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Our file Notre référence
11-HPAC-PA8-00031

Mr. Bill Ross
Chair, New Prosperity Gold-Copper Mine Project Federal Review Panel
160 Elgin Street, 22nd Floor
Ottawa, ON K1A 0H3

Via: NewProsperity@ceaa-aceaa.gc.ca

Dear Mr. Ross:

Subject: Fisheries and Oceans Canada's Submission to the Review Panel for the New Prosperity Gold-Copper Mine Project

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Thank you for your June 21, 2013 letter inviting Fisheries and Oceans Canada (DFO) to participate in the public hearings and present its review of the New Prosperity Project in relation to DFO's expertise and mandate. DFO would like to formally confirm its attendance at the topic-specific hearings on the aquatic environment scheduled for July 29th and 30th in Williams Lake, BC. We understand that DFO will present a summary of its written submission at 10:45 am on July 30th.

The DFO technical review team attending the topic-specific hearings will consist of 5 members:

Bradley Fanos, Manager, Fisheries Protection Program
Brenda Rotinsky, Senior Fisheries Protection Biologist
Alston Bonamis, Fisheries Protection Biologist
Dr. Michael Bradford, Research Scientist
Dr. Daniel Selbie, Head, Lakes Research Program

If you have any questions, please contact Brenda Rotinsky by e-mail at Brenda.Rotinsky@dfo-mpo.gc.ca or by telephone at 604-666-1349.

Sincerely,

<original signed by>

Bonnie Antcliffe
Regional Director, Ecosystem Management Branch

Enclosed:
1. New Prosperity Gold-Copper Mine Project Federal Review Panel submission of Fisheries and Oceans Canada, July 23, 2013
2. Outline of presentation
3. Qualifications of technical review team

Canada

New Prosperity Gold-Copper Mine Project

Federal Review Panel

Canadian Environmental Assessment Registry #63928

Submission of

Fisheries and Oceans Canada

July 23, 2013

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Summary

Fisheries and Oceans Canada (DFO) is participating in the environmental assessment of the New Prosperity Mine Project to provide technical expertise and information related to fish and fish habitat to the Federal Review Panel. DFO has reviewed the information on the existing values, predicted Project effects, mitigation, compensation, and adaptive management provided by the Proponent in the Environmental Impact Statement and supplemental information.

The project has been redesigned to address the concerns of the previous panel for the preservation of Fish Lake. The Proponent has also offered mitigation and compensation measures to offset the loss of fish habitat associated with direct and indirect effects of the Project. The direct effects are characterized as permanent disturbances associated with Project infrastructure such as the open pit and tailings embankments whereas the indirect effects are characterized as those effects associated with flow reduction on instream habitat.

DFO's review notes the following:

- DFO largely agrees that the description of the existing fish habitat features and values in the Fish Lake watershed are adequately characterized by the Proponent.
- DFO agrees with the Proponent's characterization of the direct project footprint and indirect stream flow effects of the Project on fish and fish habitat.
- DFO supports the habitat compensation measures/strategies proposed in the compensation plans and recognizes that the compensation and enhancement techniques are generally well understood and have been demonstrated in previous applications as technically feasible and beneficial to fish and/or fish habitats in certain circumstances.
- DFO agrees that conceptually, the direct and indirect project effects can be offset through appropriate mitigation and compensation.
- DFO has reviewed the proposed recirculation of flows in Fish Lake and has identified risks associated with the effectiveness of the mitigation. There is substantial uncertainty in the long term regarding fish habitat values and ecosystem functioning, which have the potential to reduce fisheries productivity of Fish Lake.
- Should the Project proceed to the regulatory stage, DFO would work with the proponent on the required regulatory requirements and technical details pertaining to feasibility and habitat assessments to support a fish habitat compensation plan consistent with DFO's policy objectives.
- Any adaptive management program designed for the Project should include monitoring of potential downstream effects in the Taseko River, uncertainties regarding the lake recirculation system, mitigation for Fish Lake tributary streams, and actions to ensure any required mitigation is applied appropriately.

Introduction

Fisheries and Oceans Canada (DFO) has prepared this submission to the New Prosperity Gold-Copper Mine Project Federal Review Panel (the Panel) in response to the request from the Panel to attend the public hearing and present DFOs technical review of the potential environmental effects of the New Prosperity Gold-Copper Mine Project (the Project) as proposed by Taseko Mines Limited (the Proponent). The Panel requested that DFO provide relevant information and recommendations to the Panel as they relate to the department's expertise and mandate.

The Panel has requested DFO's expertise on the following subjects:

- Aquatic ecosystems (surface waterbodies including Fish Lake, Beece Creek, Taseko River, Wasp Lake, Big Onion Lake);
- Fish and fish habitat;
- Water quality and quantity;
- Lake productivity;
- Lake eutrophication;
- Current use of lands and resources for traditional purposes;
- Mitigation measures including fish habitat compensation; and
- Monitoring and follow-up.

The New Prosperity Mine Project is a modification to the previous Prosperity Mine Project proposed by the Proponent in 2009. Following the 2009/2010 environmental assessment of the Prosperity Mine Project by way of Federal Review Panel, the Government of Canada concluded that the project as then proposed was likely to cause significant adverse environmental effects that could not be justified in the circumstances.

According to the Terms of Reference for the Federal Panel Reviewing the New Prosperity Gold-Copper Mine Project (May 9, 2012 and revised August 3, 2012), the environmental assessment of the Project is intended to thoroughly assess whether the Project addresses the environmental effects identified in the 2009/2010 environmental assessment of the previous Prosperity Mine Project proposal and thus should make use of the information obtained during the 2009/2010 environmental assessment, to the extent possible. As such, DFO reviewed information prepared by the Proponent in support of the environmental assessment of the Prosperity Mine Project from the 2009/2010 review and of the New Prosperity Mine Project proposal, where relevant. This submission is based on a review and analysis of the information available as of June 28, 2013, including:

- The 2009 and 2012 Environmental Impact Statement (EIS);
- Technical Data Reports in support of the 2009 and 2012 EIS;
- Responses to information requests by the Panel from the 2009/2010 panel review and the current panel review; and

- Additional information generated during the 2009/2010 panel process[1].

This submission is intended to provide context for DFO's involvement in the review of the Project and to convey to the Panel, the Proponent, and other interested parties DFO's technical review of the potential effects to fish and fish habitat that may be caused by the Project as they relate to DFO's expertise and mandate.

Background

The proposed Prosperity mine development plan reviewed during the 2009/2010 Panel Review included the destruction of Fish Lake, Little Fish Lake, and portions of Fish Creek which led the Panel to conclude that the Project would result in a significant adverse effect on fish and fish habitat in the Fish Creek watershed. The Panel concluded that the Prosperity Mine Project's effects on fish and fish habitat would be high magnitude, long-term and irreversible and would include the loss of an area that was stated to be of value as both a First Nation food fishery and recreational fishery[2]. To address the concerns of the previous Panel with regard to fish and fish habitat, the mine development plan proposed for the New Prosperity Mine Project aims to preserve Fish Lake[3], compensate for the direct loss of habitat in Fish Creek, and preserve the fisheries resource of Fish Lake.

Project Overview

The New Prosperity Mine Project includes the development, operation, and remediation of an open pit gold and copper mine located on the Fraser plateau, approximately 125 km southwest of Williams Lake, British Columbia. The Project as proposed would take 2 years to build and would operate for an estimated 20 years. In addition to the mine and associated tailings storage facility and ore and waste rock storage areas, the Project includes development of an onsite mill and support infrastructure, a 125 km long power transmission line, a 2.8 km mine access road to connect to existing logging roads and highways and to transport concentrate to the existing Gibraltar Mine Concentrate Load-out Facility near Macalister, 54 km north of Williams Lake. Mine closure begins at the end of tailings production and continues until the open pit begins to discharge water downstream (50 years after construction begins). This is when remediation of the mine site is proposed to occur as well.

The Prosperity Mine Project reviewed in 2009/2010 included the draining of Fish Lake, Little Fish Lake and portions of Fish Creek to accommodate the open pit development, waste rock storage and tailings impoundment. To compensate for the loss of Fish Lake, a new lake was to be created, Prosperity Lake. The revised mine development plan of New Prosperity has reduced the overall Project footprint by 32.7%[4]. The most notable difference between the mine development plan of Prosperity Mine and New Prosperity Mine relevant to DFOs review is the relocation of the tailings storage facility upstream in the Fish Lake watershed by approximately 2 km. This change effectively preserves Fish Lake although the

[1] The record for the Prosperity Gold-Copper Mine Project is located in the Canadian Environmental Assessment Registry #44811.
[2] Report of the Federal Review Panel, 2010, page 98.
[3] Taseko Mines Limited, New Prosperity Gold-Copper Mine Project EIS, 2012, executive summary.
[4] The Prosperity Mine Project proposed mine development plan was 4,407.1ha. The New Prosperity Mine Project proposed mine development plan is 2,967.2ha.

tailings storage facility continues to encompass Little Fish Lake and tributaries in the upper watershed. The footprint of the open pit remains unchanged from the old plan and continues to be located downstream of Fish Lake overlapping the outlet spawning and rearing habitat in Fish Creek Reach 5 and 6 and largely dewatering downstream reaches of Fish Creek.

The New Prosperity Mine development plan results in the isolation of Fish Lake from the upper and lower watershed of Fish Creek for approximately 50 years. To maintain the functioning of Fish Lake, the Proponent proposes a complex water management plan to manage lake inflows and outflows including groundwater dewatering wells, flood control dams, seepage collection ponds, and freshwater collection ponds. Flood control dams will block the outlet of Fish Lake and outflow water will be pumped into two inlet creeks downstream of the tailings impoundment area. Excess outflow water from Fish Lake will be pumped into the tailings impoundment area. Surface runoff from the mine roads (i.e., non-contact water) upstream of the tailings impoundment will supplement creek water flow upstream of Fish Lake. To ensure the survival of a population of rainbow trout in Fish Lake, the Proponent proposes to create and enhance spawning habitat upstream of the lake that can sustain a population that is greater than a minimum viable population size.

Although the capacity of the ore deposit exceeds the proposed mine life, the mine will begin remediation near the end of the proposed 20 year mine life. In years 17-20, excess Fish Lake outflow will be directed towards the open pit. In year 21, water from the tailings impoundment area will be pumped to the open pit to aid in pit filling. It is predicted to take approximately 31 years for the open pit to fill with water, and in year 48 the open pit will overflow to Lower Fish Creek and eventually into Taseko River once the water quality meets standards for aquatic life. To maintain the functioning of Fish Lake, the Proponent proposes to continue to pump water into the creeks upstream of the Lake in perpetuity.

DFO's Mandate, Responsibilities and Guiding Legislation

The *Constitution Act* provides the federal Government of Canada with exclusive authority for sea, coastal and inland fisheries within Canada's territorial boundaries. The Government of Canada has made special arrangements by which day-to-day management of certain inland fisheries has been delegated to the provincial government of British Columbia; however, the Minister of Fisheries and Oceans remains responsible to Parliament for all provisions of the *Fisheries Act* to deliver programs and services that support sustainable use and development of Canada's waterways and aquatic resources. Essentially, the federal government has jurisdiction to set the fishing rules in non-tidal waters, while the provinces have the jurisdiction to decide who may fish. The federal government retains the right to legislate with respect to the protection of fish habitat and waters frequented by fish. Because of shared jurisdiction over fisheries in non-tidal waters, in many provinces including British Columbia, federal administration has been delegated to provincial officials to facilitate management of the fisheries and to avoid duplication.

DFO has responsibilities under the *Fisheries Act*, *Species at Risk Act*, *Oceans Act* and the *Canadian Environmental Assessment Act,* 2012 with respect to the conservation and protection of the Canadian fisheries waters and resources. In order to fulfill these responsibilities, DFO is responsible for developing and implementing policies and programs in support of Canada's scientific, ecological, social and economic interests in oceans and fresh waters.

Canadian Environmental Assessment Act

DFO's role in the environmental assessment of the New Prosperity Mine Project changed over the course of the review (initiated on November 7, 2011) with the coming into force of the *Canadian Environmental Assessment Act, 2012*[5] (CEAA 2012). Under the former CEA Act, DFO was a Responsible Authority for the federal environmental assessment of the Project since the potential for regulatory decisions to be made under specific provisions of the *Fisheries Act* triggered the requirement for DFO to ensure that an environmental assessment was conducted prior to issuing any *Fisheries Act* authorization. In accordance with CEAA 2012, DFO is now participating in this environmental assessment as a federal department in possession of expert information or knowledge with respect to the Project under review.

As a Federal Authority, DFO is required, on request, to provide "specialist or expert information or knowledge" with respect to the Project to the Review Panel in relation to the department's regulatory and legislative mandates and responsibilities (as per section 20 of CEAA 2012).

The *Fisheries Act*

The *Fisheries Act* provides the legal framework for regulating impacts on fish and fish habitat associated with works, undertakings, and activities occurring in or around fresh and marine waters throughout Canada. The *Act* currently defines "fish habitat" as "spawning grounds and any other areas, including nursery, rearing, food supply and migration areas on which fish depend directly or indirectly to carry out their life processes" and "Fish" to include all life stages and parts of fish, shellfish, crustaceans and marine mammals. These definitions form the basis for DFO's assessment of impacts and advice to the Panel. There are five key fish and fish habitat protection provisions of the *Fisheries Act*, currently in force, that cover a wide range of powers, authorities and duties to regulate impacts to fish and fish habitat. These include:

- habitat protection provisions which are administered by DFO: fish passage (section 20); in-stream flow needs of fish (section 22); destruction of fish by any means other than fishing (section 32); and harmful, alteration disruption or destruction of fish habitat (section 35); and
- pollution prevention provision that prohibits the deposit of a deleterious substance in waters frequented by fish (section 36). Environmental Canada is responsible for administering the pollution prevention provisions.

[5] On July 6, 2012 the *Canadian Environmental Assessment Act, 2012* came into force and included transitional provisions for environmental assessments that were commenced under the former Act such as the New Prosperity Mine Project. See the Canadian Environmental Assessment Registry #63928 Document 107.

On June 29 and December 14, 2012 the *Fisheries Act* was amended and new fisheries protections provisions have been adopted that will come into force at a date to be fixed by the Governor in Council. Policies and regulations are being developed to support these new fisheries protection provisions however, existing program guidance and policies will continue to apply until updated or replaced.

Currently, the 1986 Policy for the Management of Fish Habitat continues to provides DFO with the operational guidance on administering decisions under the habitat protection provisions of the *Fisheries Act*. Although the policy is going through a renewal process as part of the new *Fisheries Act* changes, the priorities and concepts related to avoidance of impacts and application of measures to mitigate and offset impacts are expected to remain as key elements in the revised policy.

Should the Project proceed to the regulatory phase, DFO's role in a *Fisheries Act* authorization review process will be focused on ensuring compliance with applicable provisions of the *Fisheries Act* and *Species at Risk Act* and will be guided by the applicable program guidance and policies.

Metal Mining Effluent Regulation

Deleterious substances cannot be deposited into a natural waterbody frequented by fish in a manner consistent with the *Fisheries Act* unless the waterbody is listed in Schedule 2 of the *Metal Mining Effluent Regulations* (MMER)[6]. Once DFO determines that a proposed tailings impoundment area is, or is part of, a natural waterbody frequented by fish and Environment Canada determines that a deleterious substance will be deposited, Environment Canada leads the process to amend Schedule 2 of the MMER. In September 2011, DFO determined that the tailings impoundment area proposed by the Proponent for the New Prosperity Mine Project will encompass a portion of Upper Fish Creek and all of Little Fish Lake. These waterbodies will require listing in Schedule 2 to the Regulations should the project be allowed to proceed.

DFO's role in the Schedule 2 listing process is primarily associated with the approval of the Fish Habitat Compensation Plan. Section 27.1 of the MMER requires the development and implementation of a fish habitat compensation plan to offset the loss of fish habitat associated with the deposit of the deleterious substance[7]. The fish habitat compensation plan requires approval of the Minister of Fisheries and Ocean prior to the deposit occurring. The MMER also requires the Proponent to submit an irrevocable letter of credit to DFO to ensure that adequate funding is available to implement all elements of the habitat compensation plan.

[6] Pursuant to subsection 5(1) of the *Metal Mining Effluent Regulations* (MMER), waste rock or mine effluent may be deposited into a tailings impoundment area that is either: (a) a water or place set out in Schedule 2, or (b) a confined area other than a disposal area that is, or is part of, "a natural water body frequented by fish".

[7] Section 27.1 (3) (a) through (h) outlines elements to be included in the Fish Habitat Compensation Plan.

Environmental Impact Statement Overview

The Fisheries Resource

Fish Creek Watershed

The Proponent has studied the major areas of fish habitat in the Fish Creek watershed in its EIS for the New Prosperity Mine Project and the previous Prosperity Mine Project. The majority of the baseline fish and fish habitat data collection was conducted in the mid to late-90s with some additional lake sampling and confirmation of spawning habitat in the upper watershed completed in 2011 and 2012. The Proponent delineated the Fish Creek Watershed into Lower, Middle and Upper Fish Creek. Lower Fish Creek is defined as the section of stream from the confluence with the Taseko River upstream to the fish barrier (Reaches 1-3). Middle Fish Creek includes the section of stream from the barrier upstream to Fish Lake (Reaches 4-6), and Upper Fish Creek includes Fish Lake, the Fish Creek mainstem between Fish Lake and Little Fish Lake (Reaches 7-8), Little Fish Lake, and their respective tributaries (Figure 1). The Fish Creek watershed encompasses a total of 175,442 m^2 of stream habitat, of which 64,777 m^2 is fish bearing. The watershed also includes a total of 117.6 ha of lake habitat (Fish Lake = 111 ha and Little Fish Lake = 6.6 ha), of which 904,230 m^2 is shoal area. The Proponent estimates the total riparian area in the Fish Creek Watershed to be 1,923,620 m^2, of which 93% is associated with streams and the remainder associated with lakes.[8]

Fish species present in the Fish Creek watershed include rainbow trout (present throughout), Chinook salmon, bull trout, mountain whitefish and white suckers (all present in Lower Fish Creek). Impassable falls between Lower and Middle Fish Creek prevent fish species from migrating upstream, and have also resulted in a reproductively isolated, self-sustaining, monoculture population of rainbow trout throughout upper reaches (Reaches 4-10) of the Fish Creek watershed. Reaches 1 and 2 in Lower Fish Creek dewater during the summer low flow period, preventing migration of fall-spawning species (e.g. salmon) into Fish Creek from Taseko River. Dewatering of these lower reaches and the presence of an impassable barrier to fish passage limits Taseko River fish stocks access to habitat in the Fish Creek watershed. The Taseko River drains into the Chilko River, which is a tributary of the Chilcotin River, which then empties into the Fraser River. The Chilcotin watershed contains a variety of salmon and trout species that support valuable commercial, recreational, and First Nation fisheries. Aquatic productivity is high in both Fish Lake and its tributary streams, and this appears to be a function of physical habitat characteristics and water chemistry. Fish Lake has a large littoral zone (75% of the 111 ha lake area) and a mean depth of 4 m, resulting in increased productivity due to increased light penetration. Shortreed and Morton (2000) examined Fish Lake limnology and concluded that the lake was shallow and eutrophic, with significant oxygen depletion in the hypolimnion and the potential for sizeable cyanobacterial blooms. They noted that many trout producing lakes in BC have similar conditions, and because Fish Lake is sufficiently deep (13 m) and has adequate dissolved oxygen to

[8] Riparian habitat was determined using methods described in the Riparian Management Area Guidebook (MoF, 1995) and Riparian Areas Regulations (MoE, 2004).

prevent winterkill[9], Fish Lake was capable of supporting substantial trout populations. The Proponent has estimated Fish Lake to hold a population of 85,178 rainbow trout (all 2+ to 6 year age classes) and to have a fish production capacity of 24.1 kg/ha/y. The population for Little Fish Lake was estimated by Taseko to be 5,000 rainbow trout based on the capture of a single fish in Little Fish Lake and applying Fish Lake densities and the total lake area (6.6 ha) to arrive at their estimate. Based on information provided in the EIS (2012), rainbow trout age classes and fish production in Little Fish Lake were assumed to be the same as those observed in Fish Lake. The total population of rainbow trout in the Fish Lake watershed is estimated to be 165,795 fish, which includes 87,178 rainbow trout in Fish Lake and a further 78,617 rainbow trout in the adjacent creeks, tributaries, and Little Fish Lake.

