potential for overwintering. The anticipated, long-term benefits to aquatic habitat associated with full reinstatement far outweigh temporary habitat displacement associated with the necessary decommissioning of the existing roadway channel.

9. Groundwater-Fed Pool near Britannia Creek Mouth (detailed below in Section 4.3.1.2)

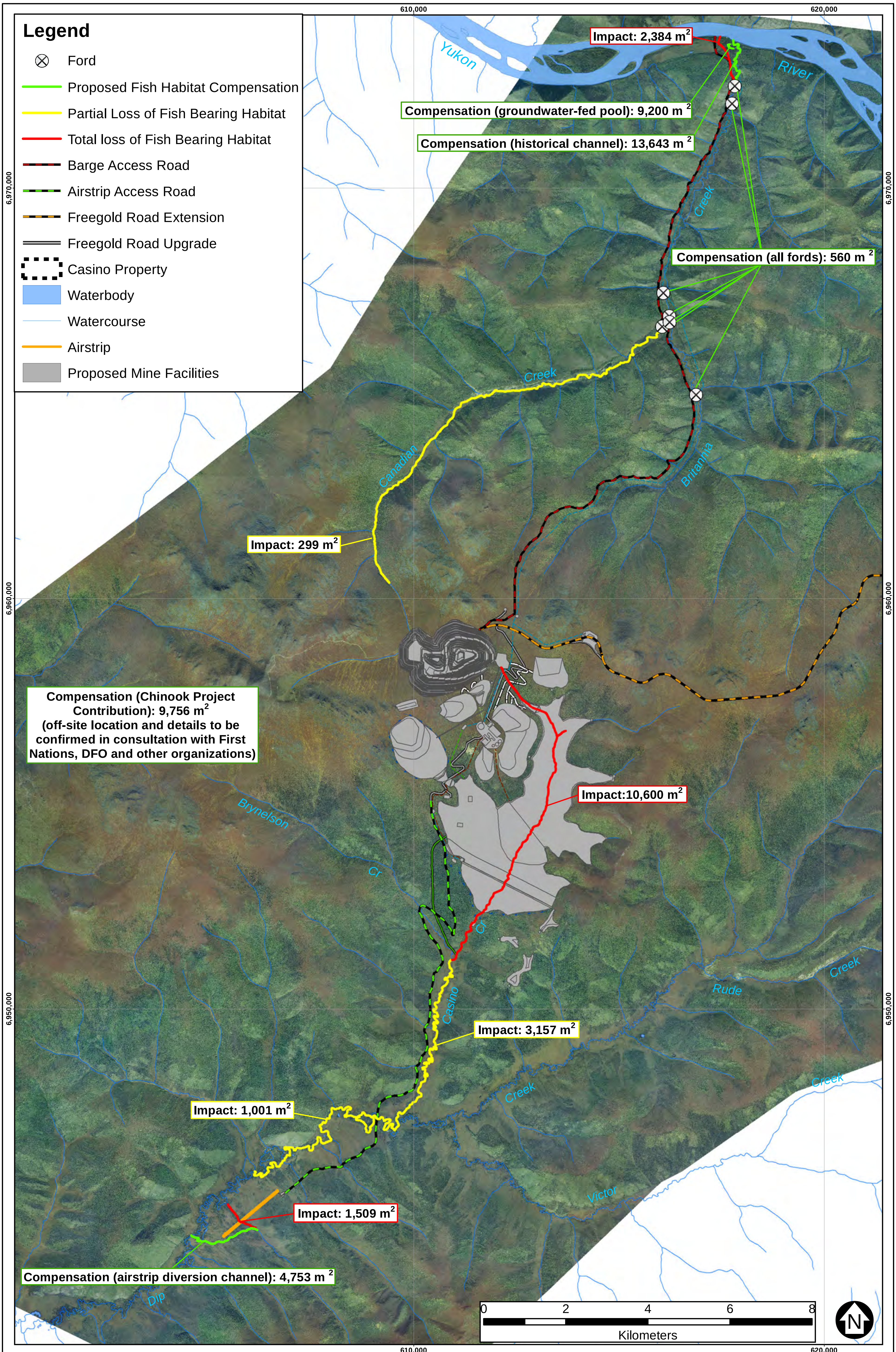
One of the greatest limitations to the productive capacity of fish habitat within the watersheds encompassing the Project is the lack of deep pools that provide overwintering habitat. A field investigation along the lower Britannia Creek valley identified a zone of groundwater discharge near the mouth of the historical channel of lower Britannia Creek. The creation of a groundwater-fed, backwater pool alongside the main creek, near the confluence with Yukon River, would provide sufficiently deep water to inhibit freeze-up during the winter months and support overwintering of Chinook salmon and Arctic grayling (**Figure 4-2**). The incorporation of a 'leaky' bank at the upper end of the pool would enable throughflow for the purposes of maintaining appropriate water quality (e.g., dissolved oxygen concentrations) and periodically flushing fine sediments that accumulate in the channel connection with the main creek.

10. Artificial Chinook Spawning Channel alongside Lower Britannia Creek

Consideration was given to creating a Chinook spawning channel alongside lower Britannia Creek, either in the historical channel itself or in an excavated tributary (**Figure 4-2**), given First Nations interests and historical information, and a low abundance of suitable spawning habitat. The critical issue is to establish a source of flow that would continue to flow year-round, including over the winter months when many tributaries to the Yukon River are frozen to their beds. Establishing a passive source of flowing water capable of maintaining an open channel is not feasible, given the absence of lakes in the watershed and the impracticality of intercepting enough groundwater flow upslope and delivering it to the spawning channel. Therefore, only one or multiple pumping wells that withdraw groundwater from the aquifer along Yukon River would represent a potential year-round source of water. The need for pumping to continue in perpetuity, the maintenance requirements, and the risk of equipment failure during critical winter periods precluded further consideration of this option.

4.3 Description of Proposed Compensation

Three of the ten compensation opportunities identified above, plus two recently developed opportunities, comprise the FHCP for the Project (**Figure 4-3**). Three are described below under the heading, Lower Britannia Creek Compensation (Section 4.3.1); the fourth is described under the heading, Naturalized Airstrip Diversion Channel (Section 4.3.2); and the fifth is introduced under the heading, Chinook Project Contribution (Section 4.3.3). Proposed compensation for impacts to riparian habitat is described in Section 4.3.4.



PREPARED BY: PALMER ENVIRONMENTAL CONSULTING GROUP INC.	
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NOTES:
1. BASE MAP: Digital Elevation Model and 1:250,000 and 1:50,000 Topographic Spatial Data provided by Geomatics - Yukon Government via online source (www.geomaticsyukon.ca)
2. PROJECTION: NAD 1983 UTM Zone 7N
3. COORDINATE GRID: METRES
4. SCALE: 1:85,000

CASINO COPPER AND GOLD

CASINO PROJECT

Locations of Fish Habitat Impacts and Proposed Compensation

FIGURE 4-3

FHCP REPORT

PN 10011

4.3.1 Lower Britannia Creek Compensation

Lower Britannia Creek is well suited for fish habitat compensation given its historical disturbances related to placer mining, which has occurred intermittently in the area and has impacted Britannia Creek and its major tributary, Canadian Creek, since 1911 (MacDonald, 2012). Lower Britannia Creek's classification by the Yukon Placer Secretariat as "Areas of Special Consideration – Cultural" virtually precludes future placer mining activity (**Figure 2-1**). A narrow road, presumably providing access to upstream mineral prospects, is visible along the Britannia Creek valley in the earliest available aerial photography in the region (1948) (**Figure 4-4**). It forded Britannia Creek at several locations downstream of its confluence with Canadian Creek, before continuing up the Britannia Creek valley (**Figure 4-3**). Sometime between 1965 and 1988, based on available historical aerial photography, lower Britannia Creek abandoned its natural, meandering channel to follow the straight, road right-of-way, which offered little resistance and a direct, downhill path. Anecdotal accounts from a local trapper indicate the avulsion likely occurred in the early 1970s. After following the roadway for about 900 m, the streamflow diverged eastward and carved a sinuous path, forming a new mouth about 150 m west of the original mouth (**Figure 4-4**).

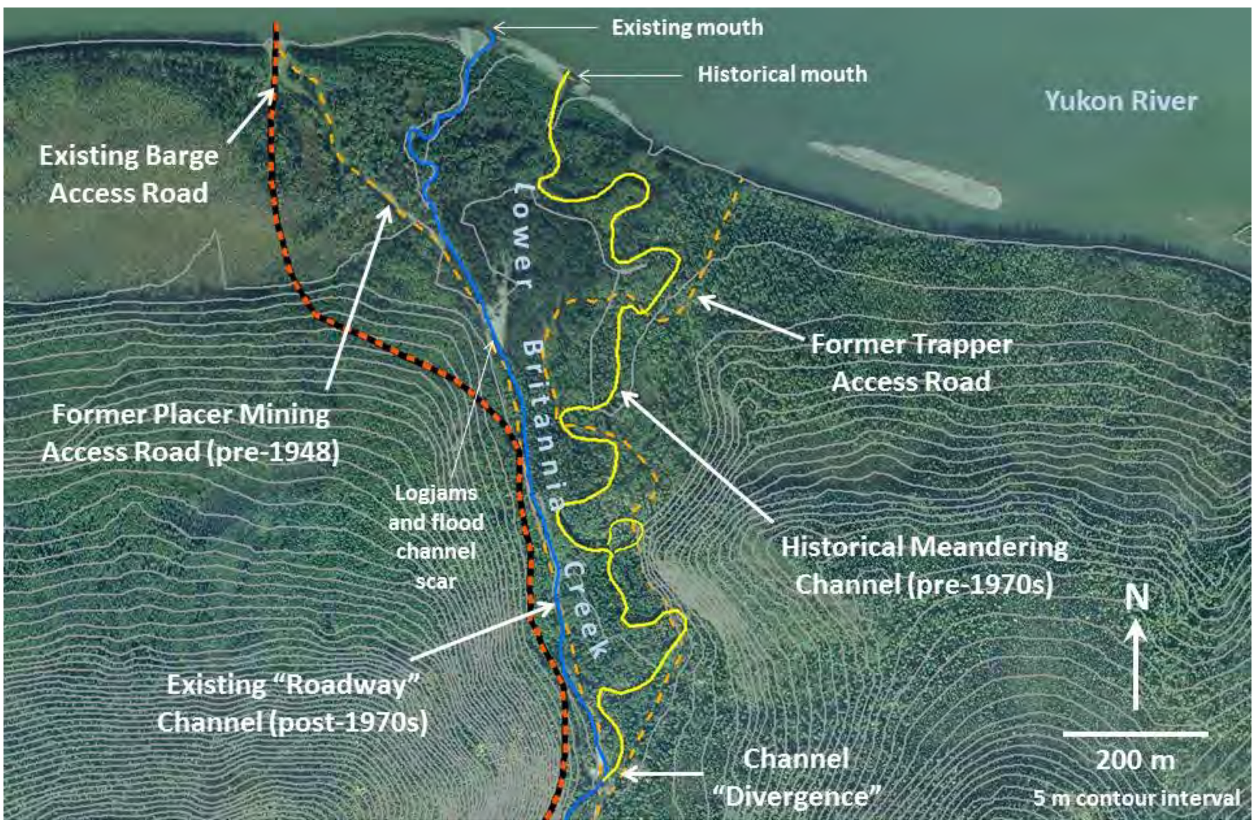

Figure 4-4. Existing and Historical Channels of Lower Britannia Creek

The unnatural avulsion of Britannia Creek onto the former road right-of-way resulted in a sudden and dramatic impact on fish habitat quality. Whereas the historical channel had a tortuous meander pattern, with deep, asymmetric pools along steep or undercut banks, the new roadway channel is mostly straight, shallow and uniformly steep with a large cobble bed and higher flow velocities (**Figure 4-5**). The historical channel, which was dynamically stable for decades to centuries, had regular sequences of riffles, runs and pools; the roadway channel is dominantly riffle-run habitat with few areas of refuge. The unstable roadway channel is expected to continue adjusting its pattern for decades, through irregular and locally severe bank erosion, until it re-adopts natural meander geometry. Logjams and a large, overbank gravel deposit are a testament to the continued instability of this roadway channel (**Figure 4-4**).