The high productivity of Fish Creek is indicated by the large standing rainbow trout stock, estimated to be approximately 60% higher than other typical interior rainbow trout streams with monoculture stocks (Ecofish, 2006)[10]. The Proponent estimates the relative abundance of rainbow trout in Middle and Upper Fish Creek drainages at approximately 73,600 fish, the majority (75%) of which occur in Reaches 5 and 6. Young-of-the-year (age 0+ years) and juvenile rainbow trout (1-2 year old) make up 99% of the population estimated for Middle and Upper Fish Creek, demonstrating the importance of these areas for trout production. The Proponent's comparison of baseline riffle habitat composition in Middle and Upper Fish Creek suggests that Reach 8 contains the most spawning habitat (45%) followed by Reach 6 (37%) and Reach 5 (17%). However, because Reaches 5 and 6 were shown to contain large numbers of young-of-the-year rainbow trout, it is likely that prevalence of gravel substrates may be a determinant of spawning success. This linkage is apparent when considering total reach length (Figure 1) in tandem with the prevalence of gravel substrates in each reach: Reaches 5 and 6 which contained 53% and 6% gravel substrates respectively have a smaller combined stream length than Reach 8, which contained 38% gravel substrates. Adult spawner migration studies conducted in 1997 showed that more than twice as many adult rainbow trout spawners were observed migrating from Fish Lake through the outlet into Fish Creek (10,148 fish) than were observed migrating through the inlet (4,593 fish) into Fish Lake.

[9] The conclusion on the likelihood of winterkills was from a one-off survey of Fish Lake in 1999 in conjunction with the historical data provided by the proponent. In the 2012 EIS, C1-30, it states "unweighted mean dissolved oxygen concentrations", indicating moderate to severe hypoxia from Jan to May (from sampling in 1993, 1996, 1997, 1998, & 1999). Presumably this is throughout the water column.

[10] Ecofish Research Limited, 2006. Fish Lake Productive Capacity with Respect to Proposed Prosperity Mine.

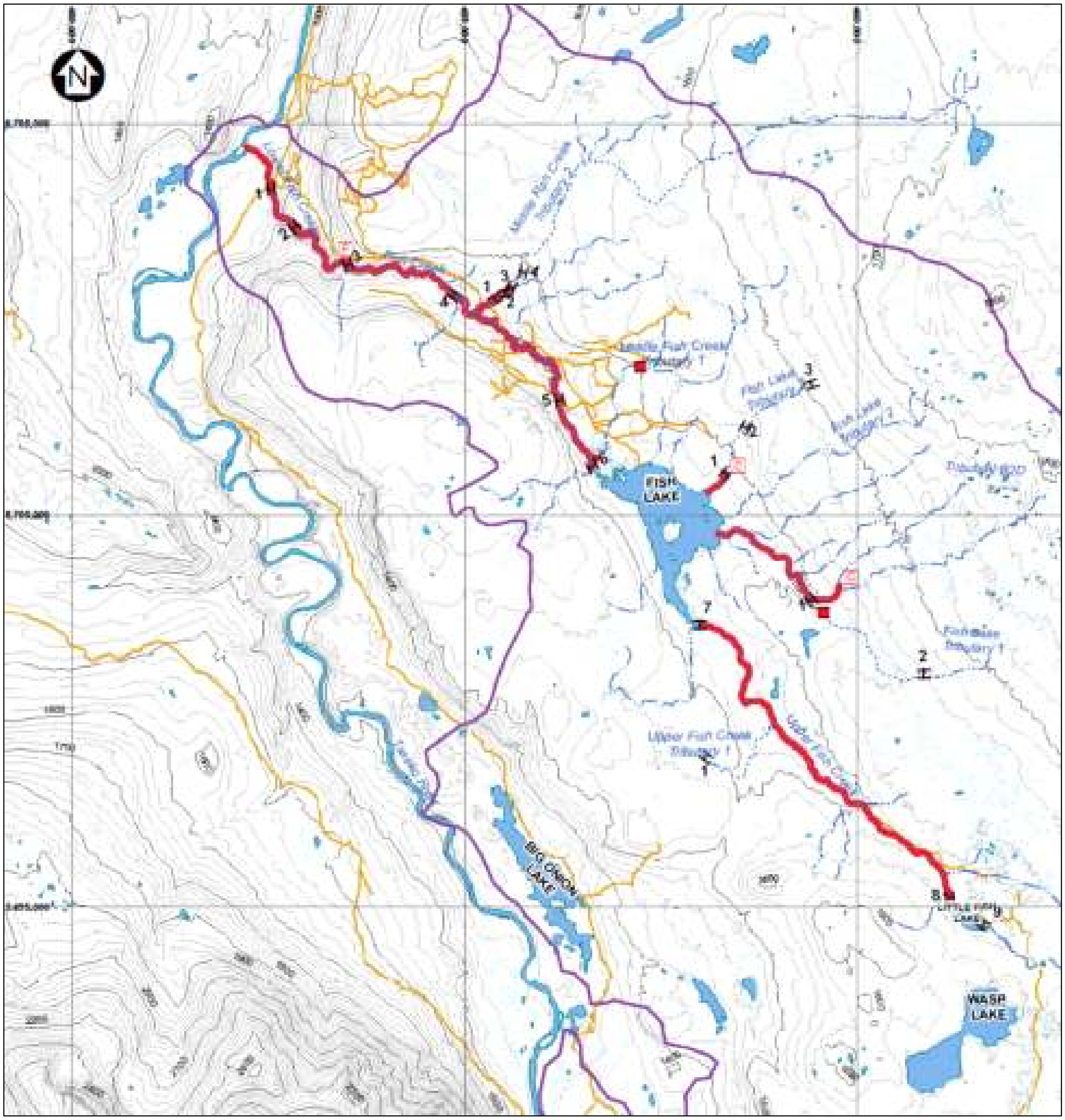

Figure 1: Fish Distribution and Reach Breaks in the Fish Creek Watershed (adapted from Taseko Mines Ltd. Environmental Impact Statement, September 2012).

Lower Fish Creek and Taseko River

The Fish Creek watershed drains into Taseko River, which flows into the Chilko River and finally into the Fraser River. Taseko River is located in the Chilcotin plateau, and is a glacial stream that serves as an important spawning, rearing and migration corridor for Chinook and Sockeye salmon (Williams, 1987).

Taseko sockeye are part of the early summer run timing group and migrate up the Fraser to spawn in the Taseko Lake (primarily) and Taseko River from mid-July to early September. Taseko sockeye belong to the Taseko Lake conservation unit (CU) as defined under Canada's Policy for the Conservation of Wild Salmon (DFO, 2005). The Taseko sockeye return is very small in relation to the neighbouring sockeye runs (e.g., Chilko River), and on average makes up under 1% of the total Fraser River sockeye return (across all run timing groups) (DFO, 2013b). A maximum escapement of 31,667 fish was observed at Taseko Lake in 1963, with recent returns (1994 - 2011) averaging 890 fish (DFO, 2013c).

Taseko River Chinook belong to the Middle Fraser River – summer timing conservation unit and spawn in Taseko River and Elkin Creek (Taseko River tributary) from early August through September. Escapement data for Taseko Chinook is recent years is unavailable however, maximum historical escapement estimates of 750 fish have been noted for Taseko River Chinook, with most recent return estimates (1980 - 1998) in the low hundreds (DFO, 2013c).

Chinook are also known to spawn in Beece Creek, however, in adjacent Lower Fish Creek, seasonal dewatering during late summer and early fall are believed to prevent Chinook spawning although spawning habitat is present (Triton, 1997). Lower Fish Creek has been shown to provide valuable rearing and overwintering habitat for juvenile Chinook salmon. Lower Fish Creek below the impassable falls is used by rainbow trout, Chinook salmon, bull trout, and mountain whitefish near the confluence with Taseko River.

Wasp Lake, Big Onion Lake, and Beece Creek

Wasp Lake is a 68 ha non-fish bearing lake located in the Beece Creek watershed with the outlet of Wasp Lake draining to Beece Creek and then to the Taseko River. Beece Creek flows into the Taseko River approximately 1.2 km downstream of the outlet of Lower Taseko Lake. This creek provides valuable spawning and rearing habitat for Chinook salmon and bull trout, and contains low densities of rainbow trout. Big Onion Lake is a 63.4 ha lake located across the watershed divide between Fish Creek and the Taseko River. The outlet of Big Onion Lake drains into the Taseko River upstream of Beece Creek.

Project Review and Risk Assessment

Project Effects

Fish Creek Watershed

As outlined in the EIS (2012), the New Prosperity Mine Project is predicted to impact the catchment hydrology supplying Fish Lake, the hydrological and hydrochemical properties of its tributaries, as well as the limnological characteristics of the lake itself. The main embankment of the tailings storage facility is predicted to intercept approximately 86% of the discharge from Fish Lake Tributary 1 and 45% of the discharge from Fish Creek Reach 8. Over 50% of the upstream catchment area for Fish Lake would be cut off from Fish Lake during the life of the mine as the Fish Lake catchment will be reduced from 68 km^2 to 28.6 km^2. This would reduce the discharge from the outlet of Fish Lake by 58%. Currently, the Fish

Lake rainbow trout population is supported by inlet tributaries and an outlet reach that provides for adult rainbow trout spawning and juvenile rearing depending on annual flow conditions. Approximately 45% of the spawning habitat in the Fish Creek watershed is present in the Fish Lake outlet channel where 69% of the spawning fish population was found to utilize this outlet habitat for spawning. This spawning habitat and the hydraulic connection to downstream reaches will be lost due to construction of the open pit mine. Discharge from the outlet of Fish Lake would be redirected and pumped up to inlet reaches of Fish Lake (i.e., Fish Lake Tributary 1 and Fish Creek Reach 8) to retain inflow to the lake and to provide for stream spawning and rearing habitat to maintain a population of rainbow trout in Fish Lake. This flow alteration would create an isolated recirculated watershed with no surface water flow connection to Lower Fish Creek reaches or the Taseko River.

The Proponent characterizes the New Prosperity Mine Project effects on fish and fish habitat as 'direct' or 'indirect' effects and undertakes a relatively standard approach to determining the quantity and quality of aquatic habitats impacted. The direct effects are characterized as permanent disturbances associated with Project infrastructure such as the open pit and tailings embankments whereas the indirect effects are characterized as those effects associated with flow reduction on instream habitat and are summarized in Table 1 below:

Table 1. Summary of the Direct and Indirect Effects of the New Prosperity Mine Project on Aquatic Fish Habitat.

Mine Component	Direct Effects (footprint impacts)	Indirect Effects (downstream)
Open Pit	Destruction of: • Fish Creek Reach 5-6 • Middle Fish Creek Tributary 1	Flow reduction to: • Fish Creek Reaches 1-4 • Taseko River Loss of outlet: • Fish Lake
Non-PAG Waste Rock Storage	Destruction of: • Middle Fish Creek Tributary 1 • Unnamed tributaries to Fish Creek	Flow reduction to: • Fish Creek Reaches 1-4 • Taseko River
Tailings Storage Dams	Destruction of: • a portion of Fish Creek Reach 8 • a portion of Fish Lake Tributary 1 • a portion of Fish Creek Reach 10	Flow reduction to: • Fish Creek Reach 8 • Fish Lake • Fish Creek Tributary 1 • Fish Lake Tributary 1 Loss of headwaters: • Fish Lake
Tailings Storage (deposit of deleterious substance)	Destruction of : • Little Fish Lake • a portion of Fish Creek Reach 8 • Fish Creek Reach 10 • Fish Lake Tributary 1 Reach 2-3 • Unnamed tributaries to Fish Creek	Flow reduction to: • Fish Creek Reach 8 • Fish Lake Tributary 1 • Fish Lake • Fish Lake Tributary 1 Loss of headwaters: • Fish Lake

The Proponent uses area calculations to determine the quantity of habitat impacted and the Habitat Evaluation Procedure (using a habitat suitability index to convert area to habitat units) to assess the quality of habitat impacted. The Proponent also uses an approach they characterize as "stream flow duration" to take into account the number of months per year that the ephemeral streams have water flow and use that to subtract the 'value' of the habitat (i.e., if a stream flows for two months a year, it is 'worth' only 20% of the total area). The loss of flow downstream of the open pit is not accounted for in the assessment by the Proponent, whereas DFO considers this a loss of habitat[11]. Although DFO does not agree with all aspects of the specific methods used by the Proponent to quantify fish habitat losses, utilizing areas (m^2) and habitat units to communicate project effects on the quantity and quality fish habitat has previously been accepted during other project reviews. Table 2 summarizes the aquatic habitat losses (direct and indirect) as a result of the New Prosperity Mine Project.

Table 2. Summary of Fish Habitat Impacts as a Result of the New Prosperity Mine Project.

Location	Reach	Fish Bearing Habitat (m^2)	Non-Fish Bearing Habitat (m^2)
Lower Fish Creek	Reach 1	5,357[12]	
	Reach 2	4,227	
	Reach 3	6,787	
Middle Fish Creek	Reach 4	7,161	
	Reach 5	14,495	
	Reach 6	4,288	
Upper Fish Creek	Reach 8	16,139	
Little Fish Lake		66,000	
Middle Fish Creek Tributary 1			1679
Fish Lake Tributary 1		4,403	4,781
Ephemeral Reaches and Tributaries			14,536
TOTAL		128,856	20,996

The total aquatic habitat loss in the Fish Creek watershed associated with the construction and operation of the New Prosperity Mine Project accounts for 11% of the total aquatic habitat available. There would be reduction of aquatic stream habitat by 48%. The New Prosperity Mine development plan is an effort to preserve the ecosystem functions of Fish Lake such that it will support a minimum viable population of rainbow trout. DFO recognizes that Fish Lake is part of watershed and ecosystem that has a complex interaction of biological and physical elements and processes to provide a productive aquatic ecosystem. The stream and wetland elements of this watershed provide critical functions in support of this productive aquatic ecosystem. The Project as proposed will retain Fish Lake; however, a substantial portion of the associated stream network will be eliminated. The loss of the stream and

[11] In the 2012 EIS the Proponent states that the loss to habitat in Lower Fish Creek is 'not significant' since spawning does not occur in those reaches, and thus do not carry forward an assessment of the loss to fish habitat.
[12] Values taken from the 2012 EIS and reflect the areas determined by the Proponent to be direct and indirect losses except for Reach 1-3 which were not considered.

wetland elements of the Fish lake watershed has consequences that represent risks for ensuring the Fish Lake aquatic ecosystem functions effectively to support a minimum viable population of rainbow trout.

The Proponent proposes mitigation for the loss of inlet and outlet spawning habitat by actively capturing and pumping the discharge from the outlet of Fish Lake to the remaining reaches of headwater streams to retain inflow to Fish Lake. DFO provides a technical assessment and describes the risks of the proposed mitigation strategies designed to maintain the productivity of the Fish Lake watershed to support a minimum viable population of rainbow trout.

Lower Fish Creek and Taseko River

The Proponent has determined that the effects of the New Prosperity Mine Project on the Taseko River remains unchanged from the previous Prosperity Mine Project effects which include a loss of surface flow contribution. The relative contribution of Fish Creek surface flow to the Taseko River represents 5% or less for most of the year. Fish Creek provides up to 12% flow contribution during the freshet (April to May). DFO agrees that the surface flow contribution does not represent a critical loss for the Taseko River. Lower Fish Creek has been shown to provide valuable rearing and overwintering habitat for juvenile Chinook salmon, however, the loss of Lower Fish Creek does not appear to represent a critical loss of habitat to the Taseko Chinook as similar rearing habitat may be provided by the proposed Taseko Lake Off-channel Compensation element.

Based on groundwater modeling, the Proponent predicts that Project construction will not significantly affect baseflow to Lower Fish Creek and Taseko River, and that construction of the TSF is expected to result in a regional rise in the water table in the Project area, leading to increased groundwater inflow into Big Onion Lake, Little Onion Lake and Wasp Lake. They also indicated that increased discharge of groundwater to these lakes is in turn expected to result in a decrease in the annual average baseflow to Taseko River during summer months (May – October) by 18% (a decline from 527 m^3/day to 433 m^3/day with seepage pump back wells).

Natural Resources Canada recently expressed concern that Taseko's seepage rate estimates for the TSF may be 11 times higher than those modeled in the EIS (Desbarats, 2013[13]). As a result, groundwater seepage estimates that were modeled in the EIS may be underestimated. If actual baseline groundwater seepage contributions into Taskeo River are significantly higher than those modeled, then development of the Project could result in impacts to Taseko River that have not been considered by the Proponent.

Wasp Lake, Big Onion Lake, and Beece Creek

Due to redesign and relocation of Project components, DFO does not expect direct downstream effects on fish and fish habitat in Wasp Lake, Big Onion Lake, and Beece Creek. Although no project components will overlap fish habitat features in these watercourses, during the post-closure phase of the New Prosperity Mine, water from the southern-most catchment of the tailings storage area will be released to Wasp Lake and ultimately to Beece Creek. However, the Proponent has noted that the

[13] As stated in the submission to the Review Panel by Natural Resources Canada on July 4, 2013: Canadian Environmental Assessment Registry 63928, Document 587.

location of the tailings storage facility in the mine development plan could contribute to elevated levels of nutrients, metals and sulphate in these waterbodies which may adversely affect aquatic communities in the absence of adequate mitigation (e.g. seepage collection ponds, depressurization well, etc.). Further to this, National Resources Canada (NRCan) in their written submissions to the Panel on November 9, 2012[14] and July 4, 2013[15] expressed concern that the Proponent's overall estimate of seepage mitigation efficiency is overly optimistic and that due to the existing subsurface hydrology below the proposed tailings storage facility, there is potential for rapid contaminant transport along preferential groundwater flow paths that bypass interception wells. This could affect the water quality in Fish Lake as well as Big Onion Lake, and consequently the ability of these lakes to support fish. The potential risks of fish contamination and any resulting human health impacts due to elevated metals are beyond the mandate and expertise of DFO and may be considered by Health Canada in their technical review of the New Prosperity Mine Project.

Fish Lake as a Recirculated, Closed System

Given the primary objective of the New Prosperity Mine development plan to address the concerns of the previous Panel and preserve the ecological functioning of Fish Lake to sustain a population of rainbow trout, DFO has undertaken an assessment of the Proponent's ability to achieve this objective (DFO, 2013[16]). The Proponent's mitigation and adaptive management plan to preserve the functioning of Fish Lake using a recirculated closed system uses unprecedented and untested technology that includes inherent uncertainty. DFO is not aware of any examples of wilderness lakes or watersheds that have been subject to a recirculation program such as that proposed. The Proponent was not able to provide any examples of wilderness lakes that have been subjected to a recirculation plan of this nature.[17]

The recirculation plan and the application of multiple adaptive management techniques, some of which are novel (i.e., whole lake water and sediment filtering) contribute to the uncertainty in the technical feasibility of the plan. DFO's review does not include an assessment of the inherent risks associated with the maintenance of the infrastructure itself such as the potential for pump or pipeline failures or the substantial costs associated with implementation and maintenance of the core plan plus the burden of ongoing management of the system. For the recirculation system to function at its basic level the Proponent is required to maintain flow continuity to the inlet stream in perpetuity and DFO recognizes the substantial undertaking of this effort. In addition, DFO also did not undertake an assessment of the water availability to maintain the system in all seasons and years to maintain flow continuity to the inlet streams. The water balance will be another key factor in the maintenance of the system. DFO's review assumes that there is adequate water available to sustain the system and that flow continuity can be achieved although DFO did not undertake an assessment of either of these elements. DFO also notes the concerns from other federal Departments such as:

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[14] Canadian Environmental Assessment Registry #63928, Document 272
[15] Canadian Environmental Assessment Registry #63928, Document 587
[16] The following sections on Stream Habitat and Lake Habitat utilize the assessments conducted in DFO, 2013.
[17] Supplemental Information Request 15/19/25/49 – Lake Productivity, Mitigation and Adaptive Management (submitted by Taseko Mines Limited to the Review Panel on June 6, 2013).

- The Proponent's ability to maintain existing water levels in Fish Lake due to pit dewatering.[18]
- The Proponent's ability to model the seepage rates from the tailings impoundment[19] and thus maintain water quality that is sufficient for aquatic productivity.[20]

DFO did not consider these concerns in the assessment below but notes that the potential for metals contamination in Fish Lake and lake dewatering increase the uncertainty in the viability of the recirculation scheme and represents additional risk factors.

DFO's review of the effects of the proposed recirculation plan to maintain the functioning of the Fish Lake ecosystem is described below in relation to biotic and abiotic factors related to the functioning of the Fish Lake system upon its isolation from the headwaters and outlet channel. Recirculation of lake outflow water to the inlet streams is likely to impact the trophic status and ecosystem structure and functioning of Fish Lake and the tributary streams, and is a concern for the future biological productivity of Fish Lake in terms of lake and stream habitat and fisheries productivity. Lake and river habitats are inherently integrated features of the watersheds from which they originate. Modifications to terrestrial catchment attributes can have important impacts on abiotic and biotic conditions in downstream aquatic habitats, such as lakes, with commensurate impacts on habitat and fisheries productivity. This connectivity necessitates the consideration of lake productivity in a watershed context to assess the ability of the recirculating lake scheme to function as sustained and productive fish habitat throughout the mine life and upon closure.

Stream Habitat

The New Prosperity Mine Project proposal will eliminate 48% of fish creek watershed resulting in a substantial reduction in the amount of spawning and juvenile rearing habitat for rainbow trout. Most of that loss occurs as a result of the loss of the outlet stream and the headwaters of upper Fish Creek, the largest inlet stream. Although the focus in the EIS is on spawning habitat (Taseko, 2012[21]) evidence from studies of other stream dwelling populations of salmonids suggests that it is likely that the availability of habitat for age-0 and age-1 juveniles in the tributary streams is the limiting factor affecting recruitment to the adult population in the lake. Results from the 1997 fence studies (Taseko, 2009[22]) clearly indicate the significance of both the inlet streams and especially the outlet stream as juvenile rearing habitats. Therefore this review considers the effects of the proposed project on both spawning and rearing habitat.

Based on wetted area under late summer flows the New Prosperity Mine Project is expected to reduce the total stream rearing area for juvenile fish by 60% (calculated from baseline data [Taseko 2012, Table 2.6.1.5-9] and projected wetted surface areas for Reach 8 and Fish Lake Tributary 1, with flow augmentation and channel modification). This estimate is similar to the projected loss in spawning

18 Canadian Environmental Assessment Registry #63928, Document 272
19 Canadian Environmental Assessment Registry #63928, Document 587
20 Canadian Environmental Assessment Registry #63928, Document 292
21 Appendix 2.7.2.4B-D Fish Lake Mitigation Flow
22 Appendix 5-3-D Fish Creek Spawner Enumeration Project, prepared by Triton, 1999

habitat, calculated at 63%[23]. If it assumed that the reduction in wetted area will cause a proportional reduction in the production of age-1 fish that migrate to the lake, the lake population could be reduced by a corresponding amount. Based on 1997 estimates of the number of adult fish (~27,000) the post-project adult (age 4+) population is predicted to be in the range of 10,000 fish which should be sufficient to avoid risks associated with small population size (Reed *et al*., 2003). The reduced number of fish recruiting to the lake will likely result in better fish growth and larger adults (Askey, 2007). Increased growth can also increase survival of fish in the lake (Post *et al*., 1999), which may counteract some of the reduction in juvenile production.

As part of the recirculation mitigation scheme, the primary functions of the two Fish Lake inlet streams for a self-sustaining rainbow trout population will be to:

1. Provide an appropriate environment for the spawning of adult rainbow trout and successful incubation of eggs and alevins.
2. Provide an appropriate environment to produce sufficient age-1 rainbow trout recruits to the lake, including habitats for both summer and winter seasons.

To mitigate the loss of spawning and rearing habitat in the outlet stream, as well as the loss of the headwaters of upper Fish Creek and Fish Lake Tributary 1, the Proponent proposes to recirculate water from the lake to the upper limit of the remaining segments of these tributaries. Upon review, it is apparent there are significant risks with this scheme for the long-term viability of the functions of the streams and the productivity of the rainbow trout population that are not identified or not fully addressed in the documentation. These are listed in the sections below.

Channel maintenance flows

It is well recognized that high flows are necessary to maintain stream function. In unregulated streams, high flow caused by spring freshet or rain events mobilizes the stream bed, removing accumulated fine sediment and organic debris. This maintains the quality of the bed for the incubation of salmonid eggs by restoring gravel permeability, and provides an appropriate substrate for the production of invertebrates that are preferred food items for young fish. Cover for young fish is also provided by the presence of unembedded stream bed materials. When high flow events are eliminated stream bed quality can deteriorate quickly, greatly reducing its potential for fish production (Schmidt and Potyondy, 2004). Hartman and Miles (2005) provide many examples of artificial spawning areas for rainbow trout that have deteriorated without high flows or other forms of maintenance. Similar experiences have been documented for other salmonid spawning areas (e.g., Pulg *et al*., 2013 and references therein). Movement and redistribution of bedload and woody debris and the undercutting of stream banks during high flow events also create important habitat structures for rearing juveniles. Freshet flows are also important for the maintenance of the riparian zone and off channel habitats. Elimination of high flows can also cause the encroachment of woody vegetation into the stream channel which can alter stream habitat conditions.

[23] Calculated from Table 2 and 4 in Appendix 2.7.2.4B-D Fish Lake Mitigation Flow

Beaver are present in the valley, and contribute to the creation of pool habitats and likely provide overwintering areas for juvenile trout in upper Fish Creek. Fish production in streams that support beaver is maintained by the balance between very high spring flows that breach dams and flush the accumulated sediments, and the activities of the beaver populations to restore them. In the absence of high flows there is the potential for beaver dams to render both tributary streams unsuitable for fish production if access for spawners is blocked, and sediment deposition behind dams eliminates spawning habitats. High flows also interact with beaver dams to flood riparian areas and recharge shallow groundwater (Westbrook *et al*., 2006). This dynamic may be altered if peaks in the hydrograph are removed.

One estimate of the peak flow for upper Fish Creek is found in Figure 2.6.1.4B-4 (Taseko, 2012), where flow in early May 2007 was estimated at 3.0 m^3s^{-1} (unit discharge 75 $l/s/km^2$, watershed area 39.8 km^2). It is unknown whether this flow was sufficient to provide channel maintenance function. Apparently only one year of flow data is available, but the 2007 hydrology analysis suggests that 10 year peak flows of 150-200 $l/s/km^2$ could occur (Taseko, 2009[24]), corresponding to a peak instantaneous flow of 6-8 m^3s^{-1}. These flows are much higher than the maximum flows for upper Fish Creek (0.45 m^3s^{-1}) to be provided by the proposed water management system.

Bankfull discharge is sometimes used as a reference point for maintenance flows; using a regional hydrology approach from Western Montana (Lawlor, 2004) based on watershed area, an estimated of 1.33 m^3s^{-1} is obtained for upper Fish Creek. Site-specific analysis should be conducted to evaluate the flows required to perform channel maintenance function.

In summary, there is a high risk that the absence of channel maintenance flows will result in the deterioration of the productivity of habitats in the inlet streams. Experience elsewhere suggests this can occur rapidly. Provision of high flows at a less than annual frequency will contribute to the maintenance of the channel and the riparian zone. Mechanical measures can be used to mitigate some of these effects although these are less effective than high flows and far more intrusive.

Thermal Regime

The predicted changes in stream water temperature resulting from recirculating water from the lake to the inlet stream are similar to those observed in releases below storage dams (Olden and Naiman, 2009). The thermal inertia of the lake results in warmer flows in the fall and winter, and cooler in the spring and summer relative to baseline stream temperatures. Although the temperatures are often within the thermal tolerances of species, the altered thermal regime can have effects on stream fish that should be considered risks.

The analysis of the thermal regime appears to rely on stream temperatures observed at the lowest segment of upper Fish Creek, where the monitoring station and fish fence were located. There is potential for a gradient in water temperature along the length of the stream, especially in summer when

[24] Taseko Mines Limited, Prosperity Gold-Copper Mine Project Application/EIS, 2009, Figure 4.8

flows are low and air temperatures are high. Thus, the background temperatures at the point of mixing may be lower than indicated in Figure 11[25], and this will introduce a slight error in the predictions.

The proposed releases will cause stream temperatures to cool by about 3°C compared to baseline during the incubation period for rainbow trout eggs (Figure 11[26]). These post-project temperatures will result in a delay in emergence timing. Rearing temperatures are predicted to be reduced through the summer to early September, which may impact growth of age-0 fish. The primary risk of these changes is that juvenile fish may be smaller or in poorer condition prior to winter. Size and condition can be important factors contributing to survival over the winter period. These effects may be slightly offset by warmer temperatures compared to baseline in the late fall.

Recirculated water will have a major impact on overwintering rearing habitat in the streams. Although upper Fish Creek is described as having ephemeral flow, previous trapping results found that large numbers of juvenile trout migrated from the creek to the lake in June and July 1997 (Taseko, 2009[27]). This suggests that trout were able to find suitable rearing habitats for the winter, likely in beaver ponds, potentially supplied by groundwater. A more recent attempt to document overwinter use was unsuccessful; however, the sampling was limited in scale. Without knowledge of the groundwater sources, fish distribution is difficult to confirm by random sampling (Bradford *et al.*, 2001).

As baseline flows recede in the fall, temperatures fall to 0°C and ice forms on the creeks. Flow augmentation is expected to increase winter temperatures (Figure 11[28]) and that may prevent the formation of a surface ice layer on the creeks. Open water can exacerbate the formation of frazil and anchor ice, expose fish to predation risk, and create bio-energetically challenging conditions (*see* Brown *et al*., 2011). Although the mitigation flows are expected to cool downstream of the outlets, it is unclear where juvenile fish will be distributed in the stream relative to the ice-free or covered sections of each stream. This is a particularly important uncertainty for upper Fish Creek as fish production appears to be sustained by localized groundwater sources.

Finally, water temperatures in the spring months are predicted to be 2-3°C lower than baseline conditions (Figure 11[29]). Juvenile growth can be rapid at this time of year (Bradford *et al*., 2001) as size at entry to the lake will likely confer a survival advantage (Post *et al*., 1999). The cooler recirculated water may impact growth and survival over the baseline condition.

In summary, there are a variety of risks to the stream fish populations associated with the change in the thermal regime resulting from augmentation flows unless these risks may be minimized by ensuring the mitigation flow temperatures mimic baseline temperatures throughout the length of the tributary streams.

[25] Appendix 2.7.2.4B-D Fish Lake Mitigation Flow
[26] Appendix 2.7.2.4B-D Fish Lake Mitigation Flow
[27] Appendix 5-3-D Fish Creek Spawner Enumeration Project, prepared by Triton, 1999
[28] Appendix 2.7.2.4B-D Fish Lake Mitigation Flow
[29] Appendix 2.7.2.4B-D Fish Lake Mitigation Flow

Eutrophication

Pumping of nutrient-rich hypolimnetic water from Fish Lake into the inlet streams during summer for temperature control has the potential to stimulate primary productivity (periphyton). Orthophosphate concentrations in the inlet streams during the growing season was estimated at 8 µg/L (Taseko, 2012[30]), much lower than the hypolimnetic concentrations in Fish Lake, which in July range from 77-205 µg/L (see below). Enhanced periphyton productivity may increase food production for fish, but may also shift periphyton species composition and contribute to the accumulation and deposition of organic matter in the stream channel, leading to the deterioration of stream bed conditions for spawning and egg incubation as noted above. Changes to the form and species of phytoplankton may also occur if there is nitrogen limitation resulting from the pumping of hypolimnetic lake water (see Lake Habitat section below; Perrin and Richardson, 1997). The Proponent has not provided an analysis of the effects of changes in nutrient chemistry however, sufficient information appears to be available to assess this risk.

Dissolved Oxygen

The analysis of the end-of-pipe oxygen concentration suggests a high probability that levels will fall below acceptable values for much of the year. The winter period in Figure 15[31] is probably too short, as ice-related depletion is likely in December. The data in Figure 15 do not account for the ambient oxygen levels in the residual flows in the two tributary streams, which are unknown. Based on the production of juveniles from upper Fish Creek (Taseko, 2009[32]), there must be sources of water in the upper Fish Creek channel that have sufficient oxygen to support fish. The addition of recirculated water with low oxygen concentration may cause conditions to deteriorate in the stream relative to the baseline.

Given the limited information provided about the mitigation of low DO in the recirculation system DFO is unable to evaluate its effectiveness. Given that the streams are short, and the short transit time of water, it may not be sufficient to rely on natural aeration to restore DO levels. Further, aeration during the winter months will require measures to avoid supercooling and the creation of frazil ice.

Changes in stream community structure and food production.

The proposed isolation of the headwater areas of the two tributary streams and pumping lake water in to the streams is a very similar situation to a small impoundment (storage dam) and a regulated discharge. These changes are well described by the Serial Discontinuity Concept (Ward and Stanford, 1983) and large body of supporting research. Some potential changes to the remaining stream include the elimination of particulate organic material, large woody debris, gravel and invertebrate drift exported from the headwaters to downstream habitats and the lake.

High flows in headwater streams mobilize stream gravels and maintain a supply of suitable size material to salmonid spawning areas from headwater areas. Isolation of headwaters by barriers (e.g., dams) eliminates that recruitment. Consequently in most regulated systems the areas below the flow control structures tend to downcut and become gravel starved. The extent of gravel loss will depend on the

[30] Appendix 2.7.2.4-B-A Effects of Reduced Inflow on Fish Lake Trophic Status Using the Mass Balance Approach, Table 2
[31] Appendix 2.7.2.4B-D Fish Lake Mitigation Flow
[32] Appendix 5-3-D Fish Creek Spawner Enumeration Project, prepared by Triton, 1999

magnitude of the peak flows, and their competency in mobilizing the bed. No analysis is provided on the potential for gravel loss although gravel replacement is listed as a mitigative measure in supplemental information provided by the Proponent[33].

Pumped water will introduce zooplankton and fine particulate material from the lake to the stream, and these changes (as well as temperature and water quality changes) can lead to reduced or altered invertebrate communities downstream of the water outlets. The proposed mitigation measures for metals (nano filtration of recirculated water) may affect stream fish communities if nutrients, particulate matter and organisms are removed from the recirculated water.

These affects usually attenuate with distance from the point of flow regulation. It is not possible to predict whether these changes will alter the potential for the residual streams to produce juvenile rainbow trout, but they should be considered a risk factor given the short length of the residual tributary streams.

Summary of Stream Habitat Assessment

To meet the Proponent's stated goal of a viable self-sustaining rainbow trout population in the Fish Lake ecosystem the two tributary streams must provide sufficiently productive spawning and juvenile rearing habitats to support the lake population.

This assessment has identified a number of risk factors associated with the isolation of the headwaters and recirculation of flow into the remaining segments of the spawning and rearing tributaries of Fish Lake. Many of these factors are very similar to those observed for water regulation and diversion projects. The need for mitigation of some of these effects (nutrients, temperature, DO) has been identified in the EIS, but few details are provided. While much of the focus of the Proponent's mitigative measures and adaptive management program is on Fish Lake, the goal of maintaining a viable ecosystem for the Fish Lake rainbow trout population cannot be achieved unless a similar program for the tributary streams is in place in the Adaptive Management Plan.

Lake Habitat

Lake productivity is governed by numerous abiotic and biotic factors, both internal and external to lake ecosystems (Wetzel, 2001). Food web productivity is closely regulated by the availability and proportions of limiting nutrients and light for autotrophic production, the efficiency of trophic energy transfers, and water quality parameters important to the persistence of fish species (Wetzel, 2001; Kalff, 2002). Other direct and indirect habitat limitations on fisheries productivity include factors that influence reproductive success and the survival of individuals and populations, such as the quantity of suitable spawning habitat, dissolved oxygen availability, sub-lethal and lethal contaminant levels in water and/or sediments, and predation rates (Hartman and Miles, 2001).