Figure 4-5. Downstream View of “Roadway” Channel of Lower Britannia Creek on Aug. 23, 2011

The compensation along lower Britannia Creek proposes to restore the lost, meandering habitat (Section 4.3.1.1), address the rarity of important overwintering habitat in the area (Section 4.3.1.2), and resolve upstream instabilities (Section 4.3.1.3).

4.3.1.1 Reinstatement of Historical Meandering Channel

At present, two distinct channels descend the gentle alluvial fan at the mouth of Britannia Creek: the mostly straight, roadway channel on the west side, which currently conveys all streamflow, and the dry, tortuously meandering historical channel on the east side (**Figure 4-4**). The reinstatement of the historical channel, which represents 13,643 m^2 of in-stream habitat and 116,940 m^2 of riparian habitat, will be accomplished in two main steps: restoration of natural morphology free of obstructions, and re-introduction of flow (**Drawing 1, Appendix A**). Since its abandonment several decades ago, the historical channel has become locally overgrown with saplings and has accumulated woody debris and organic matter on its bed (**Figure 4-6**). This material, which otherwise would form major obstructions to flow, will be selectively removed through manual labour and/or the use of small equipment (e.g., Bobcat). Channel banks will be restored at four small fords, where a trapper access road crosses the (dry) historical channel (**Figure 4-4**). Once the natural morphology of the channel has been restored, entirely "in the dry", flow will be gradually re-introduced during the waning stages of a freshet, when water in Britannia Creek and the Yukon River is already naturally turbid. This timing will minimize risk to downstream aquatic species and habitats. Further details, including the importance of conducting a fish salvage and release from the dewatered existing channel, are described below in Section 5.1.

Figure 4-6. Overgrown Historical Channel of Lower Britannia Creek

A permanent diversion berm is proposed at the divergence of the existing and historical channel in order to ensure in-stream and overbank flows are directed into the historical channel (**Drawing 2, Appendix A**). The existing channel will be filled and re-vegetated to avoid potential future reoccupation by floodwater. The bed of the historical channel is elevated slightly (<0.5 m) relative to the bed of the existing channel, which has degraded (down-cut) slightly in response to the reduction in channel length and steepening of its gradient. Therefore, a riffle will form at the entrance to the historical channel, at the downstream end of a pool in the existing channel. A vegetated setback of at least 5 m is proposed for the berm from the channel bank, in order to provide a buffer for flood attenuation.

The restored historical channel will have the same gentle profile and localized, mid-reach steepening as it did prior to abandonment several decades ago (Profile, **Drawing 1, Appendix A**). The existing, natural cross-sectional shapes are distinct for pools and riffles, as would be expected. Pools typically exhibit strong asymmetry, which promotes scour and undercutting along the outer banks of meanders and deposition of gravel and fine sediments in point bars along the inside of the bends (Typical Pool Section, **Drawing 1, Appendix A**). Riffles tend to be shallower, slightly wider and composed of cobbles; they increase dissolved oxygen levels in water, provide critical habitats for benthic invertebrates, and form local sites of hydraulic grade control (Typical Riffle Section, **Drawing 1, Appendix A**). Runs exist as transitional features at the downstream ends of riffles and upstream limits of pools, typically located at inflection points between successive meanders.

4.3.1.2 Groundwater-fed Pool

A lack of deep pools that provide in-stream or off-channel rearing habitat and overwintering refuge for fish has been identified as a key constraint on the productive capacity of fish habitat in the Project area and broader region (Section 2.3). The primary reason is that the climate is semi-arid and experiences long, cold winters, more so than any limitations of channel morphology. What little groundwater baseflow occurs during the winter months freezes to the channel bed in many areas, forcing fish to take refuge near the mouths of major tributaries or in the Yukon River itself. CMC has incorporated into its FHCP a design element that specifically addresses this habitat constraint: a groundwater-fed, backwater pool near the mouth of Britannia Creek (**Drawing 3, Appendix A**).

Critical to the success of a pool to provide overwintering habitat is an understanding of groundwater levels, flow patterns (upward or downward) and quality at potential pool sites. A groundwater/surface water specialist investigated lower Britannia Creek in September 2013, a time of seasonally low groundwater table, and determined important information on which the siting of the overwintering pool is based. It was determined that the groundwater table is generally 2 to 3 m below the bed of the historical channel of lower Britannia Creek, indicating that it was historically a “losing” reach; surface water infiltrated the substrate toward the groundwater table. An exception was identified in the final, significant meander upstream of the mouth of historical Britannia Creek, where groundwater seepage was observed maintaining several tens of centimetres of water depth in the channel (**Drawing 3, Appendix A**). A previous investigation during the summer of 2012 involved the excavation of test pits, and the subsequent water quality and temperature measurement of groundwater that filled their bottoms – in both summer and in winter, when covered by approximately 0.5 m of ice. Dissolved oxygen levels in the water beneath the ice cover in the test pits were determined to be low, in some cases approaching the tolerances of local fish species.

Based on multi-disciplinary and multi-year investigation, a strategy for providing overwintering habitat was developed. A 9,200 m^2 groundwater-fed, backwater pool is proposed to be excavated into the terrace formed by the historical alluvial fan of Britannia Creek, at the exact location of observed groundwater discharge in September 2013 (**Drawing 3, Appendix A**). The pond will be excavated up to 3 m below the observed groundwater table, in order to provide approximately 2.5 m of pool depth beneath a 0.5 m cover of ice. The pond shape and position relative to the channel is intended to mimic the natural form of an oxbow lake, situated adjacent to a meander (but separated by a terrace embankment). Water level in the pool will be controlled by groundwater table elevation during periods of baseflow, and otherwise by backwater from rainfall- or snowmelt-derived flows. Water quality within the pool will be maintained naturally by regular through-flow of creek water, which is able to enter the upstream end of the off-channel pool through a “leaky” bank composed of permeable cobble and gravel. The absence of an upstream *surface* water connection to the pool is a deliberate measure that will mitigate the risk of avulsion from the main channel to the off-channel pool. The single, downstream connection to the main channel, which will allow for fish migration in and out of the pool, will be narrow, to promote periodic flushing of any fine sediment that accumulates; deep as the main creek, to prolong and maintain a surface hydraulic connection to the main channel; and oriented with a downstream skew, to minimize its influence on local hydraulics and sediment transport in the main channel. The shoreline of the pool will be re-vegetated and punctuated by boulder-buttressed rootwads for habitat cover and diversity.

4.3.1.3 Channel Restoration at Historical Fords

Historical access roads for placer mining forded lower Britannia Creek and lowermost Canadian Creek at seven sites, in total (**Figure 4-3**). Four of the fords cross lower Britannia Creek, one crosses Canadian Creek just upstream of its confluence with Britannia Creek, and two cross Britannia Creek upstream of its confluence. All fords were formed historically, without regard for impacts to channel morphology and aquatic habitat, and are no longer required for access along the valley. The existing Barge Access Road is further elevated from the valley bottom, where no crossings of Britannia Creek are required, and has only one clear-span bridge over Canadian Creek. The abandoned fords represent sites of localized instability and sources of fine sediment.

CMC proposes to restore natural channel morphology and riparian vegetation at all seven fords, in order to reduce downstream sedimentation along the existing and historical channel (once flow is re-introduced) (**Drawing 4, Appendix A**). Ford restoration is a measure that does not yield significant gains in habitat area (only about 560 m^2), but it addresses a potential constraint on the success of the reinstatement of the historical meandering channel of lower Britannia Creek (Section 4.3.1.1). It also embodies the overall objective of restoring the channel and riparian vegetation along lower Britannia Creek. Ford restoration will be completed prior to re-introduction of flow into the historical channel (as outlined below in Section 5.1).

Ford sites were originally selected for convenience at riffles, where flow depths are shallowest, the bed is flattest, and substrates are supportive to vehicle traffic. Therefore, the typical restoration plan in **Drawing 4** (**Appendix A**) reflects the restoration of a riffle. Anomalously deep accumulations of bar sediment that deflects flows toward either bank will be removed and used to re-build natural bank morphology. Brush layers will be constructed in both banks in order to slow channel-edge velocities and promote bank stability through deep rooting. Once the natural dimensions of the channel are restored to match upstream and downstream sections, adjacent areas of floodplain will be replanted using live stakes of native willows.

4.3.2 Naturalized Airstrip Diversion Channel

As described above in Section 3.3.3, the diversion of a small, unnamed tributary of Dip Creek around the Project airstrip will be constructed in such a way that increases habitat area (4,753 m^2, compared to the existing 1,509 m^2) and enhances existing habitat quality and productivity. From its divergence upstream of the airstrip, the diversion channel will exhibit a sinuous pattern similar to its low-sinuosity, existing form (**Drawing 5, Appendix A**). A slight increase in sinuosity will be included in order to increase flow and habitat diversity. The channel will initially cross the middle of the gentle alluvial fan before entering an existing drainage path along the southern edge of the fan. Its average gradient will be approximately 2%. Pool-riffle morphology will be established on its bed, through the placement of gravel-cobble substrates and boulder groups along the straight riffle sections. Brush layers will be installed just below the tops of banks to promote bank stability and provide habitat cover. Root wads, embedded in the outer banks of meanders and secured with an anchor logs, will promote the formation of a scour pool at their bases. Sedimentation will be allowed to occur naturally along the gentle inner bank of the meanders, in the form of a point bar. Existing vegetation will be protected and preserved alongside the channel in order to provide high quality riparian cover with no lag time before establishment.

The existing channel will be filled and replanted upstream of the airstrip, in part to divert flows along the new channel course. Downstream of the airstrip, however, the channel will be allowed to fill in and re-vegetate naturally. Surface runoff from the airstrip will flow overland through dense ground vegetation, where it will gradually infiltrate, thereby avoiding potential effects on in-stream water quality. Specifications on the alignment, dimensions and construction of the airstrip diversion channel will be finalized during detailed design, given consideration to widespread shallow permafrost and the airstrip's position on an alluvial fan.

4.3.3 Chinook Project Contribution

The combined implementation of the four compensation measures described above in Sections 4.3.1.1 to 4.3.1.4 is predicted to result in greater gains than losses in habitat, but CMC proposes to complete additional compensation in order to ensure it achieves No Net Loss, allowing for the possibility that certain elements may not function as effectively as intended. CMC initially considered advancing other measures outlined in its original compilation of compensation opportunities (**Table 4-3**), but it prefers to develop and implement additional compensation measures that target the species that are in decline in the Yukon River watershed, are most valued by local First Nations communities (i.e., Chinook salmon), and have low risks of failure due to natural processes (e.g., channel migration) or anthropogenic activities (e.g., placer mining). Accordingly, CMC is in the process of consulting with SFN and Yukon-based organizations including the Yukon Salmon Sub-Committee and the Yukon River Panel to identify potential opportunities for off-site compensation specifically aimed at restoring, enhancing or creating Chinook habitat for the benefit of current and future generations.

CMC and its team are asking questions of these groups to better understand Chinook salmon spawner/migrant numbers as they enter Canada and head to this region. What is the quality of spawning habitat? What is the spawning success rate, and has this been changing in recent years? May juvenile or ocean characteristics be driving declining trends? Are there potential opportunities for data collection and scientific research designed to address significant knowledge gaps regarding fisheries productivity, such that fisheries management objectives or local restoration priorities may be established? Research in support of these questions could build on existing research and data collection programs and further enhance the understanding of Chinook population dynamics and stressors.