The recirculation of the Fish Lake watershed will impose several changes on the aquatic ecology of Fish Lake. In general, eutrophication of the system is expected, and would modify the structural and

[33] Information Request 25 – Lake Productivity – Mitigation Measures (submitted by Taseko Mines Limited to the Review Panel on February 28, 2013).

functional aspects of the lake ecosystem that support the rainbow trout population. The following sections explore what is known regarding nitrogen and phosphorus dynamics in Fish Lake in relation to the aquatic ecosystem, to aid in understanding the validity of the water quality and fish production models presented in the EIS and, in turn, the viability of the lake to function as a productive ecosystem that supports a population of rainbow trout. The discussion focusses on the native state of Fish Lake and future conditions with an adaptive management plan designed to preserve the functioning of the ecosystem as a recirculated, closed-system.

Understanding Limnology as it Relates to Fish Lake

Physical, chemical, and biological components (abiotic and biotic factors) in lakes interact to structure distinct lake ecosystems. Understanding the functional interactions between the biotic and abiotic factors comprising Fish Lake (including thermal regimes, stratification patterns, nutrient cycling/availability, and the diversity and productivity of biological communities) is a key step in assessing the ability of the Proponent to maintain the future productivity of Fish Lake under a novel recirculation regime. Unfortunately, there are no precedents for lake watershed recirculation to aid in understanding the potential effects of the New Prosperity Mine Project on the future food web and fisheries productivity in Fish Lake. Thus, water quality and fish production models that accurately characterize real food web limitations (nitrogen or phosphorus or both) throughout the growing season, that quantify dynamic cycling of nutrients within the lake, and that yield sufficient predictive power are essential to understanding changes on the trophic ecology of Fish Lake under the proposed recirculation scenario.

Determining Nutrient Limitations in Fish Lake

Nitrogen and phosphorus are the primary limiting nutrients to autotrophic productivity in lakes and are thus the basis for food web productivity supporting fish (Wetzel, 2001; Kalff, 2002). Determining whether a lake is nitrogen limited or phosphorus limited is most commonly determined through the comparison of lake water molar ratios of total nitrogen to total phosphorus ($TN:TP_{molar}$; Guildford and Hecky, 2000; Davies *et al*., 2004). Guildford and Hecky (2000) define algal productivity as nitrogen deficient when $TN:TP_{molar}$ is less than 20 and phosphorus deficient growth when $TN:TP_{molar}$ is greater than 50. Either nitrogen or phosphorus may become deficient at $TN:TP_{molar}$ values between 20 and 50. While the ratio of nitrogen and phosphorus is a broad measure of nutrient deficiency and limitation, the forms of nitrogen and phosphorus available for primary producers (i.e., bioavailable) is of critical importance to the production of biomass at higher trophic levels (i.e., trophic efficiency). As such, understanding the seasonal variation in biologically-available nutrient concentrations in the water column, in relation to lake physical processes, is important in understanding the effects of nutrient availability for primary production and ultimately food web and fisheries productivity.

The Proponent has characterized Fish Lake as a chronically phosphorus-limited ecosystem throughout the growing season. They have carried this assumption through to water quality modeling and it also forms the basis for their mitigation and adaptive management program to protect the aquatic ecology of Fish Lake in perpetuity. DFO challenged the broad characterization of Fish Lake as chronically phosphorus-limited during the 2009/2010 environmental assessment (Mainland, 2010), and in the current review, due to oversimplification in the characterization of seasonal nutrient availability in Fish Lake. Within the limitations of existing data, DFO has provided feedback to the Proponent during the current review (via the Review Panel), providing evidence for seasonal N-limiting conditions in Fish Lake (DFO, 2012a; DFO, 2012b). Data is lacking to determine the frequency, magnitude, and timing of nitrogen limitation in Fish Lake, and it could undermine the validity of the lake trophic status and fish productivity models, which are predicated upon the assumption of chronic phosphorus limitation of biological production.

Data Collection and Modeling Limitations - Seasonal Nutrient Deficiencies in Fish Lake

The Proponent's 2012 EIS assessment of nutrient limitation in Fish Lake was based upon new sampling conducted in 2011. Rather than collecting discrete water chemistry samples from specific depths, the Proponent integrated samples throughout the water column, effectively amalgamating samples from various lake layers into one sample. Such sampling does not reflect the important seasonal or spatial variation in nutrient availability in the Lake. While a water column-integrated sampling approach may approximate the overall ratio of nitrogen and phosphorus availability for the lake, annual limitation of food webs (and ultimately fisheries productivity) occurs during the ice-free, stratified period, within the biologically-active euphotic layer (area of light penetration stimulating primary productivity), and not throughout the water column (Wetzel 2001; Selbie *et al*., 2011). By contrast, previous lake water chemistry data collected for the project were sampled discretely from specific lake depths, which more accurately reflect the spatial and temporal complexity of nutrient availability in Fish Lake. These samples (data from 1993-2006) were not incorporated into the 2012 EIS analysis of nutrient limitation in Fish Lake, yet predictions of future food web productivity, fisheries productivity and water quality are directly dependent on understanding the true growing season nutrient limitation patterns in Fish Lake.

Data collected by the Proponent in their 2006 July and October sampling[34], demonstrate total nitrogen to phosphorus ratios ranging from 7.39 – 91.1, indicative of water ranging from severe nitrogen to severe phosphorus deficiency for autotrophic production. Quality assurance and control (QA/QC) samples are usually obtained to show data reliability, with replicate samples being analyzed to incorporate variability and estimate precision. Poor replication, however, and a high degree of variability in data from proximal sampling sites are evident in the 2006 data (DFO, 2013), yielding broad variability in the values available to assess nutrient limitation. Such poor data replication and the failure to incorporate spatially-resolved nutrient availability in the 2012 EIS water quality modeling substantially reduce confidence in the Proponent's characterization of Fish Lake seasonal nutrient dynamics. This leads to a greater level of uncertainty in the validity of the proposed adaptive management techniques, which employ water chemistry indicators.

The quality of model outputs is contingent upon the quality and representativeness of their inputs. It is noted that the nitrogen inputs to the water quality modeling (BATHTUB model) in both the EIS and subsequently in the responses to information requests by the Panel[35] are held constant throughout the

[34] Taseko Mines Limited, Prosperity Gold-Copper Mine Project Application/EIS, 2009
[35] Information Request 19 – Lake Productivity – Eutrophication (submitted by Taseko Mines Limited to the Review Panel on February 28, 2013).

season. As such, predicted nitrate (NO_3; readily bio-available N fraction) in the EIS and total nitrogen predictions in subsequent information[36] demonstrate exceedingly little seasonal variability. Moreover, NO_3 predictions for all mine phases and across all months predicted show no appreciable difference between epilimnetic and hypolimnetic NO_3 concentrations. The limited water chemistry data presented by the Proponent suggest that a lack of variability in predicted future nitrogen availability does not reflect real annual NO_3 availability, which is likely critically-important to future food web productivity in Fish Lake. Coupled with the Proponent's own lack of confidence in nitrogen predictions from their modeling effort, the failure to adequately capture current seasonal nutrient availability, and accurately predict future nutrient variability severely compromises confidence in the 2012 EIS predictions of future fish productivity in Fish Lake.

Seasonal Nitrogen Deficiencies in Fish Lake

The Proponent's claim that Fish Lake should be characterized as a chronically phosphorus-limited ecosystem was challenged by DFO during the 2009/2010 environmental assessment due to oversimplification in the characterization of growing season nutrient availability in Fish Lake (Mainland, 2010).

In Fish Lake, the euphotic zone is shallow (due to organic staining and biological turbidity), and is mostly contained within the density-isolated epilimnion during the growing season (Shortreed and Morton, 2000). As Fish Lake strongly stratifies for an extended period, surface waters exhibit a depletion of biologically-available inorganic nitrogen (i.e., nitrate, nitrite) within the euphotic zone throughout the growing season. While surface nitrate depletion occurs in BC lakes of varying trophic status (Shortreed *et al*., 2001; Selbie *et al*., 2011), the early onset, rate, and magnitude of NO_3 depletion in Fish Lake is great (likely due to the abundance of biologically-available phosphorous throughout the water column), and can impact the seasonal development of edible phytoplankton and energy flow to higher trophic levels including rainbow trout (DFO, 2013).

Several lines of evidence indicate Fish Lake experiences seasonal nitrogen deficient conditions for primary production. Moreover, the lake exhibits limnological characteristics that may exacerbate nitrogen deficiencies should recirculation of hypolimnetic waters to the tributaries proceed (*see* subsequent text). The historical data provided in the original EIS (Taseko, 2009) demonstrates that biologically-available inorganic nitrogen (e.g., nitrate) concentrations are at or below analytical detection limits throughout the water column across the entire growing season (i.e., May-October; DFO, 2013). This pattern suggests nitrogen must be principally sequestered in biota or exist in forms not readily available to food webs (i.e., dissolved organic nitrogen). While nitrification likely plays a role in fostering nitrate availability, as noted by Shortreed and Morton (2000) and the Proponent[37], chlorophyll *a* levels (indicative of algal production) below those expected given ambient phosphorus levels, and the presence and documented bloom formation of nitrogen fixing cyanobacteria in summer and fall

[36] Information Request 19 – Lake Productivity – Eutrophication (submitted by Taseko Mines Limited to the Review Panel on February 28, 2013).
[37] Information Request 25 – Lake Productivity – Mitigation Measures (submitted by Taseko Mines Limited to the Review Panel on February 28, 2013).

(Morton and Shortreed, 2000; Taseko, 2009[38]) suggest that the Fish Lake food web currently experiences nitrogen limitation during ecologically-important periods of the growing season. Shortreed and Morton (2000) highlight the potential ecosystem structural and physico-chemical consequences of the possible stimulation of nitrogen fixing cyanobacteria in Fish Lake:

> "Low numbers of nitrogen-fixing and potentially bloom-forming cyanobacteria (*Anabaena*, *Aphanizomenon*, and *Anabaenopsis*) were present in Fish Lake. Of these species only Anabaena was observed in Wasp Lake, and none of the three were observed in Big Onion Lake samples. Since these species are normally most abundant in summer, the low numbers of these species at the time of sampling was not unexpected. However, the low N:P ratio and high P concentration in all 3 lakes suggests that summer blooms of these deleterious nitrogen-fixing cyanobacteria may occur, given appropriate physical conditions. If of sufficient magnitude, these blooms can lead to decreases in DO, and may be a hazard to both the lake's fish population and to animals using the lakes as a water source." (Shortreed and Morton, 2000)

In contrast to seasonal nitrogen availability, biologically-available phosphorus (e.g., ortho-phosphate, PO_4^{-3}), deemed by the Proponent to be the food-web limiting nutrient, is available throughout the water column, across the growing season. While epilimnetic ortho-phosphate drawdown may occur during summer, ortho-phosphate concentrations in the metalimnion and hypolimnion increase as the growing season progresses, likely due to internal phosphorus loading from the sediments under annual hypolimnetic deoxygenation.

In response to information requested by the Panel in regards to lake mitigation[39], the Proponent indicates nitrogen limitation is not expected, but goes on to say that any nitrogen limitation will be alleviated by the biological response to nitrogen limitation suggesting:

> “Overall the process of recirculation would tend to favour the decrease in TN:TP, however we believe that this will be internally corrected in Fish Lake through the process of algal nitrification…”

While there is limited evidence for this *belief* in the 2012 EIS and subsequent information provided, and while nitrification does not principally occur via algae (but rather bacteria), a certain amount of bio-available nitrogen would likely be regenerated by nitrification of organic nitrogen, and partially via the “leakiness” of nitrogen fixing cyanobacteria. The relatively low chlorophyll *a* concentrations (indicative of algal production) in Fish Lake, given ambient phosphorus concentrations, however, do not indicate that these processes are currently adequate to offset seasonal nitrogen limitation of primary production under the current lake state, and raise uncertainty about any “internal correction” under the proposed recirculation regime. Furthermore, the direct effects of nitrogen limitation are not the sole impact on food webs. Should blooms of nitrogen fixing cyanobacteria form and/or become more prevalent during

[38] Appendix Appendix 5-2-A
[39] Information Request 25 – Lake Productivity – Mitigation Measures (submitted by Taseko Mines Limited to the Review Panel on February 28, 2013).

the growing season, shading of more energetically-important edible phytoplankton can result, intensifying reductions in primary productivity and the biomass of edible phytoplankton and supported food web features (i.e., rainbow trout).

The preceding discussion highlights the likely importance of seasonal nitrogen availability to food web productivity in Fish Lake and the potential uncertainties in future ecosystem dynamics associated with the proposed lake recirculation, yet the Proponent has predicted fish biomass using a model relating total phosphorus to fish biomass (Plante and Downing, 1993). Lower than expected chlorophyll *a* concentrations (indicative of algal production) relative to ambient total phosphorus concentrations in Fish Lake would suggest that perhaps a model using biological (i.e., phytoplankton) rather than chemical predictors would be more appropriate. In fact, the Plante and Downing (1993) model has a low predictive power ($r^2 = 0.61$), and thus higher uncertainty in predictions, relative to models that use primary productivity (i.e., photosynthetic rates) as a predictor of fish biomass such as Downing *et al*. (1990; $r^2 = 0.79$), Plante and Downing (1993; $r^2 = 0.68$), and Hume *et al*. (1996; $r^2 = 0.86$). Given the tenure of such models in the literature, it is unclear why the Proponent, in the decades of data collection prior to the 2012 EIS, did not collect data related to photosynthetic rates to support their analyses.

Ultimately, it is unclear that the current limnological characterization of Fish Lake, and the fish biomass predictions based upon chronic food web phosphorus limitation are sufficiently accurate to confidently predict changes to Fish Lake. Moreover, as indicated by the Proponent, their own predictions of future nutrient dynamics in Fish Lake are highly uncertain[40], and thus it is unclear how the recirculation of Fish Lake will impact nutrient cycling within the watershed and lake. Existing data indicate that this effort may enhance nitrogen deficiencies in the euphotic zone of Fish Lake, which have the potential to reduce fish productivity as a result of reduced food web productivity and/or trophic restructuring (i.e., stimulation of cyanobacteria).

Adaptive Management Relating to Fish Lake

The Proponent indicates that mitigation measures will be undertaken for the protection of water quality to buffer any increases in lake phosphorus concentrations and impacts on Fish Lake productivity (Taseko, 2012). In general, proposed mitigation methods to reduce phosphorus (i.e. hypolimnetic aeration, addition of alum to precipitate phosphorus), are accepted lake management practices for culturally-eutrophied lakes although success has varied across lake systems. The Proponent refers to “trigger or alert” phosphorus levels that, once exceeded, would trigger active mitigation. Based upon a reported range in baseline phosphorus conditions (15-42 µg/L), the Proponent calculated critical concentrations requiring mitigation to be in excess of 22-63 µg/L (~ 50% greater than baseline levels). The reported “trigger” range, however, was broad, and transcended multiple trophic state classifications. It was unclear what critical phosphorus concentration would precipitate mitigation actions, particularly as baseline conditions overlap with the predicted threshold range. The Review Panel requested further definition of thresholds to address these issues and further details of the

[40] Information Request 19 – Lake Productivity – Eutrophication (submitted by Taseko Mines Limited to the Review Panel on February 28, 2013).

Adaptive Management Plan for the preservation of Fish Lake which were provided in subsequent information by the Proponent which introduce new components to the plan which are assessed below[41].

The Adaptive Management Plan (AMP) developed by the Proponent has a monitoring, early warning, and action plan which will 'allow the operator to maintain a habitat capable of supporting a viable population of rainbow trout during the life of the mine'. The Proponent suggests that further details will be determined during the permitting phase, and would be adjusted as needed, effectively adaptively managing their adaptive management plan. Some details are provided and include the development of primary (i.e., total phosphorus, chlorophyll *a*, Secchi depth, dissolved oxygen) and secondary key indicators (i.e., metals, sulphates) of "lake health". The primary key indicators, aimed at detecting eutrophication have been set at 'Indication', 'Alert', and 'Action' thresholds of 15%, 35%, and 50% of baseline levels. There are several uncertainties related to the AMP proposed by the Proponent:

- Ecological effects and ultimate impacts on rainbow trout productivity from an elevation of total phosphorus from 35 µg/L to 52.5 µg/L may not be benign (i.e., induction or enhancement of N-limitation, trophic reorganization, cyanobacterial blooms).
- The timelines to design mitigation are set at 4 years which may not be realistic to address immediate concerns with nutrient levels in the lake.
- The timelines for mitigation of eutrophication (i.e. hypolimnetic aeration, hypolimnetic oxygenation) are presented as six months to one year (after design). If eutrophication occurs rapidly and enhances the depletion of hypolimnetic or under-ice oxygen, these timelines may not be realistic in preventing winter-kill of the rainbow trout population in Fish Lake.
- If depletion of the hypolimnetic or under-ice oxygen stimulate rapid internal loading, the rate of change in total phosphorus concentrations and food web effects could be faster than predicted.
- The AMP response times may not be sufficient to mitigate state-scale shifts in eutrophication caused by a non-linear internal loading.

In addition, the AMP details novel mitigation measures for anticipated metals contamination of water, which include nano filtration of a large volume of lake water at extremely high rates (~8000 L/min). Nano filtration of water is intended to remove multi-valent ions, but presumably will filter particulate matter, such as suspended organic detritus and organisms as well. This novel approach raises uncertainty about the impact of lake-water filtration on planktonic organisms as well as detrital and trophic recycling. If nitrogen recycling in the water column is important to nitrogen availability, as has been indicated by the Proponent, continuous filtration of the lake water may further impact nitrogen availability in Fish Lake. Given that the proponent does not provide an assessment of the interactions between water filtering and nutrient availability, lake water filtration raises considerable uncertainty for future nutrient dynamics in Fish Lake.

[41] Response to Federal Panel Supplemental Information Request 15/19/25/49 – Lake Productivity, Mitigation and Adaptive Management, Submitted by Taseko Mines Limited on June 5, 2013.

Similarly, contamination of lake sediments is proposed to be mitigated by way of nano-filtration. Few logistical details are offered for this approach and DFO is not aware of any examples where this approach has been conducted on this scale in a lake system. It is unclear how sediment would be removed to be filtered, and what would happen to the sediment following filtration. Additionally, the area over which this technique would be applied is not known. Further detail is required to assess the potential impacts of sediment filtration on substrate-associated fauna, lake turbidity, and sediment-sequestered nutrient and contaminant remobilization, as such changes have the potential to have harmful impacts on fish and fish habitat.

DFO recognizes the proposed mitigation efforts of nano filtration to address metal contamination in water and sediment is a relatively unique and untested approach that presents clear uncertainties in their interactive effects with plankton and nutrient recycling as well as physical impacts on benthos, water turbidity and sediment-water nutrient fluxes.