Organizations from outside Yukon have also expressed an interest in supporting a project that benefits Chinook salmon. Initial meetings with Pacific Salmon Foundation (PSF) identified the need for a better understanding of the stressors responsible for the decline in Chinook salmon populations in the Yukon River watershed, given that sufficient habitat is available to them. PSF noted that little funding has typically been available to support research on this topic. PSF indicated a potential interest in supporting a project that would investigate why Chinook salmon stocks are in decline and how best to counteract this decline. Genome BC is a research organization also interested in funding projects that will use genomics to better understand the health of Chinook salmon, their interactions with their environment and potential stressors that may impact Chinook productivity. CMC has discussed research opportunities with Dr. Scott Hinch (University of British Columbia), who is interesting in looking at the links between various stressors (riverine, ocean, climate, fishers) on physiological state, health, migration and spawning success. CMC and its consultant team believe that it is possible to examine some of this at a baseline level using some of the approaches mentioned (e.g., genomics) and linking these approaches with telemetry tracking to understand mechanisms of mortality and poor spawning (if these are indeed issues). Immediate next steps include putting together a small working group with representatives from PSF, Genome BC, DFO, CMC and other technical experts (e.g., Scott Hinch).

At the core of the Chinook Project Contribution, CMC commits to identifying, designing, constructing and monitoring at least 9,756 m^2 of new, enhanced or restored Chinook spawning and rearing habitat, with the option of introducing or re-introducing Chinook salmon to this habitat as appropriate. As discussed above, CMC is also exploring complementary measures, such as investments in data collection and scientific research related to maintaining or enhancing the productivity of commercial, recreational or Aboriginal fisheries. It is recognized that under the new changes to the *Fisheries Act*, such complementary measures may only comprise up to 10% of the required amount of offsetting and must take into account DFO's guiding principles. CMC recognizes that this form of commitment may be unconventional, but it is being made in light of recent opportunities identified in consultation with SFN and other organizations that would yield more valuable and lower-risk compensation than the lower-ranked opportunities identified in **Table 4-3**.

4.3.4 Riparian Habitat Compensation

Riparian vegetation, and the habitat it supports, helps maintain the productivity of adjacent and downstream fish habitat. Riparian habitat provides shading for cover, moderates fluctuations in water temperature, contributes allocthonous inputs, stabilizes banks and helps maintain overall channel morphology. Riparian habitat also has indirect value to fish habitat productivity by protecting water quality, temperature and stream hydrology, although these indirect values are more important in highly disturbed watersheds. In recognition of these important ecological functions, riparian habitat restoration, creation or enhancement is integrated into all proposed in-stream habitat compensation measures.

Table 4-4 summarizes the expected gains in riparian habitat that will be achieved through the implementation of the proposed compensation measures outlined in Sections 4.3.1 to 4.3.3. A 30 m buffer of riparian habitat is assumed to be gained in association with the reinstatement of the historical channel of lower Britannia Creek and the creation of the adjacent groundwater-fed pool because of anticipated utilization of the low-gradient, gravel-cobble bed tortuous meanders by Chinook salmon. This buffer also reflects the height and density of the existing riparian tree canopy. Narrower buffers of riparian habitat are assumed to be created in association with the other compensation measures.

Table 4-4. Summary of Riparian Habitat Compensation

Compensation Component	**Riparian Habitat Area (m^2)**	**Description**
Reinstatement of Lower Britannia Creek	116,940	Existing mature forest adjacent to historical channel (assumes 30 m buffer)
Groundwater-fed Pool near Britannia Creek Mouth	16,200	Existing mature forest and replanted shoreline embankments, with large woody debris structures, around perimeter of pool (assumes 30 m buffer)
Britannia Creek Ford Restoration	2,400	Replanted riparian vegetation with live willow stakes and brush layers, and native tree seedlings (assumes 15 m buffer)
Naturalized Airstrip Diversion Channel	57,030	Existing mature forest encompassing area of proposed naturalized channel diversion (assumes 15 m buffer)
Chinook Project Contribution	163,400	TBD in consultation with Selkirk First Nation, DFO and other organizations
Total:	**355,970**	**Represents 1:1 gain-to-loss ratio for riparian habitat along fish-bearing watercourses**

Full compensation for lost riparian habitat cannot be achieved solely through the fish habitat compensation measures outlined in Sections 4.3.1 and 4.3.2 for two main reasons. First, some impacts to riparian habitat are anticipated to occur without impact to adjacent in-stream fish habitat. For example, the abutments and approaches to clear-span bridges at new watercourse crossings along the access roads will impact riparian habitat but not in-stream habitat. Few to no opportunities for on-site or nearby compensation exist in the undisturbed (natural) watersheds, although these crossing areas will have fully stabilized and re-vegetated banks to ensure that water quality degradation from erosion and surface runoff does not occur. Second, the creation of the groundwater-fed pool (Section 4.3.1.2) does not provide the same opportunity for riparian habitat creation as would the buffer of a linear watercourse. The complete re-vegetation of its 540 m-long shoreline and incorporation of large woody debris structures will fully buffer the pool and provide the maximum benefit of riparian habitat to in-water habitat.

In the determination of requirements for riparian habitat compensation, consideration must also be given to the suitability and sensitivity of fish habitat supported by adjacent riparian habitat. The majority of impacts to riparian habitat are expected to occur within the upper Casino Creek watershed, alongside non-fish-bearing watercourses or reaches of creek rarely frequented by fish. The contribution of the riparian habitat in the upper Casino Creek watershed to adjacent and downstream fish habitat productivity would be relatively low, given that the overall level of disturbance in the watershed is very low to negligible. Along the high-elevation reaches, riparian trees and shrubs are low, sparse or absent, and terrestrial insects are less abundant; the potential for allocthonous inputs is low. In comparison, the contributions of riparian habitat to fish habitat productivity are anticipated to be much higher in association with the proposed compensation along lower Britannia Creek. Within this low-elevation reach, deciduous and coniferous trees are tall, forming a high, dense canopy that overhangs the historical channel, and terrestrial insects are more abundant.

In association with the original compensation option for placer restoration along lower Canadian Creek (Option 1, **Table 4-3**), consideration was given to widespread restoration of riparian vegetation. Restoration and enhancement of riparian habitat alongside the 4 km-long reach of lower Canadian Creek most severely impacted by placer mining could yield gains of more than 100,000 m^2. However, the aforementioned risk of disturbance or destruction of the riparian zone in association with future placer mining activity justifies not considering this opportunity further at this time. Additional riparian habitat compensation is proposed to be completed off-site, in association with the Chinook Project Contribution (Section 4.3.3), or through other opportunities identified in consultation with Selkirk First Nation and DFO.

4.4 Habitat Balance

A habitat balance has been prepared to summarize the predicted impacts to fish habitat from the Project and the predicted gains from proposed fish habitat compensation. **Table 4-5** provides a summary of the habitat balance between impacted in-stream fish habitat and proposed restoration, creation and enhancements of in-stream habitat. The total area of in-stream habitat impact, based on modeled losses of habitat area, where available (Section 3.2), is 18,956 m^2. The total area of proposed in-stream habitat compensation is 37,912 m^2. This 2:1 ratio of compensation habitat-to-lost habitat meets the FHCP objectives and aligns with DFO's No Net Loss policy. In addition to proposing greater gains than losses in the quantity of habitat, this FHCP proposes to compensate for impacts to relatively low quality habitat (e.g., upper Casino Creek) with the restoration, creation or enhancement of relatively high quality habitat (e.g., lower Britannia Creek).

Table 4-5. Habitat Balance Summary

In-stream Habitat Impacts		**In-stream Habitat Gains**	
Impact Site	**Area (m^2)[a]**	**Compensation Site**	**Area (m^2)**
Lower Britannia Creek "Roadway" Channel (diversion into historical channel)	2,384	Reinstatement of Historical Lower Britannia Creek	13,643
Upper Casino Creek Watershed (TMF)	10,600	Groundwater-fed Pool near Britannia Creek Mouth	9,200
Unnamed Tributary of Dip Creek (Airstrip)	1,509	Britannia Creek Ford Restoration	560
Lower Canadian Creek (flow reduction downstream of open pit)	299	Naturalized Airstrip Diversion Channel	4,753
Lower Casino Creek (flow reduction downstream of TMF)	3,157	Chinook Project Contribution	9,756
Dip Creek (flow reduction downstream of TMF)	1,001		
Nordenskiold River bridge (in-stream pier footprint)	6		
Total:	**18,956**		**37,912**

[a] *Footnotes below **Table 3-8** specify method by which each impact area was determined*

The compensation habitat created by the reinstatement of the historical channel of lower Britannia Creek is anticipated to be far better utilized by Chinook salmon and Arctic grayling than the existing roadway channel, which is why its full channel area (length times average width) is represented in the compensation totals. Field observations of the distribution and extent of pools along the existing, tortuous meanders indicate that 30 to 35% of the historical channel is estimated to comprise pool habitat, which was determined to be the primary limiting factor in the productive capacity of habitat for Arctic grayling in the existing roadway channel. The roadway channel's 8% areal coverage of pools is a significant limitation on Arctic grayling productivity, given their preference for more than 30% pool habitat (Hubert et al., 1985). Whereas the historical channel represents a mixture of pool, riffle and run habitats, the existing roadway channel exhibits long, relatively steep riffle sections. In addition, the historical channel has more diverse substrates, including gravels, and abundant areas of velocity refuge in association with functional, in-stream large woody debris and back-eddies along the inside of meanders.

The deep, groundwater-fed pool with woody habitat structures has a surface area of approximately 9,200 m^2, which represents newly created habitat targeting rearing and overwintering of Chinook salmon and Arctic grayling. The restoration of the channel bed and banks at each of the seven abandoned fords is expected to once again promote fish utilization of these impacted sites, which average about 11.5 m long and 7 m wide (i.e., 560 m^2 total restored habitat). The diversion of the existing unnamed tributary of Dip Creek around the proposed airstrip provides the opportunity to increase in-stream habitat through a slight increase in length (1,509 m, compared to 1,006 m along the existing tributary) and minor channel widening (2.5 m instead of existing 1.5 m), to ensure natural bank stability.

The Chinook Project Contribution is proposed to benefit the species of fish with the highest socio-economic, cultural and economic values for First Nations, communities and the Yukon public. Yukon River Chinook salmon populations have declined for over a decade and spawning escapement objectives have not been met in most years recently (Joint Technical Committee, 2013). Although the details of the Chinook Project Contribution remain to be determined in consultation with Selkirk First Nation, DFO and other management agencies including the Yukon River Panel and the Yukon Salmon Sub-Committee, the commitment is made to increase the productive capacity of Chinook salmon habitat in Yukon through the development of at least 9,756 m^2 of new, restored or enhanced habitat.

An area for area accounting of riparian habitat losses and gains is not necessarily appropriate, given that all in-stream habitat compensation will incorporate riparian buffers to ensure full productivity. Based on such an area by area accounting, however, more than half of riparian habitat losses alongside fish-bearing streams are proposed to be compensated for through the four main compensation components (**Table 4-4**). The remaining portion of the losses could be compensated for if necessary through riparian plantings and habitat enhancement alongside impacted watercourses utilized by Chinook, based on opportunities identified through the Chinook Project Contribution.

5 Implementation Strategy

5.1 Timeline and Construction Phasing

The timing of proposed compensation relative to proposed impacts (HADDs) is an important consideration, given its determination of the potential for a temporal loss of productive capacity within the affected watersheds. As shown in **Figure 4-1**, compensation measures are proposed to be implemented before or in conjunction with habitat impacts. The intention is to provide the greatest opportunity possible for compensation measures to become fully functional, providing the designed benefits to aquatic ecosystems, prior to project impacts. All compensation works will be completed at the commencement of project construction. All impacts will occur during the construction phase of the Project, except for the minor impacts to lower Canadian Creek, which are not anticipated to occur until project closure (Years 23-25) when flows from upper Canadian Creek are allowed to drain into the open pit.

Another important consideration in compensation planning is the phasing, or sequencing, of construction of the compensation measures. The proposed habitat restoration and enhancement measures will be completed in accordance with the applicable “reduced risk timing window” for in-water work, as established by DFO. This will minimize risk to Chinook salmon, Arctic grayling and other local fish species during activities within the channel and adjacent riparian zones. All channel works will be completed “in the dry”, either by conducting work along sections of channel that are dry or completely frozen (preferred) or by isolating the work area from flowing water. The channel restoration and enhancement works will be completed as efficiently as possible, thereby minimizing the period during which a portion of habitat is isolated from the adjacent channel.

The following sequence is proposed for the completion of the four main elements of compensation, demonstrating to DFO the feasibility of protecting fish and fish habitat during their implementation:

1. **Britannia Creek Ford Restoration** – Restoration of the fords will completed at or prior to project construction commencement, in order to stabilize and restore the banks to reduce downstream sedimentation. Coffer dams will be placed in the channel to isolate one half of the channel at a time, while allowing flow to continue in the other half. Any fish that become stranded in the isolated work area will be captured, identified and released upstream by a qualified fisheries technician with a collection license. Anomalous mounds of sand and gravel will be removed from the channel and used in the reconstruction of the channel banks. Once one side is complete, work will be completed on the other side of the channel in the same manner, with the same precautions for the protection of local and downstream habitat.

2. **Groundwater-fed Pool near Britannia Creek Mouth** – Erosion and sediment control measures will be established around the work area, with particular attention given to the installation of perimeter sediment controls adjacent to the (dry) historical channel. Trees will be felled and stockpiled for subsequent use in large woody debris structures. Ground vegetation will be stripped, and organic-rich topsoils will be salvaged for later placement on upper pond embankments. Excavation will be completed beginning at the centre of the pool area, gradually

working outwards toward the shore area, allowing groundwater to naturally seep in and fill the bottom of the excavation. Excavated material will be stockpiled within sediment control perimeters in a location away from any water features, for later use in fill of the existing, roadway channel. The 'leaky' bank will be created, following isolation of the historical channel using a small coffer dam. The narrow connector channel to the main creek will be excavated to its downstream end, which will be abutted by a coffer dam. The pool will only be connected to the historical channel once it has been successfully brushed out and restored.

3. **Reinstatement of Historical Britannia Creek Channel** – The restoration of the historical channel is proposed to be completed through the following steps:

   i. Isolate historical (dry) channel by blocking upstream and then downstream ends with coffer dams.

   ii. Conduct a fish salvage, if necessary, from any remnant pools especially at the lower end of the channel near the Yukon River. After recording the fish species, release them into the Yukon River.

   iii. Selectively remove woody debris that does not have an important, well-established ecological role (including any existing logjams), in order to minimize channel obstructions during reintroduction of flow.

   iv. Remove the downstream and then upstream coffer dams within the historical channel.

   v. During the waning stages of a freshet (if preferred by DFO), when turbidity is still naturally high, divert a small portion of the flow (e.g., 10-20%) from the existing Britannia Creek roadway channel into the historical channel, by temporarily placing appropriately sized rip-rap on the existing channel bed to form a riffle immediately downstream of the slightly raised entrance to the historical channel. Allow the back-water formed upstream of the artificial riffle in the existing channel to spill into the historical channel. Station field crews along the historical channel to monitor the reintroduction of flow and inhibit the formation of woody debris jams, by manually disaggregating and removing accumulations of debris as they form.

   vi. Incrementally and gradually (over a period of a few days) raise the height of the riffle with additional rip-rap, each time diverting a greater portion of flow into the historical channel. Field crews should continue to discourage logjam formation. Continue raising the riffle until all of the flow (100%) has been diverted into the historical channel.

   vii. Install a coffer dam immediately downstream of the artificial riffle, in order to inhibit throughflow and allow the roadway channel to passively dewater to its mouth.

   viii. Conduct a fish salvage from remnant pools, walking downstream along the entire length of the straight reach to the Yukon River. After recording the fish species, release in Britannia Creek upstream of the flow diversion (or into Yukon River, whichever is closer).

   ix. Construct a permanent flow diversion earth berm, armoured on its upstream face and ends with rip-rap, set back at least 5 m from the coffer dam.

   x. Install a coffer dam along the upstream edge of the artificial riffle.

xi. Remove the coffer dam from the downstream side of the artificial riffle, then re-distribute the rip-rap forming the riffle along the toe of the diversion berm, and fill the former channel to its tie-in with the surrounding floodplain and bank of the reinstated historical channel.

xii. Remove the coffer dam that was built along the upstream edge of the riffle.

4. **Naturalized Airstrip Diversion Channel** – Erosion and sediment control measures will be established along the length of the proposed corridor for the diversion channel, and at the proposed divergence from the existing channel. Trees will be felled and stockpiled for subsequent use in large woody debris structures. The channel will be excavated according to design criteria, with stones placed at specified locations to create riffles and root wad structures embedded in the outer banks of meanders. Excavated material will be stockpiled within sediment control perimeters in a location away from any water features, for later use in fill of the existing channel upstream of the airstrip, or off-site use or disposal. A temporary coffer dam will be installed at the point of divergence, directing flow into the newly excavated and restored channel. A fish salvage will be completed along the naturally dewatered existing reach downstream of the divergence, before filling of the portion upstream of the airstrip. The coffer dam will be removed once the existing channel has been filled and stabilized.

5.2 Erosion and Sediment Control

An erosion and sediment control (ESC) plan will be developed as part of an overall environmental management plan, prior to initiation of habitat compensation activities as a basis for protecting aquatic and riparian ecosystems during construction of habitat restoration, creation and enhancement measures. The plan will focus on controlling surface run-off and minimizing the extent and duration of exposed soils, in order to inhibit erosion and sedimentation along any watercourses. The plan will reflect best management practices as outlined in *Best Management Practices for Works Affecting Water in Yukon* (Environment Yukon, 2011) to fulfill Section 36(3) of the *Fisheries Act* and Section 9(1) of the *Yukon Waters Act*, which prohibit the deposit of any waste (i.e., any substance that is detrimental to people, animals, fish or plants), including sediment, into any water body. In addition to detailing all physical ESC measures, the plan will specify the necessary frequency of inspection, relative to key construction activities, weather conditions and site-specific environmental conditions. Inspection should be completed regularly during the construction process to ensure that ESC measures are functioning as intended and to provide for the timely cleaning, repair and ultimate removal of ESC measures.

The appropriate combination and distribution of ESC measures will be finalized during detailed design and specified on the ESC plan. All measures will be in place and operational prior to construction commencement. Key details of the plan may include, but not be limited to, the following:

- Strategies for preventing off-site water from entering the work area, and for managing on-site water;
- Erosion control strategies, including techniques, materials and installation methods;
- Sediment control strategies, including techniques, materials and installation methods;
- Delineation of areas of greatest ecological risk;

- Site restoration and re-vegetation prescriptions;
- Locations for storing and refueling all equipment (>30 m from any water feature);
- Contingency plans for unforeseen high flow events; and
- Monitoring program details.

5.3 Monitoring and Adaptive Management

In accordance with DFO's (2013a,b) guidelines, two main types of monitoring will be conducted to ensure the success of this FHCP: *construction monitoring* and *effectiveness monitoring*. Adaptive management is the process of promptly responding to and alleviating any identified deficiencies or failures in compensation works, based on the results of monitoring.

The purpose of *construction monitoring* is to minimize risks to fish and fish habitat during implementation of the compensation works. An environmental monitoring technician will be on-site throughout the period of in-water work to document compliance with all environmental protection measures and inspect and report on all ESC measures. It is recommended that field inspections be conducted periodically before and during construction to document and photograph site conditions associated with channel and bank restoration activities, diversion berm construction, pool excavation, and airstrip diversion channel creation. The field inspections should be conducted at least once prior to construction and weekly during the construction period. Photographs should be collected from the same vantage point and with the same field of view to allow for time series comparison. A qualified professional with experience in the supervision of channel restoration projects (e.g., fluvial geomorphologist, habitat restoration specialist) will visit the site at critical times during construction to ensure all elements of compensation works are completed according to design specifications, and to assist with field-fit modifications, where required.

Key elements of construction to supervise include, but are not limited to, the following:

- Implementation of functional erosion and sediment control measures, including flow by-pass measures;
- Removal of existing vegetation within, and protection of vegetation in close proximity to, the works area and access route;
- Establishment of key profile (elevation) points and channel dimensions;
- Installation of habitat cover features (e.g., root wads, boulders, brush layers, live stakes); and
- Construction of transitions to the upstream and downstream tie-in points.

Detailed as-built surveys and drawings should be completed immediately following construction by the contractor in consultation with the habitat design consultant.

The purpose of *effectiveness monitoring* is to ensure that compensation measures are functioning as designed, providing an opportunity for adaptive management where necessary, and to assess their effectiveness at achieving No Net Loss over the long-term. A monitoring program will be established that focuses on the biological effectiveness of compensation works. It will incorporate measurements of channel morphology and fish habitat features, monitoring of water quality and sampling of fish communities. The condition of riparian vegetation will be assessed, most frequently during the first year following planting. Maintenance may include selective irrigation, removal of invasive species, documentation and replacement of unsuccessful plantings, stabilization of erosion sites and identification and mitigation of animal intrusion or damage. The general schedule of post-construction monitoring consists of several key events:

- Seasonal assessments of physical and biological aspects of compensation during the first year following construction (four assessments), including immediately after freshet;
- Winter assessments of overwintering fish use of the groundwater-fed pool and mouth of the reinstated historical Britannia Creek; and
- Summer assessments of fish use in all compensation elements.

A specific trigger-response action plan will be established during detailed design in order to standardize how and when follow-up to particular identified conditions should be completed. This will allow remedial or adaptive measures to be taken at an appropriately early time.

5.4 Cost Estimate

An approximate cost estimate for implementing the FHCP is $3.2 million. **Table 5-1** provides the estimated cost breakdown for each of the five elements of compensation.

Table 5-1. Estimated Habitat Compensation Costs

Compensation Element	Materials	Labour	Indirect[1]	Monitoring[2]	Contingency[3]	Total Cost
Reinstatement of Historical Lower Britannia Creek	$18,000	$289,000	$123,000	$43,000	$142,000	$615,000
Groundwater-fed Pool near Britannia Creek Mouth	$30,000	$679,000	$283,000	$99,000	$327,000	$1,418,000
Britannia Creek Ford Restoration	$6,000	$30,000	$15,000	$5,000	$17,000	$73,000
Naturalized Airstrip Diversion Channel	$14,000	$31,000	$18,000	$6,000	$21,000	$91,000
Chinook Project Contribution[4]	TBD	TBD	TBD	TBD	TBD	$1,000,000
Total:	**$68,000**	**$1,029,000**	**$439,000**	**$154,000**	**$507,000**	**$3,197,000**

[1] Includes engineering costs, construction management, mobilization/freight, etc. (assumed 40% of direct materials and labour cost).

[2] Includes construction monitoring and effectiveness monitoring (assumed 10% of materials, labour and indirect costs).

[3] Assumed 30% of materials, labour, indirect and monitoring costs.

[4] Assumed approx. $1,000,000 total cost based on area in comparison to other compensation elements.

Several important opportunities for cost savings accounted for in the tabulated estimates warrant acknowledgment:

- The historical channel of lower Britannia Creek already exists; no excavation is required, only selective removal of non-functional woody debris.
- All fill required in the construction of the earth diversion berm and filling of the existing straight channel of Britannia Creek can be sourced locally, mainly in association with the excavation of the groundwater-fed pool. Similarly, fill required in association with the airstrip diversion channel will be locally sourced during channel excavation.
- Large woody debris, boulders, spruce seedlings and topsoil to be used in channel and pool shoreline restoration can be sourced locally, mainly in association with the excavation of the groundwater-fed pool.
- Heavy machinery will be on site for construction of the mine facilities and will not require separate transport to and from compensation areas.