The mitigation, or at least delay in the eutrophication in Fish Lake might be achievable given the proposed mitigation techniques for reducing nutrients and enhancing oxygen. Uncertainties exist, however, as to the sub-mitigation habitat and fishery productivity effects of eutrophication in Fish Lake, and whether remediation timelines (i.e. months to years) are achievable and commensurate with persistence of a rainbow trout population (i.e., enhanced oxygen depletion and winter kill prior to successful mitigation). Successful adaptive management would be directly contingent upon monitoring efforts of sufficient duration, extent, and quality.

Summary of Lake Habitat Assessment

The recirculation of the Fish Lake watershed to support mine development will impose several changes on the aquatic ecology of Fish Lake. In general, eutrophication of the system is expected, and would modify structural and functional aspects of the ecosystem that support the rainbow trout monoculture.

The Proponent has attempted to predict the future water quality and fisheries production in Fish Lake under the proposed recirculation regime. Concern exists that current and future impacts of N-deficits on ecosystem productivity may be more substantial than has been characterized by the Proponent in the EIS and subsequent information. It is concluded that the recirculation regime may exacerbate existing N-limitations of food web production in Fish Lake, by recirculating N-deficient hypolimnetic waters to the inlets to maintain flows in spawning and rearing lotic habitats, and to combat the anticipated impacts of climate change on both lotic and lentic habitats in the manipulated watershed. Existing water quality model inputs likely do not capture real seasonal variability in N-availability in Fish Lake throughout the growing season, necessarily dampening variability in future water chemistry predictions. As predictions of future fish biomass in Fish Lake are predicated upon using a model assuming P-limitation (i.e. Plante and Downing 1993), the future dynamics of N in the system are critically important to the future abundance and biomass of rainbow trout in Fish Lake. At present, significant uncertainty exists in the predictions of fisheries productivity.

Several instances of poor data replication are noted in the historical data (Taseko 2009), which demonstrate a lack of representativeness in water chemistry sampling by the Proponent, and compromise assessment of the spatial and temporal complexities of nutrient limitation within the lake. These Quality Assurance and Quality Control issues raise concern and uncertainty regarding the likelihood that adequate monitoring will be undertaken to effectively implement the proposed adaptive management plan to mitigate unexpected ecosystem changes, as the adaptive management plan is based largely upon key water quality indicators. Furthermore, the ecological impacts of sub-Action Threshold changes (i.e. at Indication and Alert levels) on habitat quality and food web and fisheries productivity are not known, and raise uncertainty in the impacts of eutrophication on the rainbow trout population. Additionally, the Proponent describes novel filtration approaches to metals contamination of water and sediment. As noted, no assessment is provided on the potential impacts of these approaches on water quality, despite potentially important influences on habitat quality for rainbow trout (i.e. nutrient cycling, turbidity, filtration of seston).

Ultimately, as noted, there are a number of risks associated with the proposed recirculation that have not been addressed that raise substantial uncertainty in the future habitat and fisheries productivity of Fish Lake during and after mine development, and the ability of the lake system to support a self-sustaining rainbow trout population.

Fish and Fish Habitat Compensation Plan

In this section, DFO provides an assessment of the fish habitat compensation proposed by the Proponent to offset direct losses to fish habitat associated with the New Prosperity Mine Project. This assessment is focused on the conceptual merits of habitat compensation measures that have been proposed recognizing that should the project proceed to the regulatory stage a more detailed plan and assessment will be required. At present, DFO uses the existing habitat policies and program operational procedures (including the 1986 Policy for the Management of Fish Habitat) to guide regulatory decisions under the *Fisheries Act*. Generally, the habitat compensation proposed by the Proponent has been developed in accordance with the principles in the 1986 Policy and is generally consistent with that Policy. Further work would be required with the Proponent, the Province, and First Nations to ensure that the habitat gains expected to offset Project impacts are realized through the implementation of the compensation plans. Should the project proceed to the regulatory phase, DFO would work with the Proponent to finalize the accounting of the habitat gains predicted to ensure that they are accurately quantified based on appropriate metrics.

The Proponent predicts the New Prosperity Mine Project will directly affect 15,139 m^2 of stream habitat and 199,170 m^2 of riparian habitat in Middle and Upper Fish Creek and all of Little Fish Lake (6.6 ha). The direct effects associated with the Tailing Impoundment Area associated with the MMER are described separately from those associated with the other mine development impacts that are regulated through the *Fisheries Act*.

Fish and Fish Habitat Compensation related to the *Fisheries Act*

Impacts to fish and fish habitat outside of the tailings impoundment area footprint are regulated under the *Fisheries Act*, and include impacts to 12,367 m^2 of fish-bearing habitat and 2,772 m^2 of non-fish bearing habitat. Affected areas include portions of Reaches 5, 6, and 8 (all fish-bearing), Middle Fish Creek Tributary 1, Fish Lake Tributary 1, and portions of first order ephemeral stream. All 4,250 m^2 of naturally occurring spawning habitat upstream of Fish Lake is to be retained and access to additional 860 m^2 of rainbow trout spawning habitat through barrier removal and flow augmentation in Fish Lake Tributary 1 is proposed. Complete utilization of this spawning habitat during the Project is expected to support approximately 6,200 spawners, which is predicted to result in a population of 35,000 fish in Fish Lake.

To offset impacts to fish and fish habitat in the Fish Creek watershed, the following compensation is proposed:

1. Enhancement of Fish Lake tributaries through barrier removal and habitat enhancement;
2. Fish passage restoration;
3. Upgrades to existing diversion structures in the Haines Creek and Elkin Creek watersheds;
4. Riparian planting along drainage ditches and replanting along all restored watercourses and around the TSF and open pit; and
5. Re-commissioning the Hanceville Hatchery and fry outplanting to maintain genetic integrity of the Fish Lake stock.

1. Enhancement of Fish Lake tributaries through barrier removal and habitat enhancement

Taseko proposes to compensate for losses of tributary habitats by:

- creating approximately 860 m^2 of additional spawning and rearing habitat in Fish Lake Tributary 1 through channel excavation;
- enhancing rainbow trout spawning and rearing habitat in Fish Lake Tributary 1 and Reach 8;
- modifying or removing beaver dams as required to increase spawning habitat availability in Upper Fish Creek; and
- removing a barrier to fish passage in Fish Lake Tributary 3 to provide access to an additional 350 m of fish habitat.

While the proposed compensation options listed are relatively common measures that are well understood and technically feasible, more information would be required to quantify what the direct benefits to fish and fish habitat would be in the receiving environments.

Channel excavation above Reach 1 of Fish Lake Tributary 1 may allow fish access to Reach 2, however, this reach runs directly downstream of the proposed location of the western embankment of the tailings impoundment area, and may subject fish spawning and migrating in Fish Lake Tributary 1 to seepage water. As noted previously, Natural Resources Canada has questioned the validity of the Proponents predictions of groundwater seepage rates and thus the potential for contamination is uncertain. The proposed channel excavation will serve to improve hydraulic connectivity with Fish Lake and therefore there is a risk that Fish Lake Tributary 1 may become a rapid pathway for contaminant transport. A similar situation may exist for Reach 8 of Upper Fish Creek, which provides vital spawning habitat for Fish Lake rainbow trout. More detailed technical design information and existing habitat information would be necessary to provide a more thorough assessment of this measure; however, DFO accepts this as a technically feasible habitat compensation measures to offset spawning and rearing habitats that are impacted by the project.

Flow augmentation is also proposed by the Proponent as compensation in Reach 8 and Fish Lake Tributary 1, however, DFO considers this to be mitigation of potential Project effects and therefore the risks and uncertainties in the effectiveness of the flow augmentation in Fish Lake Tributary 1 and Reach 8 to enhance rainbow trout spawning and rearing habitat was discussed in the Fish Lake Mitigation section above.

Although beaver dams may provide fish habitat by creating upstream ponds, stabilizing flows and adding woody debris for cover, they may also present a barrier to fish movement, alter sediment transport regimes and increase water temperatures. Removal of beaver dams have the potential to negatively affect fish and fish habitat by dewatering the upstream pond, stranding fish and releasing sediment and large volumes of water (that can be devoid of oxygen, particularly in winter) downstream. Careful consideration of downstream impacts is necessary to avoid sedimentation or washing away of spawning gravels. If appropriate removal methods are utilized and careful consideration is given to impacts associated with beaver dam removal the resulting benefits of increasing spawning habitat availability in Upper Fish Creek may be realized. Further details on the existing habitats and operational designs and plans would be required to assessing the benefits from a more quantitative perspective.

2. Fish passage restoration

The Proponent proposes to conduct culvert replacements at 15 sites in the region surrounding the Project area, representing 272,445 m^2 of compensatory fish habitat. Of these sites, 5 culvert crossings are believed to be full barriers to fish passage and the remaining 10 sites are either partial barriers to fish passage (i.e., undersized culverts) or may be barriers to passage during low flows. There is a risk that improvements to fish passage may not realize significant benefits or see any fish use if resident fish populations are naturally small or have a limited range, and/or if habitats upstream of the barriers are not of sufficient quality and quantity to be of use to fish. While the Proponent has provided a good description of the area (m^2) of habitat that would be made accessible upstream of barriers, they have not provided a detailed breakdown of habitat type, quality or quantity, relying simply on an assumed ratio of 40:20:40 of pool:riffle:run. These ratios are based on observations made in sections of the Fish Creek watershed, which is more than 30 km away from some of these sites, making it difficult for DFO to draw reliable conclusions on the specific potential benefits of barrier removal at each of the proposed sites.

Culvert replacements to improve fish passage are considered an acceptable strategy as part of a broader compensation plan however, consideration of watershed location, existing habitat features and provincial fisheries management objectives will be important to ensure benefits are realized.

The Proponent has also proposed channel restoration, riparian planting and cattle fencing works associated with barrier site FP 13 on Nemaiah Creek, which Cariboo Envirotech Ltd. (2008) notes has been impacted by overgrazing cattle and horses resulting in poor quality spawning habitat in 400 m section of stream. Such proposed restoration works could be very beneficial to the resident rainbow trout and Bull trout populations, by providing high value spawning habitat for these species.

3. Upgrades to existing diversion structures in the Haines Creek and Elkin Creek watersheds

Upgrades to existing diversion structures in Haines Creek are proposed to enhance rainbow trout spawning and rearing habitats in Haines Creek and at the Eleven Sisters Lake, which will maintain (or increase) First Nation and recreational fishing opportunities. In the Elkin Creek watershed, a flow control structure is proposed to be upgraded and a protective set-back berm is proposed to be constructed to reduce bank erosion and sedimentation and increase flows to downstream habitats in Elkin Creek during freshet periods. The increased flows to lower Elkin Creek are expected to increase the quantity of perennial habitat for Steelhead, rainbow trout, Bull trout, Chinook salmon, Kokanee and several minnow species. Annual monitoring and management is estimated to cost $25,000 for each site. The Proponent notes that potential habitat gains associated with upgrades in both watersheds is uncertain.

The upgrades proposed by the Proponent in both watersheds will be beneficial to fish and fish habitat and have been proposed in consultation with the Ministry of Forest, Lands, and Natural Resource Operations staff. The proposed works appear to be technically feasible and the habitat gains associated with these works remains to be quantified. As such, DFO considers these works to be a viable component of the proposed fish habitat compensation plan at this time.

4. Riparian planting along drainage ditches and replanting along all restored watercourses and around the tailings storage and open pit

The Proponent proposes to plant or establish riparian areas totaling approximately 200,000 m^2. Some aspects of riparian reclamation are expected to be completed during the life-of-mine, such as planting along construction access road drainage ditches, whereas others are expected to be completed during closure, such as reclamation planting around the pit and tailings impoundment after approximately year 27. Although riparian areas are important to the overall functioning of a watershed, the some of the planting proposed may not function to offset direct project effects during the life of the mine. For example, drainage ditches for contact water from access roads are unlikely to provide food and nutrient values to fish habitat downstream but rather they may convey deleterious substances such as turbid run- off and contaminants. Riparian planting and restoration works are reasonably routine activities in fish habitat compensation plans, and such DFO does not have concerns regarding the technical feasibility of these compensation works provided planting occurs according to established guidelines and in priority areas where there are benefits to fish habitat. However, the relative merits of on-site planting compared to other compensation projects would need to be considered during the permitting phase should the project proceed.

5. Re-commissioning the Hanceville Hatchery and Recipient Lake Outplanting

To partly meet the objectives of the provincial Benchmark Statement Fish Management Objectives (MOE, 2008) , the Proponent proposes to re-commission the Hanceville Hatchery and outplant Fish Lake fry produced at the hatchery to two recipient lakes (Slim Lake and Lake 6267). Fish culture and lake stocking has been shown to be technically feasible and biologically sound. However, in the case of this Project, hatchery operation and outplanting may be required in perpetuity to achieve the desired results. Recipient lakes may be subject to substantial winter kill during severe winters and the outplanted rainbow trout populations may require supplementation on an ongoing basis. To maintain the genetic integrity of the Fish Lake stock, adequate numbers of fry need to be outplanted to recipient lakes. Thus, while DFO agrees that hatchery operations and fry outplanting are technically and biologically feasible, in order to determine the long-term sustainability of these activities to the success of the recreational fisheries and First Nations subsistence fisheries on recipient lakes, DFO recommends that the BC Ministry of Forests, Lands and Natural Resource Operations as well as First Nations be integral in the management of the hatchery and outplant operations. .

The Proponent also proposes to conduct angler awareness campaigns to attract recreational anglers to Fish Lake and the outplanted lakes. The success of outplanting activities will rely on ensuring that sufficient numbers of fish are outplanted to produce a genetically viable population and will likely require persistent human intervention beyond the planned mine life to maintain recreational angling opportunities. For instance, Slim Lake, a proposed recipient lake in the Proponent's outplant program, is relatively shallow lake (maximum depth = 14 m; mean depth = 5.6 m) and maybe subject to winterkill during severe winters. In such instances a portion of the stocked rainbow trout population may not survive and restocking may be necessary.

Fish and Fish Habitat Compensation related to the Metal Mining Effluent Regulation

As calculated by the Proponent, construction of the tailings impoundment area is expected to result in direct effects on 20,262 m^2 of instream fish habitat, 6.6 ha of lake habitat, and 117,805 m^2 of riparian fish habitat. The Proponent proposes to develop the Taseko Lake Off-Channel (TLOC) compensation site within the Taseko River watershed to offset these impacts. The TLOC will be connected to the Taseko River mainstem and is designed to provide habitat (all types) for Rainbow trout, Bull trout, Chinook Salmon, and other regionally important species. The TLOC design incorporates over 20 pools and alcoves that are intended to offset the loss in productive capacity of lake habitat as a result of the incorporation of Little Fish Lake into the tailings impoundment. Development of the TLOC is expected to replace rainbow trout habitat in upper Fish Creek and Little Fish Lake primarily with anadromous salmonid habitat. Cariboo Envirotech Ltd. (2008) determined there to be a general paucity of off-channel habitat in the Taseko River and suggested absences of this habitat type as potentially limiting salmonid production. The TLCO compensation element would provide perennial rearing, spawning and overwintering habitat for salmon, trout, and char.

As proposed, the TLOC appears to be a valuable compensation element in the Proponent's Fish Habitat Compensation Plan. DFO notes that this compensation plan is not directly offsetting the concerns raised by the TNG for the loss of Little Fish Lake.

From a preliminary assessment DFO is supportive of this conceptual plan and the potential benefits that could accrue, however, the Proponent has yet to determine land tenure, conduct groundwater assessments, topographic/LIDAR/geodetic surveys and an archaeological assessment to enable a proper technical evaluation of the feasibility of this compensation element.

Due to the lack of feasibility studies DFO notes the uncertainty associated with building the proposed off channel habitat:

- There may be a lack of hydraulic gradient between the lake and proposed channel that would prevent groundwater movement within the pools/channel.
- There is a risk that the required flow gradient cannot be realized based on the topography present at the site (assumptions are made for the adequacy of water supply to sustain the spawning habitat).
- There may be long term maintenance at the intake structure to ensure it functions.
- There may be long term maintenance if the blind pools experience sediment build-up and lack of flushing. If adequate groundwater is present at the site, the extensive use of blind pools in the design is more feasible.
- There is risk that isolated pools can become depleted in oxygen in winter, resulting in fish mortality (also noted by the Proponent[42]).

At a conceptual level DFO generally supports the habitat compensation measures/strategies proposed in both compensation plans and recognizes that the compensation and enhancement techniques are generally well understood and have been demonstrated in previous applications as technically feasible and beneficial to fish and/or fish habitats in certain circumstances. DFO agrees that the proposed compensation plan has elements that are consistent with existing DFO policies and that at a conceptual level the direct (footprint impacts) and indirect (flow) effects to fish habitat can be offset through the application of mitigation, compensation, and enhancement measures.

Should the Project proceed to the regulatory stage, DFO would work with the proponent on the required regulatory requirements and technical details pertaining to feasibility and habitat assessments to support a fish habitat compensation plan consistent with DFO's policy objectives.

Monitoring and Follow-up Plans

The Proponent proposes to design and implement follow-up and monitoring plans and programs to confirm the efficacy of mitigation measures, verify the accuracy of predicted environmental effects on aquatic ecology (i.e., water quality, fish health, benthic invertebrates, fish tissues, etc.) and ensure

[42] Response to Federal Panel Supplemental Information Request 26 – Fish Habitat Compensation Plan, Submitted by Taseko Mines Limited on February 28, 2013.

compliance with regulatory obligations. These monitoring plans and follow-up programs are expected to be implemented during construction, operations and mine closure. The Proponent also proposes to develop monitoring plans to examine the effectiveness of the fish habitat compensation works constructed as part of the Project.

The EIS identifies adaptive management as a valuable tool for mitigating environmental effects by monitoring outcomes of activities (e.g., mitigation measures) and identifying thresholds for concern ("alert" levels) and remedial action ("action" levels). When implement correctly, adaptive management can be a valuable tool to mitigate or avoid negative environmental effects, however, it relies heavily on carefully planned and detailed monitoring and follow-up plans and programs. Details regarding monitoring plans and follow-up programs have not been provided; however, the Proponent, has committed to provide this information during the regulatory phase of the Project should it proceed. In order to reliably evaluate the efficacy of the proposed Fish Lake recirculation system, the potential for failure of this mitigation, and associated effects on fish and fish habitat, a detailed understanding of relevant monitoring plans and follow-up programs is important. The supplemental information provided by the Proponent on the adaptive management plan, for fish habitat related monitoring plans and follow-up programs is limited and relatively generic in nature such that, DFO is unable to draw specific conclusions on the merit, technical feasibility or biological relevance of these plans/programs.

DFO recommends that any adaptive management program designed for the Project include monitoring of potential downstream effects in the Taseko River and actions to ensure any required mitigation is applied appropriately. As noted earlier, uncertainties exist in the adaptive management program proposed by the Proponent to maintain Fish Lake as a functioning ecosystem including uncertainty as to the effectiveness of the trigger values and appropriateness of primary indicators, timelines, and duration of mitigation. Furthermore, any adaptive management to ensure Fish Lake functions to support a minimum viable population of rainbow trout should include monitoring and mitigation for the tributary streams as they are integral to the functioning of the Fish Lake system.