5.5 Uncertainties and Next Steps

The success of habitat restoration and enhancement projects depends, in part, on the identification of uncertainties and strategies for their management. Key uncertainties and their management are outlined below:

- **Uncertainty in the feasibility of the compensation** – The preliminary designs included in this FHCP have been prepared by multi-disciplinary teams, leveraging past experience on other similar habitat compensation projects. During detailed design, more comprehensive, site-specific topographic and geomorphic information will be collected to support the development of construction drawings and specifications.
- **Uncertainty in the quantity and quality of proposed compensation habitats relative to impacted habitats** – This FHCP proposes net gains in habitat, with a compensation ratio of 2:1 for in-stream habitat, in order to allow for the possibility that certain elements of the compensation may not fully function as intended. In addition, proposed compensation habitats generally have higher ecological value than impacted habitats, given an emphasis on addressing known limitations to the productive capacity of local habitats.
- **Uncertainty in the timeframe over which the benefits of compensation will be realized** – Many of the compensation habitats proposed in this project will take advantage of existing, mature riparian vegetation, thereby minimizing the period before which habitat is fully functional. Also, compensation work will be completed before or in conjunction with occurrence of the HADDs.

Hydrological, geomorphological and biological data have been collected over a period of several years to support the preparation of this FHCP. The level of detail provided is commensurate with that required by DFO and other review organizations to confirm the feasibility and appropriateness of the compensation measures outlined above. Additional information is still required to support detailed design and permitting in association with the FHCP.

In order to meet its target 2:1 compensation ratio for in-stream habitat, CMC has committed to restoring, creating or enhancing at least 9,756 m^2 of Chinook salmon habitat. It is currently in discussion with SFN and organizations with an interest in supporting Chinook salmon projects, including the Yukon Salmon Sub-Committee, about the best candidate sites for this Chinook Project. CMC looks forward to identifying the preferred option to implement in consultation with DFO.

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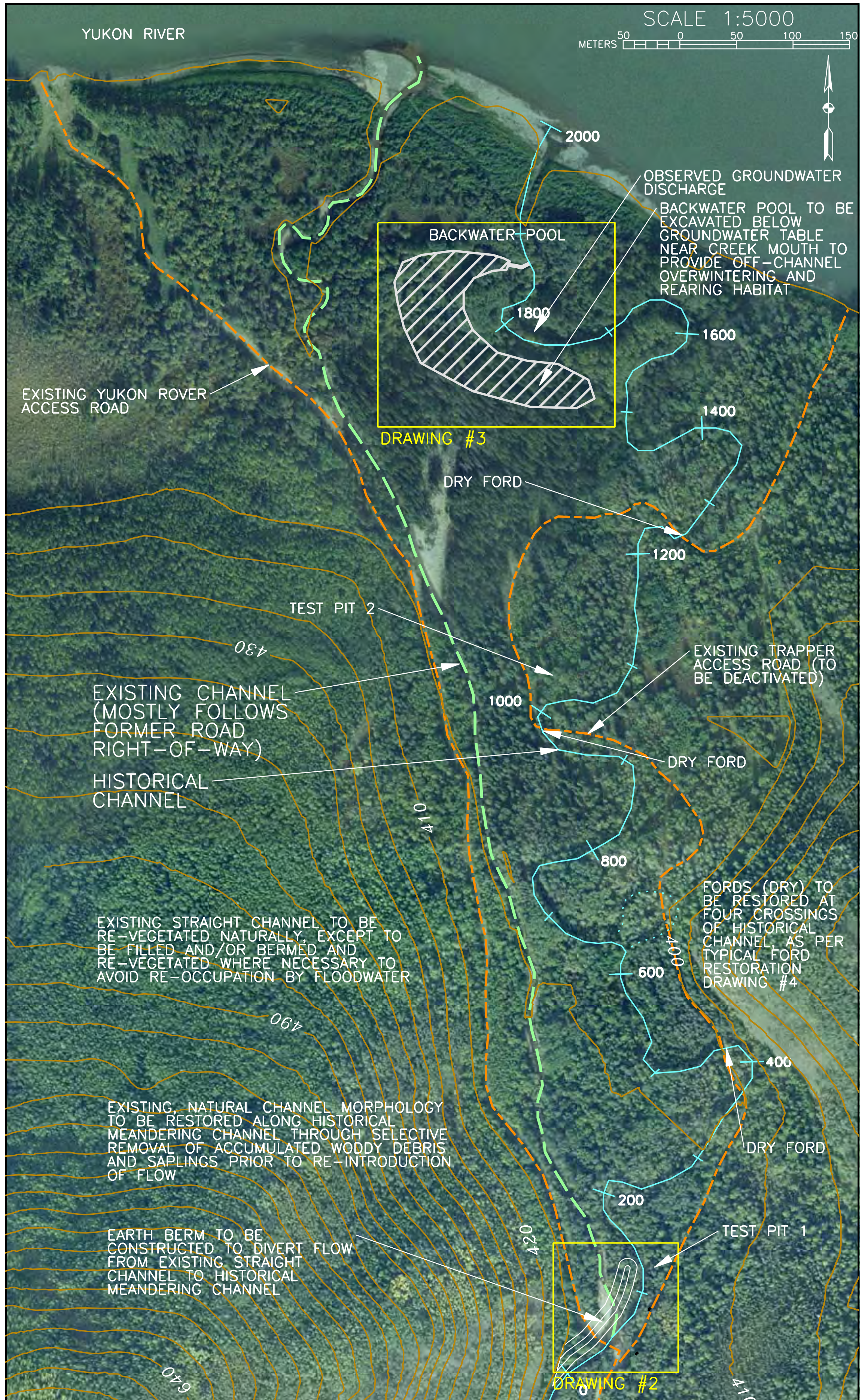
Appendix A

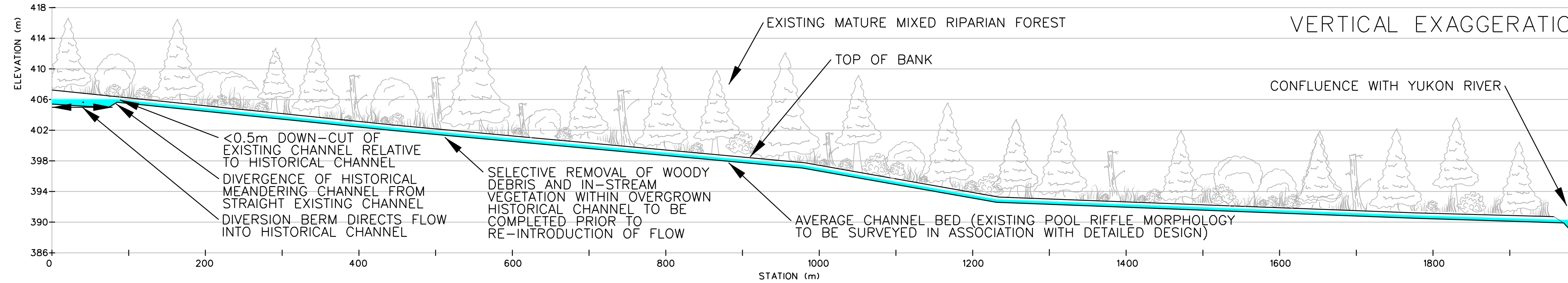
Fish Habitat Compensation Preliminary Design Drawings

- **Drawing 1 – Lower Britannia Creek Compensation Overview**
- **Drawing 2 – Lower Britannia Creek Diversion Berm**
- **Drawing 3 – Groundwater-fed Backwater Pool**
- **Drawing 4 – Typical Channel Restoration at Abandoned Fords**
- **Drawing 5 – Naturalized Airstrip Diversion Channel**

PLAN-LOWER BRITANNIA CREEK



PROFILE-HISTORICAL MEANDERING CHANNEL



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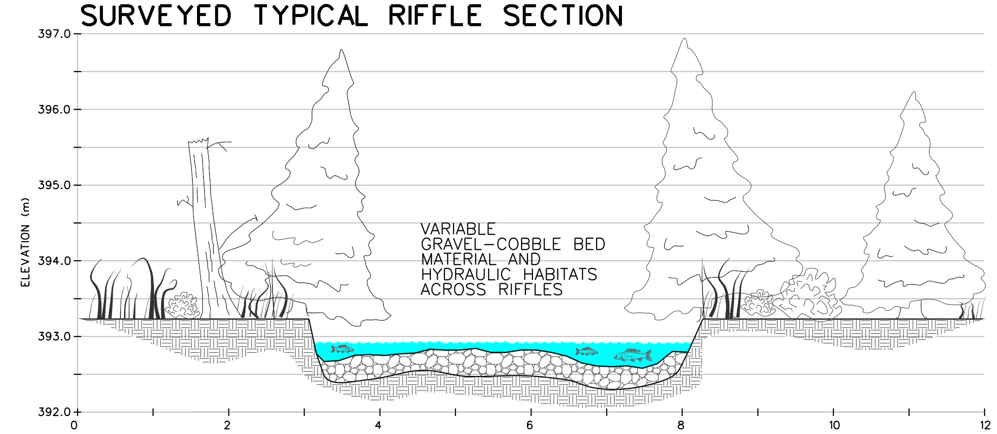

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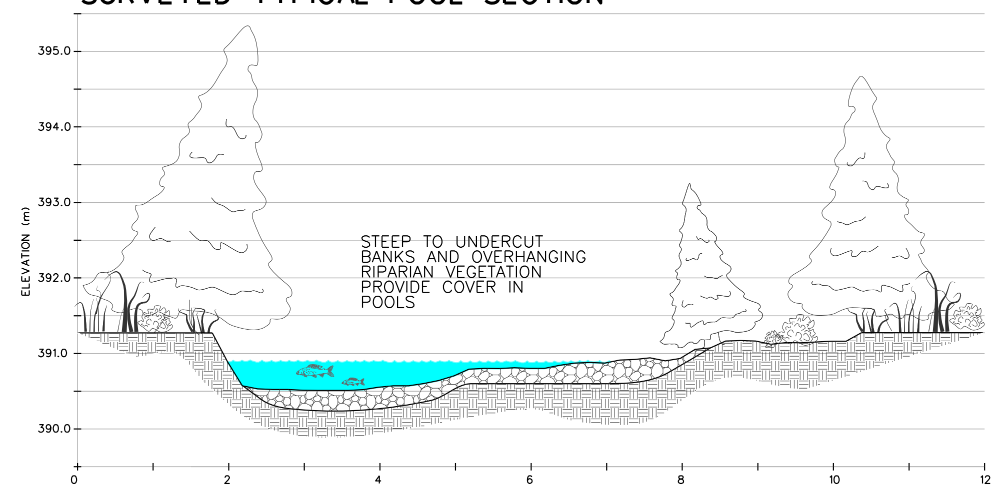

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DESIGN BY PALMER ENVIRONMENTAL CONSULTING GROUP INC.
DESIGN REVIEW AND DRAFTING BY GRECK AND ASSOCIATES LIMITED.

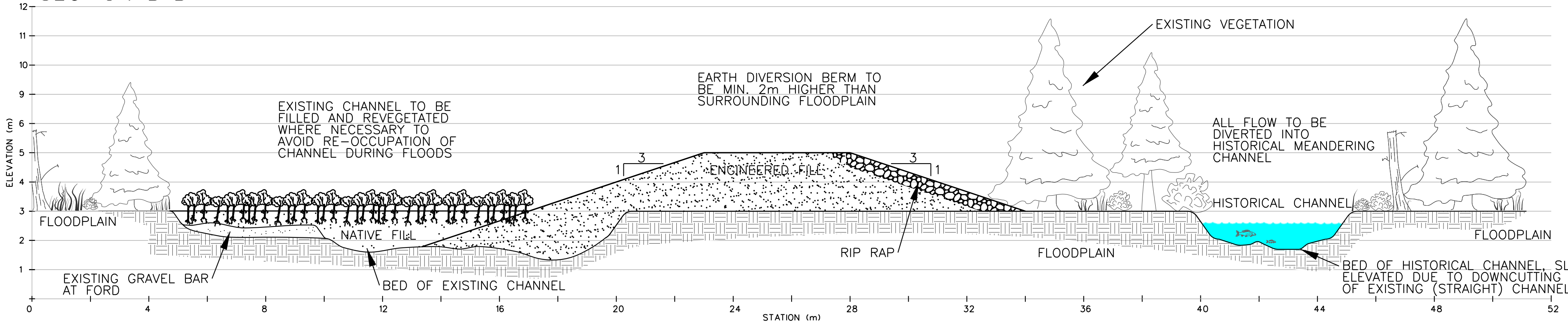
DATE	REVISION	BY
9/25/2013	DRAFT FOR REVIEW	E.G.
10/3/2013	FINAL FOR SUBMISSION	E.G.