Conclusion

The project has been redesigned to address the concerns of the previous panel for the preservation of Fish Lake. The Proponent has also offered mitigation and compensation measures to offset the loss of fish habitat associated with direct and indirect effects of the Project. The direct effects are characterized as permanent disturbances associated with Project infrastructure such as the open pit and tailings embankments whereas the indirect effects are characterized as those effects associated with flow reduction on instream habitat.

DFO's review notes the following:

- DFO generally agrees that the description of the existing fish habitat features and values in the Fish Lake watershed are adequately characterized by the Proponent.
- DFO generally agrees with the Proponent's characterization of the direct project footprint and indirect stream flow effects of the Project.

- DFO generally supports the habitat compensation measures/strategies proposed in the compensation plans and recognizes that the compensation and enhancement techniques are generally well understood and have been demonstrated in previous applications as technically feasible and beneficial to fish and/or fish habitats in certain circumstances.
- DFO agrees that conceptually, the direct and indirect project effects can be offset through appropriate mitigation and compensation.
- DFO has reviewed the proposed recirculation of flows in Fish Lake and has identified risks associated with the effectiveness of the mitigation. There is substantial uncertainty in the long term regarding fish habitat values and ecosystem functioning, which have the potential to reduce fisheries productivity of Fish Lake.
- Should the Project proceed to the regulatory stage, DFO would work with the proponent on the required regulatory requirements and technical details pertaining to feasibility and habitat assessments to support a fish habitat compensation plan consistent with DFO's policy objectives.
- Any adaptive management program designed for the Project should include monitoring of potential downstream effects in the Taseko River, uncertainties regarding the lake recirculation system, mitigation for Fish Lake tributary streams, and actions to ensure any required mitigation is applied appropriately.

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Fisheries and Oceans Canada | Pêches et Océans Canada

Fisheries and Oceans Canada

Submission to the
New Prosperity Gold-Copper Mine Project
Federal Review Panel

July 30, 2013

Canada

Fisheries and Oceans Canada | Pêches et Océans Canada

Outline

This presentation highlights the key points in DFO's written submission:

- Introduction
- Context for DFO's Review
- EIS Overview Relating to DFO's Review
- Project Effects
- Fish Habitat Compensation
- Fish Lake as a Recirculated, Closed System
- Monitoring and Follow-up
- Conclusions

2

Canada

Alston Bonamis

Alston has completed his Master's degree in Fisheries Science and Management, and has over 7 years of experience working in various areas of British Columbia on projects pertaining to fish and fish habitat.

SKILLS AND QUALIFICATIONS

People Skills
Effective interpersonal and communication skills. Able to work well in teams and independently.

Research Skills
Able to synthesize information from a variety of sources and present pertinent information in scientific and technical reports and multimedia presentations. Data entry and database management skills.

Computer Skills
Excellent aptitude in the use of MS Word, Excel, Access, PowerPoint and Publisher. Good working knowledge in the use of the R Statistical Package and ArcGIS.

Certifications
Class 5 BC Driver's Licence, Pleasure Craft Operators Card, Wilderness First Aid, Aircraft Underwater Egress, Electrofishing Certification, Canadian Aquatic Biomonitoring Field Technician Certification.

EDUCATION

Simon Fraser University, Burnaby, B.C. 2008 – 2012
Masters in Resource Management (M.R.M)

British Columbia Institute of Technology, Burnaby, B.C. 2004 – 2006
Diploma of Technology in Fisheries, Wildlife & Recreation Management

The University of British Columbia, Vancouver, B.C. 2000 – 2004
B.Sc. in Biology

PROFESSIONAL WORK EXPERIENCE

Fisheries and Oceans Canada, Vancouver, B.C October 2012 - Present
Fisheries Biologist (BI-02)

- Conducting regulatory reviews of small and large scale development projects in B.C. with the potential to affect fish and fish habitat
- Drafting Fisheries Act Authorizations, ensuring consistency with DFO's policy, mandate and legislative regime
- Engaging with DFO Science, Stock Assessment, Fisheries Management, the Salmon Enhancement Program, the Species at Risk Unit and other DFO programs to seek advice and input when conducting Project reviews and developing conditions of Authorizations
- Conducting compliance monitoring to ensure Proponent compliance with the conditions of Authorizations and with the Fisheries Act
- Liaising with other federal departments, First Nations and the province in environmental assessments for Projects where DFO is a Federal Authority

Fisheries and Oceans Canada, Vancouver, B.C. October 2011 - September 2012
Habitat Biologist (BI-02):

- Conducted statistical analyses using R and MS Excel to examine the effectiveness of DFO in achieving No Net Loss of Fish Habitat
- Co-authored two technical manuscript reports (currently in draft and under manager review)
- Conducted field habitat monitoring assessments of development projects authorized by DFO to examine proponent compliance and conformance with conditions of Authorizations
- Coordinated revisions of the Regional Habitat Monitoring Database and conducted QA/QC of field data entered during 2011-2012
- Developed a MS Excel data entry form to improve efficiency of data entry for remote Area offices and to facilitate easier uploading of field data to the Regional Habitat Monitoring Database

Parks Canada Agency, Vancouver, B.C. April 2011 - June 2011
Species at Risk Consultant (Contractor):

- Mapped critical habitat for species at risk using ArcGIS, and identified affected interests and stakeholders using BC's Integrated Land and Resource Registry
- Contacted First Nation groups to inform them of proposed critical habitat identified in traditional territories
- Communicated with land managers and landowners regarding designated critical habitat on private lands
- Liaised with Regional governments and municipalities to obtain landowner contact information and other information relevant to species at risk consultations
- Worked closely with Species at Risk teams to develop consultation plans for species at risk and appropriate messaging for communication materials

Fisheries and Oceans Canada, **CRMI,** Burnaby, B.C. May 2009 – December 2009
Fisheries Species at Risk Research Technician (EG-03):

- Conducted statistical analyses using the R Statistical Package to estimate baseline population abundance of the endangered Nooksack Dace and developed a quantitative model to predict Nooksack Dace capture efficiency
- Designed and compiled a multi-attribute MS Access database for Nooksack Dace field data
- Completed permit requests and filed scientific reports with government agencies
- Summarized preliminary technical and scientific findings at conferences and at a roundtable Recovery Planning Workshop for the Nooksack Dace
- Performed habitat surveys, mark-recapture sampling and single-pass electrofishing sampling
- Reviewed existing literature and legislation to develop preliminary long-term monitoring protocols and protection mechanisms for recovery of the Nooksack

Evergreen, Vancouver, B.C. February 2008 - August 2008
Environmental Stewardship Coordinator:

- Coordinated and led community stewardship and educational events at sites across the GVRD
- Liaised with city staff and members of non-profit organizations to plan, develop and deliver initiatives to engage local communities in environmental stewardship activities
- Recruited, trained, educated and coordinated volunteers for hands-on stewardship events, including the 8th Annual Earth Day Vancouver Celebration
- Reached out to multicultural community groups and agencies to encourage more diverse participation at stewardship events

- Designed, developed and distributed communication materials, including newsletters, brochures, flyers and posters
- Completed fundraising reports and proposals

Fisheries and Oceans Canada, Kamloops, B.C. August 2007 - November 2007
Fisheries Stock Assessment Technician (EG-02):

- Assisted in the application of fish tags for a sockeye mark-recapture project of the Horsefly river
- Performed seines on the river to obtain fish for tagging and sampling purposes
- Collected scale and otolith samples for study by the Pacific Salmon Commission
- Conducted live fish counts in rivers, lakes and streams via boat and on foot
- Monitored a fish enumeration fence to obtain an accurate estimate of migrating Cultus Lake Sockeye, a species at risk

Ducks Unlimited Canada, Dawson Creek, B.C. April 2007 - August 2007
Conservation Field Crew Supervisor:

- Met with managers to schedule and plan fieldwork for multiple wetland enhancement projects
- Met with field crews to outline project tasks, work locations and work completion deadlines
- Wrote project summary reports, completed expense forms and submitted invoices
- Worked in remote areas with field crews to maintain, restore and enhance wetlands
- Lead nature walks and educated students about natural systems and ecological processes
- Assisted researchers in conducting waterfowl surveys and bird banding studies
- Performed water quality analysis to determine habitat suitability for waterfowl and wildlife

Fisheries and Oceans Canada, North Vancouver, B.C. January 2007 – April 2007
Fish Habitat Laboratory Technician (EG-01):

- Worked in a laboratory setting and used laboratory equipment to assist researchers in conducting a baseline study on freshwater invertebrates
- Managed databases and performed data entry to maintain accurate and reliable records for analysis and interpretation
- Followed standard operating procedures and protocols for identification, classification and analysis of freshwater invertebrates

REFERENCES

Available upon Request

MICHAEL JAMES BRADFORD

Fisheries and Oceans Canada and Cooperative Resource Management Institute, School of Resource and Environmental Management, Simon Fraser University, Burnaby BC, V5A 1S6. 604-666-7912. mike.bradford@dfo-mpo.gc.ca

Mike Bradford has over 20 years experience as a Research Scientist with the Fisheries and Oceans Canada in the Environment Science and Salmon and Freshwater Ecosystems Divisions of DFO's Science Branch. He has conducted research on a wide range of topics, generally focused on the interactions between fish populations and freshwater habitats, impacts of human activities on habitat, and strategies for the management of fish and fish habitat. Areas of specialization include the ecology of salmonids in streams, the effects of flow alterations on fish and habitat, and the use of adaptive management to resolve resource management issues. He is consulted widely on these topics, and has been involved in advisory processes from Alaska to Arizona.

Education

1987-1991	Doctor of Philosophy, McGill University, Montreal, QC. Thesis: 'The role of environmental heterogeneity in the evolution of life history strategies of the striped ground cricket.'
1982-1984	Master of Science, Biology, Simon Fraser University. Thesis: 'The use of otolith microstructure to estimate the size and growth of juvenile chinook salmon'.
1975-1980	Bachelor of Science, Biology, Simon Fraser University, Vancouver, B.C.

Awards

1991	NSERC and FCAR (Quebec) Post-doctoral fellowship (both declined)
1990-1991	Max Bell fellowship, McGill University
1987-1990	NSERC Post-graduate scholarship
1979-1984	Science subvention grant, CDFO; B.C. Packers fisheries scholarship

Recent Work Experience

1992- Present Research Scientist, Dept. Fisheries and Oceans. Current research activities:
- -Effects of flow regulation on stream ecosystems and salmonid fishes.
- -Conservation of threatened salmon populations.
- - Ecology of juvenile chinook salmon in the Fraser and Yukon rivers.
- - Status of endangered freshwater fish

1996-Present Visiting Assistant (1996-1998) and Adjunct Professor, School of Environment and Resource Management, Simon Fraser University. Instructor for graduate class 'Simulation Modeling in Resource Management', graduate student advisor.

1984-1987 Research assistant for Dr. R.M. Peterman, Simon Fraser University.

Select Recent Professional Activities

2013	Member of expert panel, southern BC chinook salmon
2012	Invited speaker, Canadian Water Resources Association symposium on Environmental Flows, Banff AB.

2012	Member of expert panel, Alaska-Yukon-Kuskokwim Strategic Science Initiative
2011	Expert witness, Cohen Commission on the decline of Fraser River sockeye salmon
2010-2011	Member, Monitoring and Technical Task Group, Athabasca River (CEMA).
2010	Member of expert panel, Pacific Salmon Commission Workshop on the Decline of Fraser River Sockeye Salmon. Nanaimo.
2009	Chair, Aquatics Protocol Evaluation Panel, Grand Canyon Adaptive Management Program, Flagstaff Arizona
2008	Symposium Chair, AFS Annual Meeting "Hydropower and sustainable fisheries"
2007	Project leader, Biological Risk Assessment for Six Invasive Freshwater Fish Species
2006	External Reviewer, Canadian Atlantic Salmon Status Review, Moncton NB
2006	Invited speaker, Sustainability of the Arctic-Yukon-Kuskokwim salmon fisheries symposium, Anchorage AK.
2006	Invited participant, workshop on long-term experimental plan, Grand Canyon Adaptive Management Program, Flagstaff AZ.
2004-Present	Associate Editor, Canadian Journal of Fisheries and Aquatic Sciences
2003-2005	Associate Editor, North American Journal of Fisheries Management
2003-2005	Member, Cultus Lake Sockeye Salmon recovery team
2003-2005	Member, Interior Fraser Coho Salmon recovery team.
1997-Present	Member, Salmon Subcommittee, Pacific Science Advice Review Committee, DFO
2002	Invited speaker, Oregon salmon habitat restoration workshop, Portland OR.
2001	Chair, Protocol Evaluation Panel, Fisheries and Aquatic program review, Grand Canyon Monitoring and Research Center, Flagstaff AZ.

Refereed Publications

Cleary, J.S., Bradford, M.J., D.M. Janz. 2012. Seasonal and spatial variation in lipid and triacylglycerol levels in juvenile chinook salmon (*Oncorhynchus tshawytscha*) from the Bridge River, British Columbia. Limnologica 42:144-50

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Mossop, B. and M.J. Bradford. 2004. Importance of large woody debris for juvenile chinook salmon habitat in small boreal forest streams in the upper Yukon River basin, Canada. Can. J. For. Res. 34:1955-1936.

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93:263-267.

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Shardlow, T., R. Hilborn, R.M. Peterman, G.J. Steer and M.J. Bradford. 1985. Density dependent catchability coefficients. Trans. Amer. Fish. Soc. 114:436-440.

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Peterman R.M., D. Marmorek, B. Beckman, M. Bradford, N. Mantua, B.E. Riddell, M. Scheuerell, M. Staley, K. Wieckowski, J.R. Winton, C.C. Wood. 2010. Synthesis of evidence from a workshop on the decline of Fraser River sockeye. June 15-17, 2010. A Report to the Pacific Salmon Commission, Vancouver, B.C.

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Bradford, M.J., Hume, J.M.B., Withler, R.E., Lofthouse, D., Barnetson, S. Grant, S., Folkes, M., Schubert, N., Huang, A-M. 2010. Status of Cultus Lake sockeye salmon. DFO Can. Sci. Advis. Sec. Res. Doc. 2010/nnn. vi + xx p.

Brown, T.G., Runciman, B., Bradford, M.J. and Pollard, S. 2009. A biological synopsis of yellow perch (*Perca flavescens*). Can. Man. Rept. Fish. Aquat. Sci. 2887.

Brown, T.G., Runciman, B., Pollard, S., Grant, A.D.A., and M.J. Bradford. Biological synopsis of smallmouth bass (*Micropterus dolomieu*). Can. Man. Rept. Fish. Aquat. Sci. 2887.

Bradford, M.J., C.P. Tovey and Herborg, L.M. 2008. Biological Risk Assessment for Yellow Perch (*Perca flavescens*) in British Columbia. Canadian Science Advice Secretariat Res. Doc 2008:073.

Bradford, M.J., C.P. Tovey and Herborg, L.M. 2008. Biological Risk Assessment for Northern Pike (*Esox lucius*), Pumpkinseed (*Lepomis gibbosus*), and Walleye (*Sander vitreus*) in British Columbia. Canadian Science Advice Secretariat Res. Doc 2008:074.

Tovey, C.P., M.J. Bradford and Herborg, L.M. 2008. Biological Risk Assessment for Smallmouth Bass (*Micropterus dolomieu*) and Largemouth bass (*Micropterus salmoides*) in British Columbia. Canadian Science Advice Secretariat Res. Doc 2008:075.

Bradford, M.J.,J. Amos, C.P. Tovey, J.M.B. Hume, S. Grant, and B. Mossop. 2007. Abundance and migratory behaviour of northern pikeminnow (*Ptychocheilus oregonensis*) in Cultus Lake, British Columbia and implications for predator control. Can. Tech. Rept. Fish. Aquat. Sci. 2723.

Bradford, M.J. and C.C. Wood. 2004. A review of biological principles and methods involved in setting minimum population sizes and recovery objectives for the September 2004 drafts of the Cultus and Sakinaw Lake sockeye salmon and Interior Fraser coho salmon recovery plans. Canadian Scientific Advisory Secretariat Res. Doc. 2004/128

Hatfield, T, Lewis, A., Ohlsen, D. and M.J. Bradford 2004. Development of instream flow thresholds as guidelines for reviewing proposed water uses. Report to the Province of British Columbia.

Cultus Sockeye Recovery Team. 2004. National recovery strategy for sockeye salmon (*Oncorhynchus nerka*), Cultus Lake population, in British Columbia. National Recovery Strategy No. XXX. Recovery of Nationally Endangered Wildlife (RENEW). Ottawa, Ontario, 57 pp.

Interior Fraser Coho Recovery Team. (2004). National recovery strategy for coho salmon (*Oncorhynchus kisutch*) in the Interior Fraser River watershed, British Columbia, Consultative Draft. 124 pp

Mossop, B. and M.J. Bradford. 2004. Effects of marine and freshwater environmental variables on the survival rates of Thompson River coho salmon. Contract report to Randall Peterman, SFU.

Bradford, M.J. and T. Hatfield. 2004. Development of instream flow screening tool and guidelines for small hydro in the Pacific Region. Pp 71-72 in Randall, R.G. et al. eds. Science technology transfer workshop- science contributions towards improving fish habitat management. CSAS Proceedings Series 2004/10.

Jang, J. and M.J. Bradford. Yukon River Juvenile Chinook and Chum Salmon Out-Migration Timing and Sampling Characteristics as Determined Using a Rotary Auger Trap, 2002. Contract report to the Yukon River Panel. Whitehorse YT.

Bradford, M.J., and five coauthors. 2001. Report of the Aquatic Protocol Evaluation Program Panel. For: Grand Canyon Monitoring And Research Center, Protocols Evaluation Program. 43pp.

Irvine, J.R. and M.J. Bradford. 2000. Declines in the abundance of Thompson River coho salmon in the interior of southern British Columbia, and Canada's coho recovery plan In L. Darling (editor). Proceedings Biology and Management of Species and Habitats At Risk conference, 15 – 19 February, 1999, University College of the Cariboo, Kamloops, B.C. B.C. Environment, Wildlife Branch, Victoria, B.C. and University College of the Cariboo, Kamloops. B.C.

Irvine, J.R., R. E. Bailey, M. J. Bradford, R. K. Kadowaki, and W. S. Shaw. 1999 Assessment of Thompson River/Upper Fraser River Coho Salmon. Can. Stock Assess. Secretariat Res. Doc. 99/128.

Bradford. M.J. 1998. A risk assessment for Thompson River coho salmon. Canadian Stock Assessment Secretariat Report 98/92.

Bradford, M.J. 1997. Partitioning mortality in Pacific salmon. In RL Emmett and MH Schiewe (eds.). Estuarine and ocean survival of Northeastern Pacific Ocean. NOAA/NMFS-NWFSC-29.

Taylor, G.C., J. A. Allan and M.J. Bradford. 1996. Juvenile chinook sampling data, Slim Creek, and Bowron River, British Columbia, 1995. Can. Data Rept. Fish. Aquat. Sci. 979:30 pp.

Taylor, G.C., J. A. Allan and M.J. Bradford. 1995. Juvenile chinook sampling data, Slim Creek, and Fraser River mainstem, British Columbia, 1994. Can. Data Rept. Fish. Aquat. Sci. 964

Allan, J.A., Taylor, G.C., and M.J. Bradford. 1995. Juvenile chinook sampling data, Chilcotin watershed, British Columbia, 1994. Can. Data Rept. Fish. Aquat. Sci. 942

Bradford, M.J. and G.C. Taylor. 1995. An update on methods for measuring the intragravel environment of incubating salmon eggs and larvae. Can. Tech. Rept. Fish. Aquat. Sci. 2025.

Taylor, G.C., J. A. Allan and M.J. Bradford. 1994. Juvenile chinook sampling data, Slim Creek, British Columbia, 1993. Can. Data Rept. Fish. Aquat. Sci. 942

Taylor, G.C. and M.J. Bradford. 1993. Results of rotary auger trap sampling, lower Stuart River, in April and May, 1992. Canadian Manuscript Report of Fisheries and Aquatic Sciences 2211.

EDUCATION

UNIVERSITY OF BRITISH COLUMBIA, Vancouver, BC **1989**

Bachelor of Science degree in Zoology (B.Sc.). Specializing in Marine Biology and Ecology

RELEVENT EXPERIENCE

ECOSYSTEM MANAGEMENT BRANCH
Fisheries Protection Program

Regulatory Review Manager **2013 to present**

- Leading and managing the Fisheries Protection Units located in Vancouver and the Triage and Planning Unit responsible for delivery of the regulatory activities for the Fisheries Protection Program.
- Liaising with clients and stakeholders to build relationships and provide advice and direction on Fisheries Act, CEAA regulatory responsibilities and supporting program activities.
- Coordinating with BC and Yukon government on priority Fisheries Protection Program activities to facilitate regulatory coordination and streamlining to achieve regional, national and international Fisheries Protection Program operational goals and objectives.
- Participating and supporting national program committees and working groups to support policy development and interpretations and program operational guidance.

Habitat Protection and Sustainable Development, Pacific Region

Regional Habitat Manager **2010 to 2013**

- Leading the delivery of the Regional Habitat Management Program across all 5 Pacific Region Areas to ensure consistent and coherent delivery of the regulatory program and associated supporting activities. Working with Area Managers to develop annual regional priorities, guidelines, and operating procedures to meet operational needs consistent with national program Standard Operating Policies;
- Responsible for managing a team of 16 people in Regional Headquarters on multiple program areas, including Federal Contaminated Sites Action Plan, Habitat Compliance Monitoring, and Regional Regulatory Improvement Initiative;
- Liaising with clients and stakeholders to build relationships and provide advice and direction on Fisheries Act, CEAA regulatory responsibilities and supporting program activities.
- Coordinating with BC and Yukon government on priority Habitat Management program activities to facilitate regulatory coordination and streamlining.
- Participating and supporting national program committees and working groups to support policy development and interpretations and program operational guidance.

Regional Habitat Coordinator / Team Leader-Water **2007-2010**

- Coordinating Regional Habitat Management Program regulatory activities to ensure consistent delivery of the Program consistent with Regional priorities and Operating Policies;
- Leading and coordinating Regional involvement in various National and Regional Working Groups and policy development committees related to the Habitat Management Program;
- Preparing briefings and regulatory advice for senior mangers on issues related to the delivery of the Habitat Management Program, associated federal legislation and departmental policies;
- Partnering and collaborating with Provincial government agencies and non-governmental stakeholders and industry clients groups such as, BC Hydro, Coastal Forest Industry, on developing regulatory streamlining and guidance tools and various initiatives aimed at improving the delivery of the Habitat Management Program;

FISHERIES AND AQUACULTURE MANAGEMENT,

Resource Management, Regional Headquarters

Ecosystem Approach Officer **2009**

- Regional coordination and support for the implementation of ecosystem based management of fisheries consistent with the Sustainable Fisheries Framework. Lead Regional contact for ecosystem issues for the department on ecosystem based fisheries management initiatives, including tools and initiatives under the Sustainable Fisheries Framework, including the Fisheries Checklist, Sensitive Benthic Areas Policy, Ecological Risk Assessment Framework, Precautionary Framework, and Forage Species Policy;
- Coordinated with Science and Resource Management units on short and long term planning for and the development of regional strategies for implementation of the SFF policies and initiatives;

ECOSYSTEM MANAGEMENT BRANCH,

Environmental Assessment Major Projects, Regional Headquarters

Senior Assessment Biologist / Habitat Biologist **2000-2002 & 2004-2007**

- Conducted environmental impact assessments on major projects as well as on smaller scale projects on urban, agricultural and industrial development proposals in freshwater and marine habitats. Leading departmental participation in environmental assessment processes under *Canadian Environmental Assessment Act* (*CEAA)*;
- Provided authoritative scientific advise to regional managers, clients and stakeholders and on environmental assessment legislation (CEAA), and departmental policies to the regional DFO Habitat Management operations and activities and associated compliance requirements;
- Responsible for reviewing and preparing environmental assessment reports, *Fisheries Act* authorizations, and briefing notes and ministerial correspondence for senior management;
- Evaluated and negotiated fish habitat protection conditions, mitigation measures, habitat compensation measures in accordance with current DFO Habitat Management Policies;
- Prepared *Fisheries Act* authorizations and conducting compliance and effectiveness monitoring for approved work sites/projects. Based on monitoring and site investigations for potential *Fisheries Act* violations, conduct appropriate actions related to compliance and enforcement;

SCIENCE BRANCH

Stock Assessment, Lower Fraser Area, Delta, BC

Program Head / Senior Technician **1993-2000 & 2002-2004**

- Planned, implemented and managed the stock assessment program for pink and sockeye salmon stocks in the Lower Fraser Area. Provided scientific support, advice and recommendations to fisheries managers, international clients and First Nations on programs, policies and strategies to support management of fisheries and conservation of fish stocks;
- Analyzed and interpreted stock assessment data and reporting trends in abundance to local, regional and international clients. Responsible for the preparation of stock status reports and technical reports summarizing stock status and assessment activities;
- Responsible for planning, managing and leading project teams conducting stock assessment studies and field activities on sockeye and pink salmon stocks throughout the Fraser River watershed;

Previous Experience (prior to 1993)

- Salmon farm biologist
- Consultant field biologist

DANIEL THOMAS SELBIE, Ph.D.

Head, Lakes Research Program
Science Branch, Fisheries and Oceans, Canada
Cultus Lake Salmon Research Laboratory
4222 Columbia Valley Hwy.
Cultus Lake, BC V2R 5B6 Canada
Phone: (604) 824-4702; Fax: (604) 858-3757
E-mail: Daniel.Selbie@dfo-mpo.gc.ca

Adjunct Professor
Cooperative Resource Management Institute
School of Resource and Environmental Management
Faculty of Environment
Simon Fraser University, Burnaby BC

and

Department of Geography,
University of the Fraser Valley,
Abbotsford, BC

Education and Training:

2006-2008 **Moore Foundation Research Fellow,** *Department of Biology, McGill University, Montréal, QC, Canada*
Research Focus: Long-term perspectives on sockeye salmon productivity throughout the North Pacific Ocean
Principal Investigators: I. Gregory-Eaves, McGill University; D.E. Schindler, University of Washington; P.R. Leavitt, University of Regina and B.P. Finney, Idaho State University

2002-2008 **Doctor of Philosophy (Ph.D.)**, *Department of Biology, Queen's University at Kingston, ON, Canada*
Thesis: Large-scale exogenous forcing of Pacific salmon population and ecosystem dynamics in western North America; Supervisor: John P. Smol

2002 **Promotion to Ph.D. Programme***, Department of Biology, Queen's University, Kingston, ON, Canada*
Mini-MSc. Thesis: Water quality impacts of freshwater cage and hatchery aquaculture; Supervisor: John P. Smol

1996-2000 **Bachelor of Science, Honours** (**BScH)**, *Environmental Biology, School of Environmental Studies and Department of Biology, Queen's University, Kingston, ON*
Thesis: Net diatoms as bio-indicators of lake trophic status in southeastern Ontario; Supervisor: J.P. Smol

Relevant Employment and Appointments:

2013-Present **Associate Editor, Editorial Advisory Board, Environmental Reviews,** *National Research Council (NRC) Research Press*

Cultus Lake Sockeye Salmon Recovery Team Member, *Fisheries and Oceans Canada*

2011-Present **Adjunct Professor,** *Department of Geography, University of the Fraser Valley, Abbotsford, BC, Canada*

DFO Science Branch Designate, *Fisheries and Oceans Canada Committee on the Renegotiation of the Columbia River Treaty between Canada and the United States of America*

Water Quality Technical Team Member, *Shuswap Lakes Integrated Planning Process (Inter-governmental initiative)*

2010-Present **Section Head (8 acting appointments; > 4 months total),** *Freshwater Ecosystems Section, Fisheries and Oceans Canada*

2009-Present **Designated Senior Officer (DSO),** *Cultus Lake Salmon Research Laboratory, Fisheries and Oceans Canada, Cultus Lake, BC, Canada*

2009-Present **Program Head,** *Lakes Research Program, Fisheries and Oceans Canada, Cultus Lake Salmon Research Laboratory, Cultus Lake, BC, Canada*

Adjunct Professor, *School of Resource and Environmental Management, Faculty of Applied Sciences, Simon Fraser University, Burnaby, BC, Canada;* (Renewed to Dec 2014)

Research Program Advisor, *Quesnel River Research Centre, University of Northern British Columbia*

2008-Present **Research Biologist,** *Science Branch, Fisheries and Oceans Canada, Cultus Lake Salmon Research Laboratory, Cultus Lake, BC, Canada*

2001 **Editorial Assistant,** *Springer Academic Publishers; Assisted in production of the Atlas of Chrysophycean Cysts: Volume II*

Editorial Assistant, *Hodder-Arnold Publishers; Assisted in the production of Pollution of Lakes and Rivers: A Paleoenvironmental Perspective*

1999-2000 **Project Manager**, *Haliburton Drag River Rehabilitation Project, Haliburton, ON, Canada*
Joint Ontario Ministry of Natural Resources/Human Resources and Development Canada walleye fisheries enhancement and community development initiative ($750,000 CDN);

Project Focus: Fish habitat and geotechnical enhancement, contaminated groundwater remediation;

Responsibilities: Project design and implementation; identification and elimination of stressors; provincial and federal permit application; employee and volunteer acquisition, supervision and management (14 people); community, steering committee and governmental liaison

Academic & Research Service:

2006-Present **Journal and Technical Report Peer Reviewer,** *The Cohen Commission of Inquiry into the Decline of Sockeye Salmon in the Fraser River, Committee on the Status of Endangered Wildlife in Canada (COSEWIC), Frontiers in Ecology and the Environment, Canadian Journal of Fisheries and Aquatic Sciences, Canadian Water Resources Journal, Diatom Research, Journal of Paleolimnology, American Fisheries Society Symposium Series, Canadian Technical Reports in Fisheries and Aquatic Sciences*

2005-Present **International Funding Proposal Reviewer,** *North Pacific Research Board, Pacific Salmon Commission Northern Endowment Fund, Sigma Delta Epsilon Graduate Women in Science Program*

2011 **Session Co-Chair, Recent Effects of Climate Change on Lakes** *Canadian Conference for Fisheries Research (CCFFR) / Society of Canadian Limnologists (SCL) Conference. Toronto, ON.*

2011 **Textbook Reviewer,** *Experiential Science 30: Freshwater Systems, Introduction to Freshwater Ecology, University of British Columbia Press*

2008 **Academic Integrity Arbitrator,** *University of Sussex, UK, Independent Dissertation Integrity Review*

2002-2003 **Seminar Series Organizer,** *Limnology & Aquatic Ecology Seminars, Department of Biology, Queen's University*

Merit-Based Scholarships, Fellowships and Awards:

2009-2010	**FQRNT Québec Provincial Postdoctoral Fellowship**	**$60,000 (Declined)**
2005-2006	**Queen's University Thesis Completion Bursary**	**$4,000**
2005	**Queen's University Graduate Award**	**$4,500**
	Best Student Presentation Award, *IGBP-PAGES (International Geosphere-Biosphere Programme* Past Global Changes) 2nd International	

Open Science Meeting, Paleoclimate, Beijing, China

2004	**Ontario Graduate Scholarship**	**$15,000**
	Reuben Wells Leonard Graduate Fellowship	**$10,000 (Declined)**
	Queen's University Athletics Club Award for Dedication	
2003	**Fisheries and Oceans Canada (DFO) NSERC Scholarship**	**$5,000**
	Queen's University Doctoral Travel Award	**$3,000**
2002-2004	**Natural Sciences and Engineering Research Council (NSERC) Doctoral Scholarship**	**$40,100**
	NSERC Northern Graduate Scholarship	**$10,000**
2001	**Ontario Graduate Scholarship (OGS)**	**$15,000**
2000-2006	**Queen's University Conference Travel Awards**	**$2,100**
2000	**Queen's University Graduate Award (QGA)**	**$5,900**

Competitive Research Grants and Support:

2013-2014	**Pacific Salmon Commission: Northern Endowment Fund** *Investigating freshwater mechanisms for reduced survival of Skeena River sockeye production: Babine Lake (With Skeena Fisheries Commission; $163,568 for Selbie)*	**$177,568**
	Pacific Salmon Commission: Southern Endowment Fund *Mechanisms regulating juvenile growth and survival of Shuswap Lake sockeye salmon ($50,000 for Selbie)*	**$50,000**
2012-2013	**Fisheries and Oceans Canada: Aquatic Climate Change Adaptation Services Program** *Linking variations in Fraser River sockeye salmon stocks to Pacific Ocean productivity and climate variability using stable isotopes ($40,800 for Selbie)*	**$40,800**
	Shuswap Lakes Integrated Planning Process (SLIPP) *Water quality changes in Shuswap and Mara Lakes and their influence on Pacific salmon production in freshwater ($47,000 for Selbie)*	**$47,000**
2011-2013	**Canadian Space Agency: Earth Observation Application Development Program (EOADP)** *LakeView: Earth observation of water quality in salmonid lakes in British Columbia (With ASL Environmental Sciences; capital acquisitions for Selbie)*	**$533,257**
	Canadian Wildlife Federation: Endangered Species Fund *A nutrient loading and source model for Cultus Lake, BC: Critical habitat for endangered sockeye salmon and threatened pygmy sculpin (With Fraser Basin Council; $55,590 for Selbie)*	**$60,190**
2011-2012	**Shuswap Lakes Integrated Planning Process (SLIPP)** *Water quality changes in Shuswap and Mara Lakes and their influence on Pacific salmon production in freshwater ($17,000 for Selbie)*	**$17,000**
2011	**Fraser Salmon and Watersheds Program** *A nutrient loading and source model for Cultus Lake, BC: Critical habitat for endangered sockeye salmon and threatened pygmy sculpin (With Fraser Basin Council; $19,000 for Selbie)*	**$44,000**

2009	**Yukon Geological Survey** *Heterogeneity in northern climate trends and freshwater resources: The influence of glacial modulation (with I. Gregory-Eaves (McGill), J.P. Smol (Queen's), J. Sweetman (Parks Canada)*	**$15,000**
2008-2011	**Canadian Foundation for Climate and Atmospheric Sciences** *Heterogeneity in northern climate trends and freshwater resources: The influence of glacial modulation (with I. Gregory-Eaves (McGill), J.P. Smol (Queen's), J. Sweetman (Parks Canada)*	**$199,500**
2003	**Fisheries and Oceans Canada** *Cumulative impacts of climate change and salmon introductions*	**$4,000**
	Indian and Northern Affairs Canada, Northern Scientific Training Program	**$2,400**
2002	**Indian and Northern Affairs Canada, Northern Scientific Training Program**	**$2,620**
	Champagne and Aishihik First Nations *Landscape modification of Pacific salmon colonization and extirpation; Validating oral history and exploring past salmon-human interactions*	**$5,000**

Peer-Reviewed Scientific Publications: (underline indicates supervised student, post-doc, or employee)

Rogers, L.A., Schindler, D.E., Lisi, P.J., Holtgrieve, G.W., Leavitt, P.R., Bunting, L., Finney, B.P., **Selbie, D.T**, Chen, G., Gregory-Eaves, I., Lisac, M.J., and P.B. Walsh. 2013. Centennial-scale fluctuations and regional complexity characterize Pacific salmon population dynamics over the last five centuries. ***Proceedings of the National Academy of Sciences of the United States of America.*** 110: 1750-1755.

Selbie, D.T. 2012. Sufficiency review of lake productivity information contained in the environmental impact statement for the New Prosperity Gold-Copper Mine project. ***Canadian Science Advisory Secretariat.*** Science Special Response 2012/039.

Selbie, D.T. and E.A. MacIsaac. 2012. Sufficiency review of the draft lake productivity information submitted in relation to the New Prosperity Gold-Copper Mine project. ***Canadian Science Advisory Secretariat.*** Science Special Response 2012/40.

Holtgrieve, G.W., Schindler, D.E., Hobbs, W.O., Leavitt, P.R., Ward, E.J., Bunting, L., <u>Chen, G.J.</u>, Finney, B.P., Gregory-Eaves, I., Holmgren, S., Lisac, M.J., Lisi, P.J., Nydick, K., Rogers, L.A., Saros, J.E., **Selbie, D.T.**, Shapley, M.D., Walsh, P., and A.P. Wolfe. 2011. A coherent signature of anthropogenic nitrogen deposition to remote watersheds of the Northern Hemisphere. ***Science.*** 334:1545-1548.

<u>Chen, G.</u>, **Selbie, D.T.**, <u>Griffiths, K.</u>, Sweetman, J.N., Botrel, M., Michelutti, N., Smol, J.P., and I. Gregory-Eaves. 2011. Spatio-temporal distributions of sedimentary chironomids from southwestern Yukon lakes and their relationships with environmental conditions. ***Geohydro 2011 Proceedings.*** Pp. 1-6.

Selbie, D.T., Sweetman, J.N., Etherton, P., Hyatt, K.D., Rankin, D.P., Finney, B.P., and J.P. Smol. 2011. Climate change modulates structural and functional lake ecosystem responses to introduced anadromous salmon. ***Canadian Journal of Fisheries and Aquatic Sciences.*** 68: 675-692.

Chen, G., **Selbie, D.T.**, Bunting, L., Finney, B.P., Leavitt, P.R., Schindler, D.E., Shapley, M.D., and I. Gregory-Eaves. 2011. Long-term zooplankton responses to subsidies of nutrients and consumers to coastal lakes arising from migratory sockeye salmon (*Oncorhynchus nerka*). ***Oikos.*** 120: 1317-1326.