LOWER BRITANNIA CREEK
COMPENSATION OVERVIEW
CASINO PROJECT

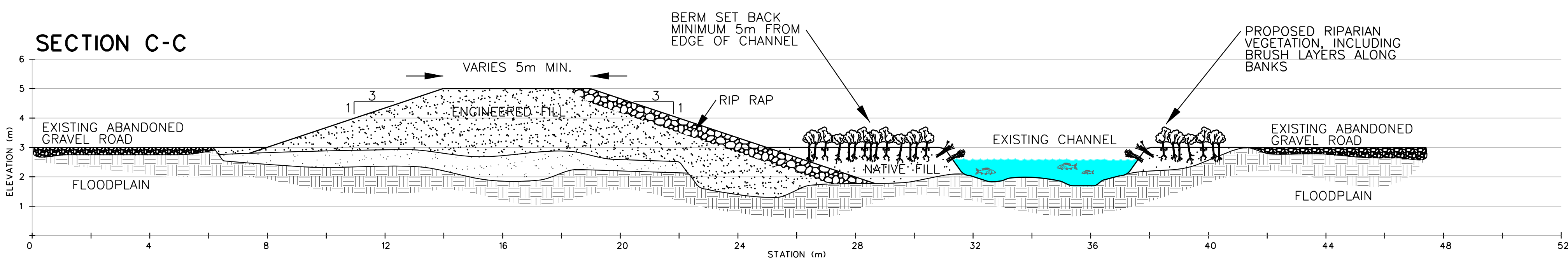
PRELIMINARY DESIGN

DATE: SEPTEMBER 25TH, 2013	DESIGN BY E.G.	CHKD. BY B.G.	APPD. BY R.M.
SCALE	AS SHOWN	DRAWING NO. 1	
		SHEET NO. 1	

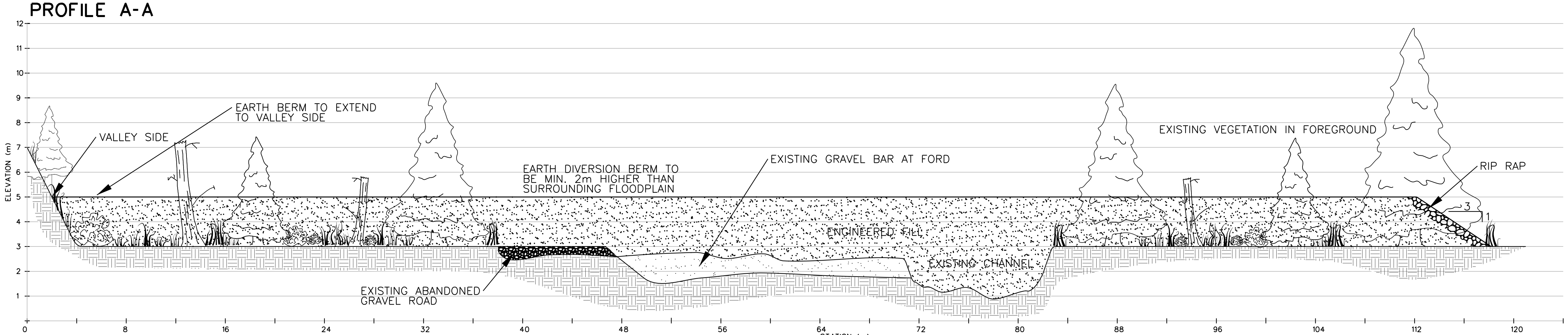
SECTION B-B



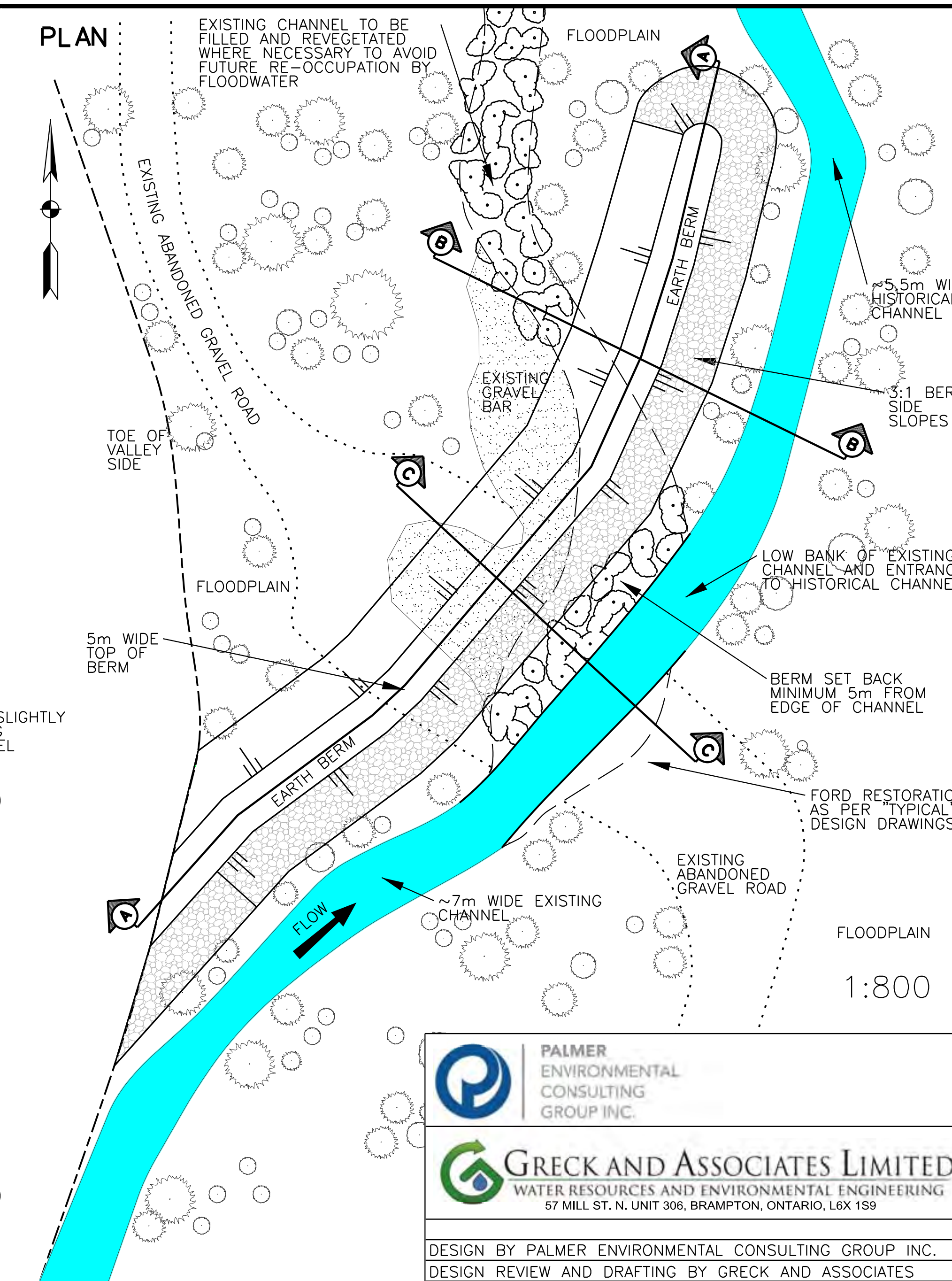
SECTION C-C



PROFILE A-A



PLAN



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DESIGN BY PALMER ENVIRONMENTAL CONSULTING GROUP INC.
DESIGN REVIEW AND DRAFTING BY GRECK AND ASSOCIATES LIMITED.

DATE	REVISION	BY
9/14/2013	DRAFT FOR REVIEW	E.G.
10/3/2013	FINAL FOR SUBMISSION	E.G.

LOWER BRITANNIA CREEK DIVERSION BERM

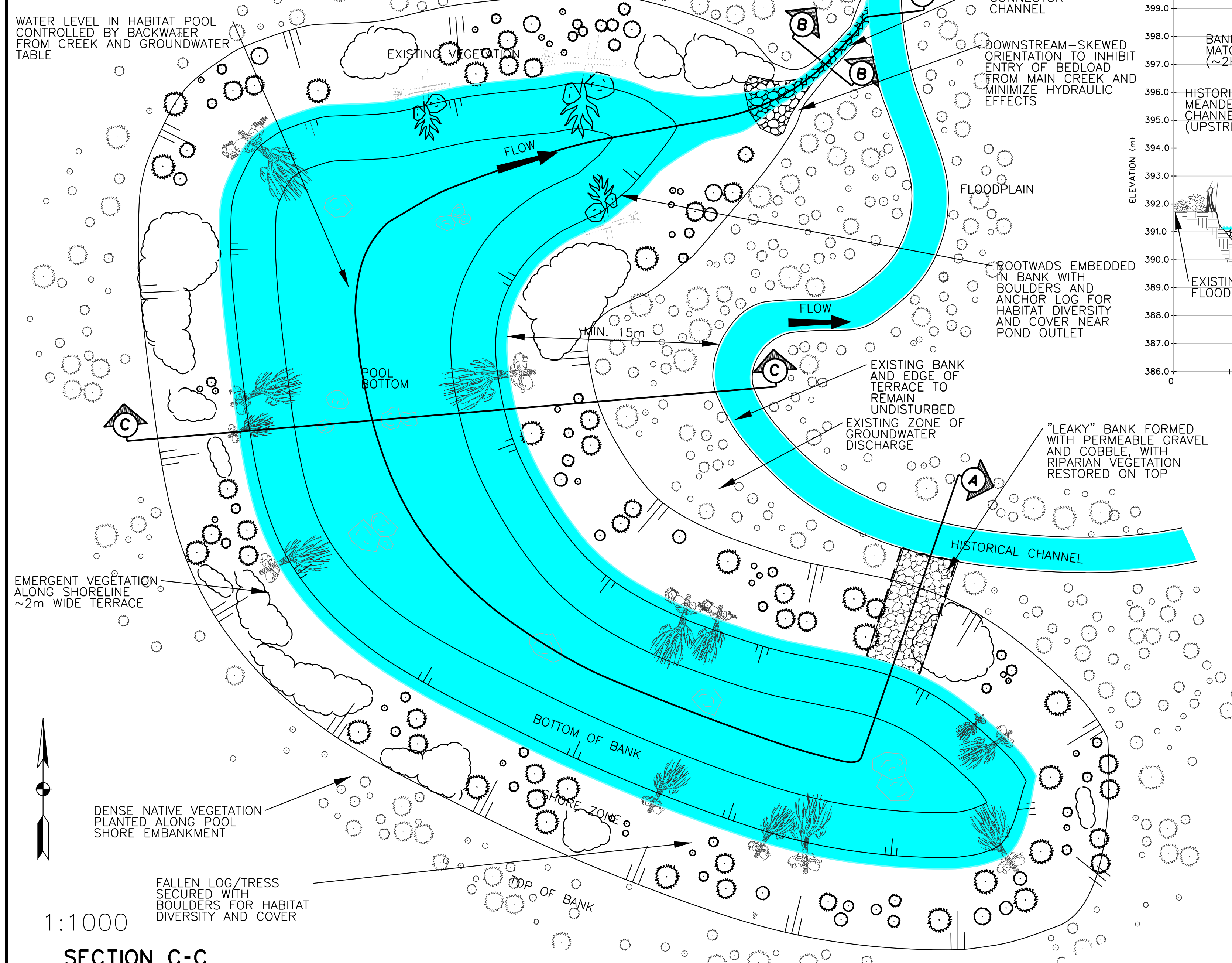
CASINO PROJECT

PRELIMINARY DESIGN

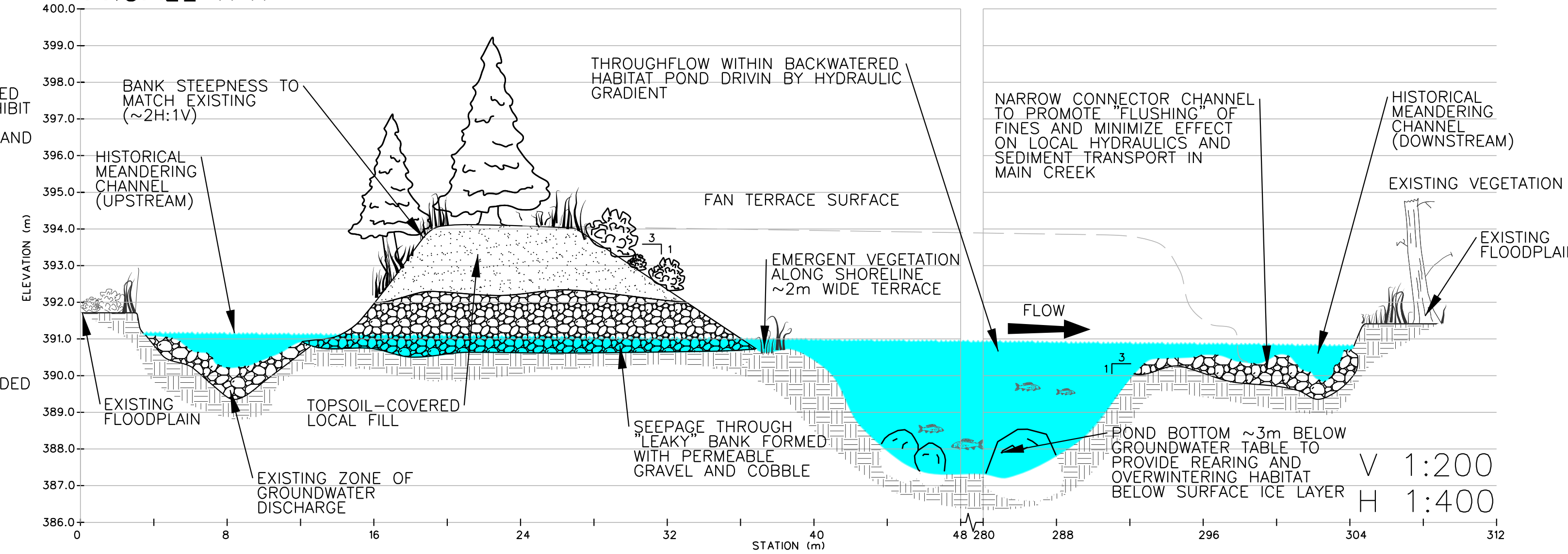
DATE: SEPTEMBER 14TH, 2013	DESIGN BY E.G.	CHKD. BY B.G.	APPD. BY R.M.
SCALE	AS SHOWN	DRAWING NO. 2	
		SHEET NO. 1	

PLAN

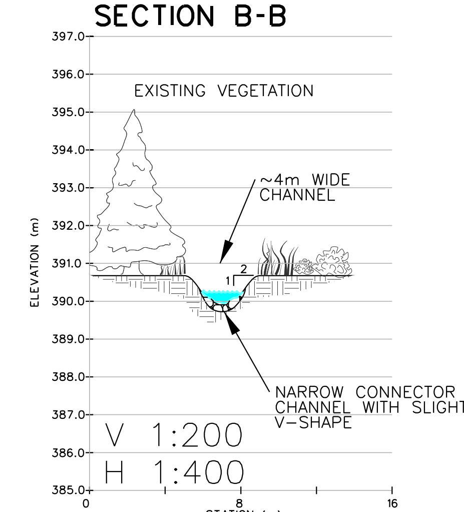
REFER TO DRAWING 1 FOR POOL LOCATION



PROFILE A-A



SECTION B-B



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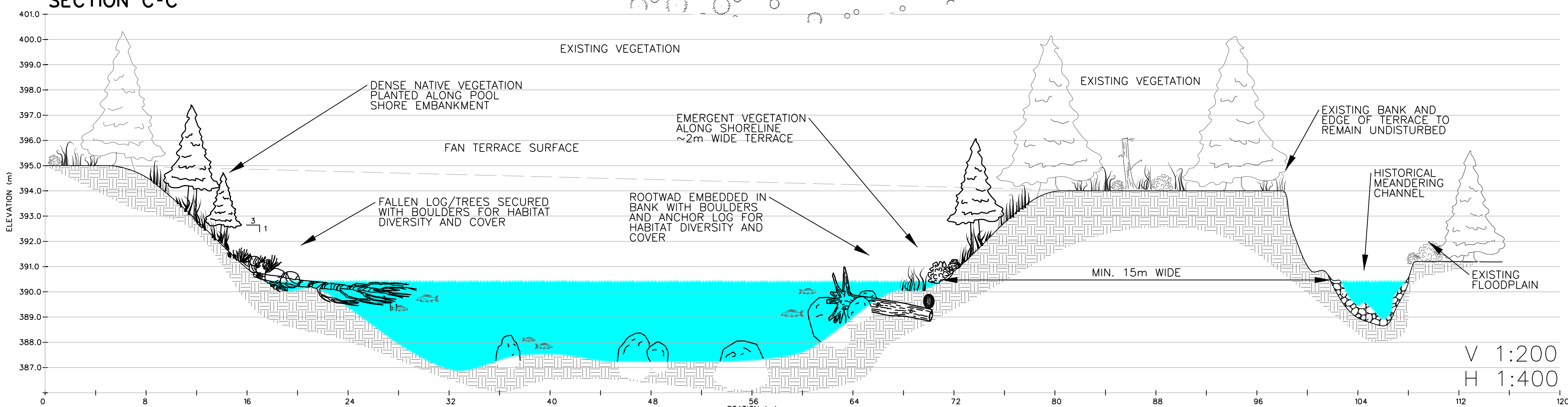

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GRECK AND ASSOCIATES LIMITED
WATER RESOURCES AND ENVIRONMENTAL ENGINEERING
57 MILL ST. N. UNIT 306, BRAMPTON, ONTARIO, L6X 1S9

DESIGN BY PALMER ENVIRONMENTAL CONSULTING GROUP INC.
DESIGN REVIEW AND DRAFTING BY GRECK AND ASSOCIATES LIMITED.

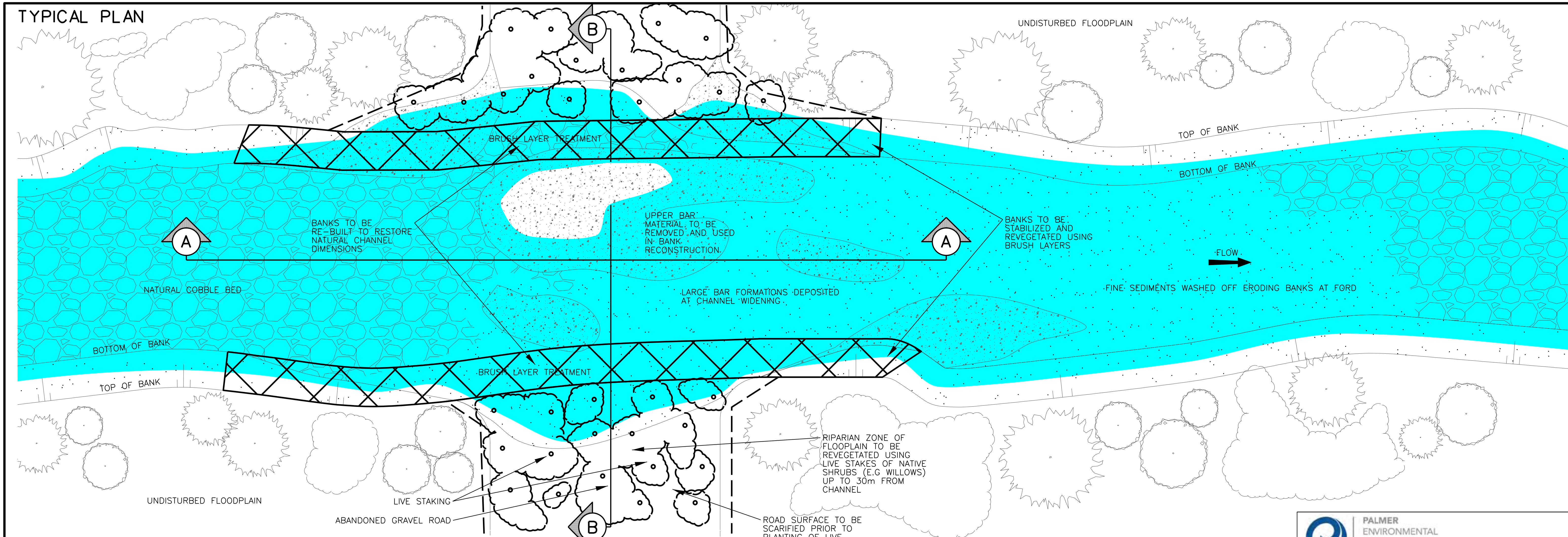
DATE	REVISION	BY
9/25/2013	DRAFT FOR REVIEW	E.G.
10/3/2013	FINAL FOR SUBMISSION	E.G.

GROUNDWATER–FED BACKWATER POOL
CASINO PROJECT

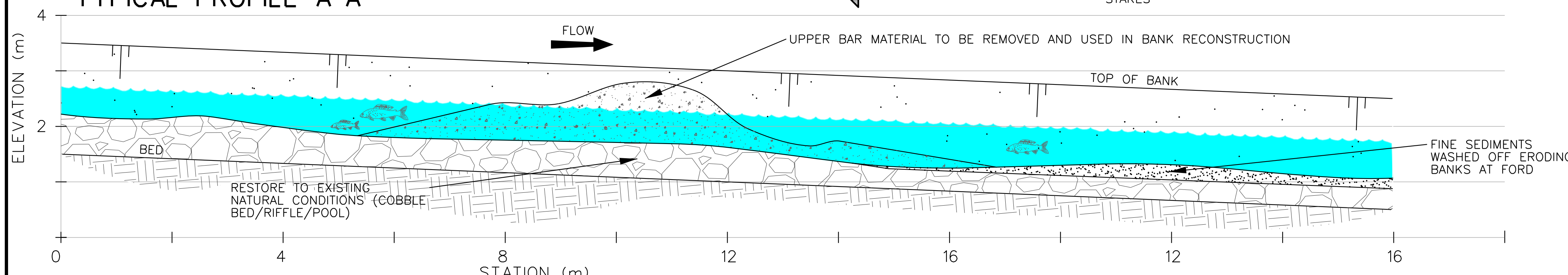
PRELIMINARY DESIGN

DATE: SEPTEMBER 25TH, 2013	DESIGN BY E.G.	CHKD. BY B.G.	APPD. BY R.M.
SCALE	AS SHOWN	DRAWING NO. 3	
		SHEET NO. 1	

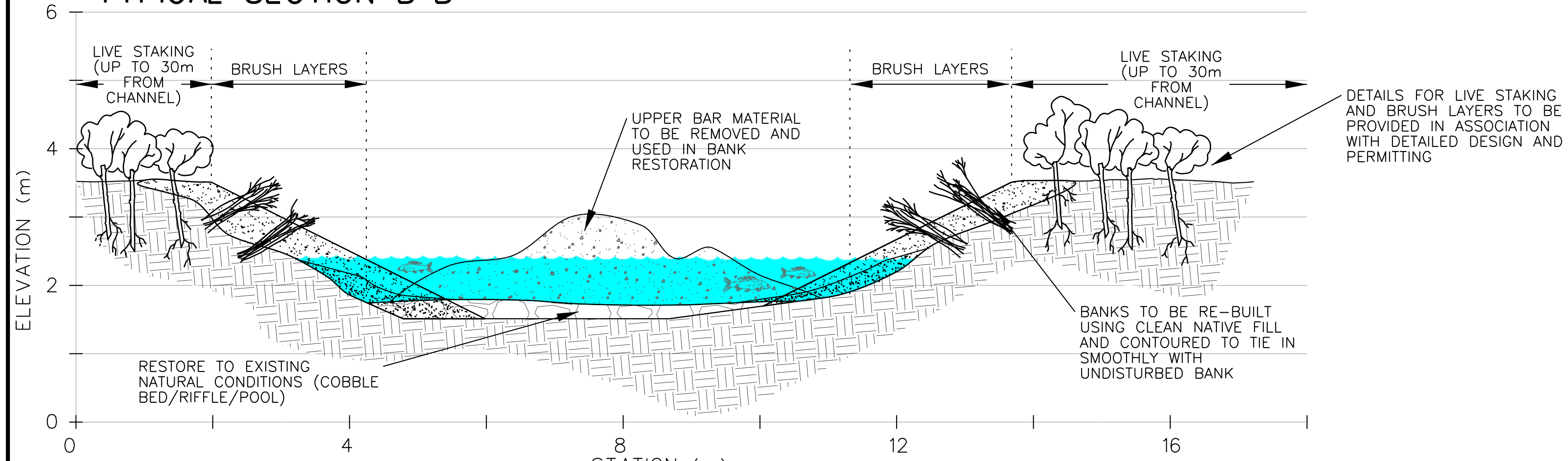
TYPICAL PLAN



TYPICAL PROFILE A-A



TYPICAL SECTION B-B



REFER TO FIGURE 4-3 FOR LOCATIONS OF ABANDONED FORDS TO BE RESTORED

PALMER ENVIRONMENTAL CONSULTING GROUP INC.

GRECK AND ASSOCIATES LIMITED
WATER RESOURCES AND ENVIRONMENTAL ENGINEERING
57 MILL ST. N. UNIT 306, BRAMPTON, ONTARIO, L6X 1S9

DESIGN BY PALMER ENVIRONMENTAL CONSULTING GROUP INC.
DESIGN REVIEW AND DRAFTING BY GRECK AND ASSOCIATES LIMITED.

DATE	REVISION	BY
8/12/2013	DRAFT FOR REVIEW	E.G.
11/6/2013	FINAL FOR SUBMISSION	E.G.

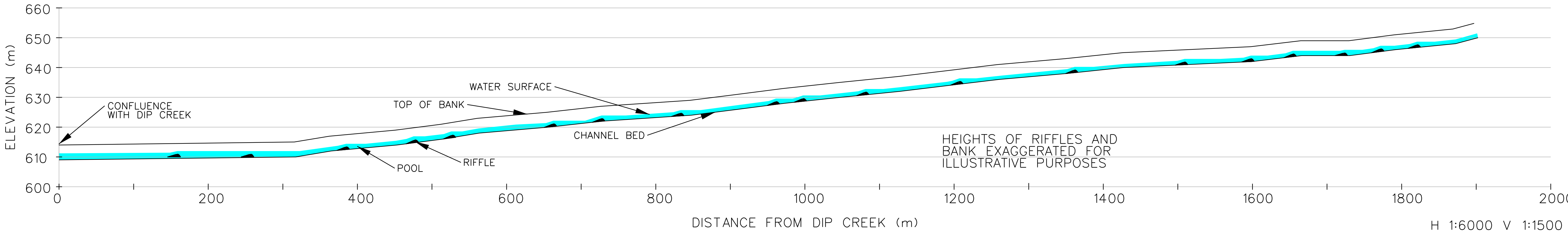
TYPICAL CHANNEL RESTORATION AT ABANDONED FORDS

CASINO PROJECT

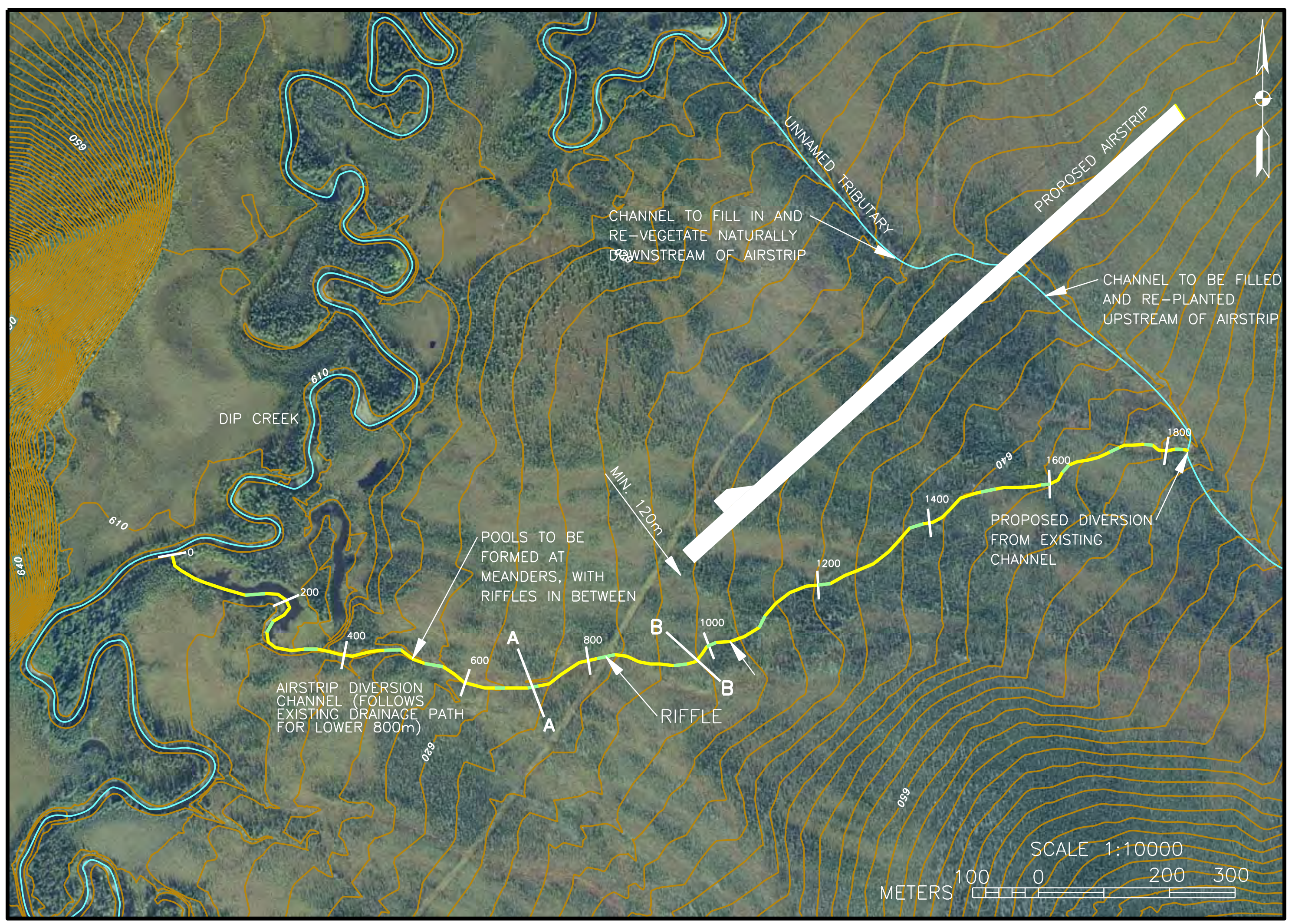
PRELIMINARY DESIGN

DATE: AUGUST 12TH, 2013	DESIGN BY E.G.	CHKD. BY B.G.	APPD. BY R.M.
SCALE N.T.S.	DRAWING NO. 4	SHEET NO. 1	

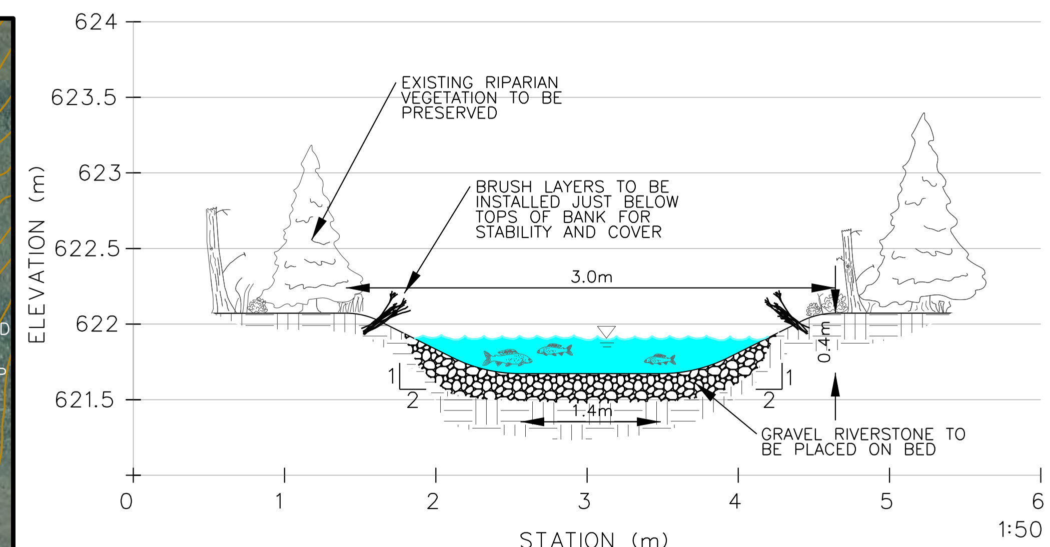
PROFILE



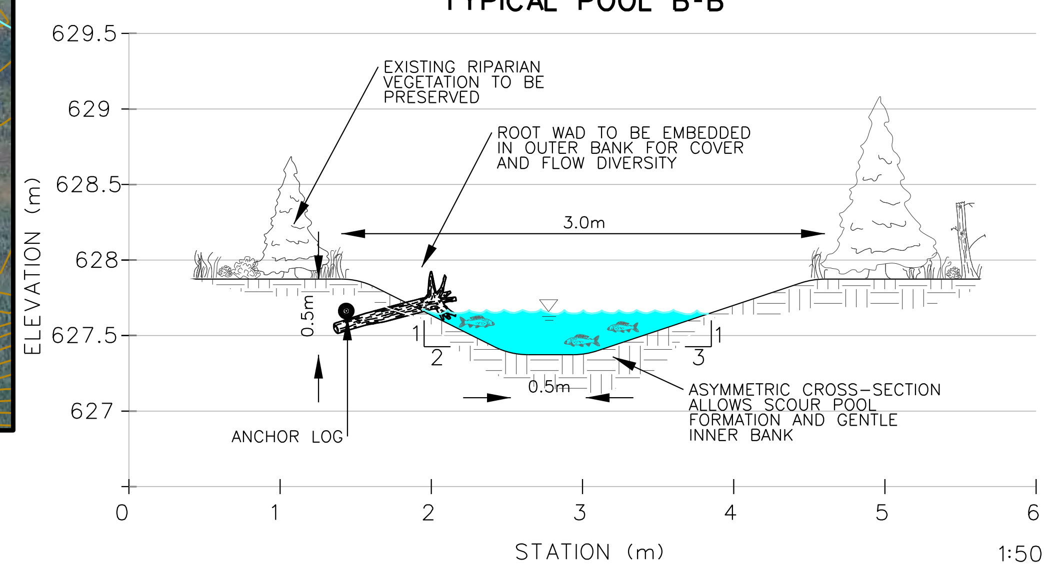
PLAN



TYPICAL RIFFLE A-A



TYPICAL POOL B-B



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DATE	REVISION	BY
11/07/2013	FINAL FOR SUBMISSION	E.G.

NATURALIZED AIRSTRIP DIVERSION CHANNEL
CASINO PROJECT

PRELIMINARY DESIGN

DATE: NOVEMBER 7TH, 2013	DESIGN BY E.G.	CHKD. BY B.G.	APPD. BY R.M.
SCALE AS SHOWN	DRAWING NO. 5		
	SHEET NO. 1		