Chen, G., Saulnier-Talbot, E., **Selbie, D.T**., Brown, E., Schindler, D.E., Bunting, L., Leavitt, P.R., Finney, B.P., and I. Gregory-Eaves. 2011. Salmon-derived nutrients drive diatom beta-diversity patterns. ***Freshwater Biology***. 56: 292-301.

Selbie, D.T., Finney, B.P. Barto, D., Bunting, L., Chen, G., Leavitt, P.R., MacIsaac, E.A., Schindler, D.E., Shapley, M.D., and I. Gregory-Eaves. 2009. Ecological, landscape, and climatic regulation of sedimentary geochemistry in North American sockeye salmon nursery lakes: Insights for paleoecological salmon investigations. ***Limnology and Oceanography.*** 54:1733-1745.

Gregory-Eaves, I., **Selbie, D.T.**, Sweetman, J.N., Finney, B.P., and J.P. Smol. 2009. Tracking sockeye salmon population dynamics from lake sediment cores: a review and synthesis. ***American Fisheries Society Symposium Series***. 69: 379-393. ***Invited submission.**

Selbie, D.T., Lewis, B., Smol, J.P., and B.P. Finney. 2007. Long-term population dynamics of the endangered Snake River sockeye salmon: evidence of past influences on stock decline and impediments to recovery. ***Transactions of the American Fisheries Society*.** 136: 800-821.

Clerk, S., **Selbie, D.T.**, and J.P. Smol. 2004. Cage aquaculture and water-quality changes in the LaCloche Channel, Lake Huron, Canada: a paleolimnological assessment. ***Canadian Journal of Fisheries and Aquatic Sciences*.** 61: 1691-1701.

Holtham, A., Gregory-Eaves, I. Pellatt, M., **Selbie, D.T.,** Stewart, L. and J. P. Smol. 2004. The influence of flushing rates, terrestrial input and low escapement densities on paleolimnological reconstructions of sockeye salmon (*Oncorhynchus nerka*) nutrient dynamics in Alaska and British Columbia. ***Journal of Paleolimnology*.** 32: 255-271.

Other Scientific Publications: (underline indicates supervised student, post-doc, or employee)

Selbie, D.T. 2013. 2011 growing season primary productivity of Shuswap and Mara lakes, British Columbia. ***Shuswap Lakes Integrated Planning Process (SLIPP) Technical Report.***

Pon, L.B., and **D.T. Selbie.** 2012. Monitoring plan for the threatened Coastrange Sculpin (*Cottus aleuticus*), Cultus Population. ***Fisheries and Oceans Canada Report under the Species at Risk Act.***

Pon, L.B., and **D.T. Selbie.** 2012. Guidelines for the collection of threatened Coastrange Sculpin (*Cottus aleuticus*), Cultus Population. ***Fisheries and Oceans Canada Report under the Species at Risk Act.***

Selbie, D.T. 2011. Climate Change in the Upper Columbia River Watershed: Context for Canada's Position on the Columbia River Treaty. Chapter in ***The Columbia River Treaty Review Process: Establishing a Path Forward for DFO***. Fisheries and Oceans Canada Discussion Paper.

Selbie, D.T., Bradford, M.J., Hague, M.J., Hume, J.M.B., MacIsaac, E.A., and D.A. Patterson. 2010. Are freshwater habitat conditions in the Fraser River watershed an important contributor to the Fraser sockeye salmon situation? A report submitted to the Pacific Salmon Commission appointed panel for the ***Workshop to Examine the Decline in Survival of Fraser River Sockeye.*** June 15-16.

Gregory-Eaves, I., Smol, J.P., Sweetman, J.N., and **D.T. Selbie**. 2011. Heterogeneity in northern climate trends: Assessing the role of glacial modulation. Final Report to the Canadian Foundation for Climate and Atmospheric Sciences. Grant No. GR-7060.

Scientific Manuscripts Currently in Peer-Review or Revision:
(underline indicates supervised student, post-doc, or employee)

Chen, G., **Selbie, D.T.**, Griffiths, K., Sweetman, J.N., Botrel, M., Taranu, Z., Knops, S., Bondy, J., Michelutti, N., Smol, J.P., and I. Gregory-Eaves. (*in review*) The cryospheric landscape and lake depth as modulators of paleoclimatic records: A regional study from southwest Yukon, Canada. ***Journal of Paleolimnology.***

Hall, P.E.D., Bocking, R.C., Hume, J.M.B., **Selbie, D.T.**, Candy, J.R., Alexander, R.F., and A.S. Gottesfeld. (*accepted with revisions*) Status of Nass River sockeye salmon (*Oncorhynchus nerka*). ***Canadian Science Advisory Secretariat (CSAS). Research Document. Fisheries and Oceans, Canada.***

Chiang, E., Velema, G., **Selbie, D.T.**, Hume, J.M.B., Brown, T., and P. Woodruff. (*accepted with revisions*) The identification of critical habitat for Coastrange Sculpin (Cultus Population) (*Cottus sp.*). ***Canadian Science Advisory Secretariat (CSAS). Research Document. Fisheries and Oceans, Canada.***

Forthcoming Scientific Manuscripts:

Hume, **J.M.B. Selbie, D.T.,** Herunter, H., and S. Grant. Cultus Lake, British Columbia: Freshwater habitat context for species at risk. ***Canadian Technical Reports of Fisheries and Aquatic Sciences.***

Selbie, D.T., Finney, B.P., Thomson, D.J., and J.P. Smol. Long-term climatic and solar forcing of North Pacific salmon production. In preparation for ***Science****.*

Selbie, D.T., and K.S. Shortreed. Pacific salmon-derived nutrient loadings induce complex multi-trophic production responses in Quesnel Lake, British Columbia, Canada. In preparation for ***Limnology and Oceanography.***

Selbie, D.T., Gregory-Eaves, I., Schindler, D.E., Leavitt, P.R., Finney, B.P., and L. Godbout. Long-term natural and anthropogenic freshwater habitat changes in Cultus Lake, British Columbia, Canada: A paleoecological context for management of species at risk. In preparation for ***Canadian Journal of Fisheries and Aquatic Sciences****.*

Malange, K., Shortreed, K.S., and **D.T. Selbie**. Results of a three-year (2000-2003) limnological study of Anderson and Seton lakes and Carpenter Reservoir. In preparation for ***Canadian Data Reports in Fisheries and Aquatic Sciences.***

Schindler, D.E., Holtgrieve, G.W., Leavitt, P.R., Bunting, L., Finney, B.P., **Selbie, D.T.**, and I. Gregory-Eaves. Reconstructing pre-historical salmon population dynamics from lake sediment biogeochemical signals. In preparation for ***Journal of Paleolimnology.***

Selbie, D.T., Finney, B.P., Bunting, L., Chen, G., Cumming, B.F., Laird, K., Leavitt, P.R., Schindler, D.E., Shapley, M.D., and I. Gregory-Eaves. Establishing the influence of forestry, wildfire and other landscape disturbances on lakes in interior and coastal British Columbia: a sediment geochemical analysis. In preparation for ***Canadian Journal of Fisheries and Aquatic Sciences****.*

Selbie, D.T., Finney, B.P., Bunting, L., Chen, G., Leavitt, P.R., Schindler, D.E., Shapley, M.D., Smol, J.P., and I. Gregory-Eaves. Variability in the baseline carbon and nitrogen stable isotopic and elemental sediment geochemistry across 250 lakes from Pacific North America: Regional implications for the reconstruction of Pacific salmon population dynamics. In preparation for ***Limnology and Oceanography****.*

Selbie, D.T., Clerk, S., and J.P. Smol. Impacts of freshwater hatchery aquaculture effluents on downstream receiving freshwaters. In preparation for ***Canadian Journal of Fisheries and Aquatic Sciences*****.**

Selbie, D.T., Gregory-Eaves, I., Reavie, E.D., and J.P. Smol. Seasonality in planktonic diatoms in southeast Ontario Lakes: Implications for paleoenvironmental reconstructions. In preparation for ***Hydrobiologia****.*

Conference and Workshop Presentations:

Invited Research Presentations: (underline indicates supervised/co-supervised student or post-doc)

Selbie, D.T. 2013. Aquatic context for Eurasian watermilfoil (*Myriophyllum spicatum*): Cultus and Nicola lakes, British Columbia. ***Water Quality and Eurasian Watermilfoil Workshop.*** *Chilliwack, BC, Canada. February 15.* **** Plenary Presentation***

Selbie, D.T., Hume, J.M.B., Tompkins, A., Grant, S.C.H., Whitehouse, T., and M.J. Bradford. 2011. Are over-escapement and delayed density dependence important contributors to the Fraser sockeye salmon situation? ***Fisheries and Oceans Canada Workshop on the Declines in Fraser Sockeye Salmon.*** *Nanaimo, BC, Canada. April 14-15. Oral Presentation.*

Selbie, D.T., Bradford, M.J., Hague, M.J., Hume, J.M.B., MacIsaac, E.A., and D.A. Patterson. 2010. Are freshwater habitat conditions in the Fraser River watershed an important contributor to the Fraser sockeye salmon situation? ***Pacific Salmon Commission Workshop to Examine the Decline in Survival of Fraser River Sockeye Salmon.*** *Victoria, BC, Canada. June 15-16. Oral Presentation*

Selbie, D.T., Hume, J.M.B., and K.S. Shortreed. 2010. Nass River watershed sockeye salmon: A comparative nursery ecosystem overview. ***Nass Sockeye Salmon Technical Workshop.*** *Terrace, BC, Canada. May 31-June 1. Oral Presentation.*

Schindler, D.E., Holtgrieve, G., Lisi, P., Gregory-Eaves, I., Chen., G., Leavitt, P., Bunting, L., Finney, B., Shapley, M., Walsh, P., Lisac, M., and **D.T. Selbie**. 2010. How many salmon were there before commercial fishing, and how have fisheries altered the productivity of coastal freshwater ecosystems? *Research presentation to the Editorial Board of* ***Science Magazine (American Association for the Advancement of Science)*** *January 15.* ****Solicited Publication Presentation***

Selbie, D.T., Gregory-Eaves, I. Chen, G., Griffiths, K., Michelutti, N., Workman, L. and J.P. Smol. 2009. Glacial modulation of climate change: A mechanism for heterogeneity in northern climate warming? ***Climate Change in our Back Yard II Workshop.*** *Champagne and Aishihik First Nations and the Alsek Renewable Resource Council, Haines Junction, YT, Canada. March 9-12. Poster Presentation*

Selbie, D.T. Biogeoclimatic controls on the reconstruction of sockeye salmon from lake sediments. 2008. ***Applications of Paleolimnology to Sockeye Salmon Nursery Lakes in the Pacific Northwest and Alaska Workshop.*** *Fisheries and Oceans Canada, Institute of Ocean Sciences, North Saanich, BC, Canada. Oral Presentation, October 8-9.* **** Plenary Presentation***

Selbie, D.T. , Finney, B.P., Leavitt, P.R., Schindler, D.E. Smol, J.P., and I. Gregory-Eaves. 2008. Long-term climatic forcing of North Pacific salmon populations: Understanding future fisheries production in the context of natural variability. ***American Fisheries Society (AFS) Annual Meeting, Special Symposium: Sensitivity of Fish and Fisheries to Climate Change: Response and Adaptation***, *Ottawa, ON, Canada. August 17-21. Oral Presentation.*

Gregory-Eaves I., **Selbie, D.T.,** Chen, G., Finney, B.P., Schindler, D.E., and P.R. Leavitt. 2007. What can long-term paleolimnological records of sockeye salmon dynamics tell us? ***Ecological Society of America*** **(ESA)** ***Meeting. Special Symposium, Stepping Back in Time: The Application of Historical and Fossil Records to Recovering Ecological Baselines.*** *San Jose, NM, USA. August 5-10. Oral Presentation.*

Smol, J.P., Gregory-Eaves, I., **Selbie, D.T.**, Thomson, D.J., Douglas, M.S.V., Sweetman, J.N., and B.P. Finney. 2007. Salmon, nutrient cycling and lake sediments: A window on the past and a view to the future. ***American Fisheries Society*** **(AFS)** ***2nd International Scientific Symposium on Diadramous Fishes: Challenges for Diadromous Fishes in a Dynamic Global Environment*****.** *Halifax, NS, Canada. June 18-21.* **** Keynote Presentation***

Research Presentations: (underline indicates supervised/co-supervised student or post-doc)

Putt, A., MacIsaac, E.A., Cooper, A., Herunter, H., and **D.T. Selbie**. 2012. Cultural eutrophication and species at risk: Assessing nutrient loading to Cultus Lake, BC. ***The 33rd Annual Pacific Ecology and Evolution Conference***. *Bamfield, BC, Canada. March 2-4. Oral Presentation.*

Tran, T., **Selbie, D.T.** Leavitt, P.R., Godbout, L., Finney, B.P., Schindler, D.E., and I. Gregory-Eaves. 2012. Tracking long-term ecological changes in critical habitat for species at risk: Cultus Lake, British Columbia. ***Groupe de Recherche Interuniversitaire en Limnologie*** **(GRIL)** ***22nd Annual Conference.*** *Saint-Ferdinand, QC, Canada. March 8-10. Poster Presentation.*

Griffiths, K.G., **Selbie, D.T.,** Chen, G., Sweetman, J.N., Michelutti, N., Gregory-Eaves, I., and J.P. Smol. 2011. The influence of terrestrial ice fields on Holocene climate: A paleolimnological assessment of three lakes from the southwest Yukon Territory. ***The Canadian Quaternary Association (CANQUA) Annual Conference.*** *Quebec City, QC, Canada. August 28-31. Poster Presentation.* ****Awarded best student presentation (Lortie Award).***

Griffiths, K.G., **Selbie, D.T.**, Chen, G.J., Sweetman, J.N., Michelutti, N., Gregory-Eaves, I., and J.P. Smol. 2011. Chironomid assemblage reconstruction from three lakes in southwest Yukon: Assessing the modulation of climate by the Wrangell-St. Elias Ice Fields. ***Quebec-Ontario Paleolimnology Symposium.*** *Montreal, QC, Canada. May 25-27. Oral Presentation.*

Griffiths, K.G., **Selbie, D.T.**, Chen, G.J., Sweetman, J.N., Michelutti, N., Gregory-Eaves, I., and J.P. Smol. 2011. The influence of terrestrial ice fields on Holocene climate: a paleolimnological assessment of three lakes from the southwest Yukon. ***Geohydro 2011.*** *Quebec City, QC, Canada. August 28-31. Oral Presentation.*

Chen, G.J., **Selbie, D.T.**, Griffiths, K.G., Sweetman, J.N., Michelutti, N., Smol, J.P., and I. Gregory-Eaves. 2011. Paleolimnological reconstruction of regional environmental changes in southwest Yukon – Evaluating the cooling impact of the Wrangell-St. Elias ice fields. ***Geohydro 2011.*** *Quebec City, QC, Canada. August 28-31. Oral Presentation.*

Selbie, D.T., Sweetman, J.N., Etherton, P., Hyatt, K.D., Rankin, D.P., Finney, B.P., and J.P. Smol. 2011. Climate change modulates structural and functional ecosystem responses to introduced anadromous salmon. ***Canadian Conference for Fisheries Research (CCFFR) / Society of Canadian Limnologists (SCL) Conference****. Toronto, ON, Canada. January 6-8. Oral Presentation.*

Chen, G., Gregory-Eaves, I., **Selbie, D.T.,** Griffiths, K., Michelutti, N., Smol, J., and J.N. Sweetman. 2010. Can Ice fields modulate regional climate dynamics? A multi-proxy paleolimnological study from northwestern North America. ***The 18th International Conference on Environmental Indicators (ISEI)***. *Heifei, China. September 13-16. Oral Presentation.*

Griffiths, K.G., **Selbie, D.T.,** Gregory-Eaves, I., Chen, G., Sweetman, J.N., Michelutti, N. and J.P. Smol. 2010. Investigating the importance of cryospheric features in producing regional climate heterogeneity: A paleolimnological study of two lakes in SW Yukon. ***2010 Ontario-Québec Paleolimnology Symposium (PALS).*** *Kingston, ON, Canada. May 13-15. Oral Presentation.*

Chen, G., **Selbie, D.T.,** Knops, S., Griffiths, K., Sweetman, J.N., Michelutti, N., Smol, J.P. and I. Gregory-Eaves. 2010. Assessing the role of glaciers in modulating regional climate dynamics: A multi-centennial Yukon Territory paleolimnological study. ***2010 Ontario-Québec Paleolimnology Symposium (PALS).*** *Kingston, ON, Canada. May 13-15. Oral Presentation.*

Griffiths, K., **Selbie, D.T.**, Gregory-Eaves, I., Chen, G., Sweetman, J.N. , Michelutti, N., and J.P. Smol. 2009. Investigating cryospheric modulation as a mechanism of heterogeneous climate warming for two lakes in the southwest Yukon. ***11th International Paleolimnology Symposium.*** *Guadalajara, Jalisco, Mexico. December 15-18.* **** Honourable mention, best student presentation.***

Holtgrieve, G., Schindler, D., **Selbie, D.**, Leavitt, P., and I. Gregory-Eaves. 2008. Latitudinal variation in nitrogen loading to coastal North Pacific lakes as inferred from nitrogen stable isotopes. ***Ecological Society of America (ESA) Annual Meeting.*** *Milwaukee, WI, USA. August 3-8. Oral presentation.*

Bunting, L., Leavitt, P.R., Schindler, D.E., Finney, B.P., Gregory-Eaves, I., **Selbie, D.T.**, Chen, G., Pellatt, M.G., and D.G. Bos. 2008. Continental gradients in the effects of marine derived nutrients from salmon on lake primary production. ***American Society of Limnology and Oceanography (ASLO) Conference.*** *St. John's, NL, Canada. June 8-13. Oral Presentation.*

Chen, G., **Selbie, D.T.,** Finney, B.P., Schindler, D.E., Bunting, L., Leavitt, P.R. and I. Gregory-Eaves. 2008. Zooplankton dynamics in Pacific salmon lakes of Alaska – A limnological and paleolimnological perspective. ***American Society of Limnology and Oceanography (ASLO) Conference.*** *St. John's, NL, Canada. June 8-13. Oral Presentation.*

Chen, G., Gregory-Eaves, I., **Selbie, D.T.**, Sweetman, J.N., Finney, B.P., Schindler, D.E., Bunting, L., and P.R. Leavitt. 2007. Zooplankton responses to salmon-derived nutrients in the Northeast Pacific: A paleolimnological perspective. ***30th Congress of the International Association of Theoretical and Applied Limnology* (SIL)*.*** *Montréal, QC, Canada. August 12-18. Oral Presentation.*

Selbie, D.T., Gregory-Eaves, I., Bunting, L., Chen, G., Leavitt, P.R., Schindler, D.E., Smol, J.P., and B.P. Finney. 2007. Long-term spatial and temporal variability in North Pacific salmon production: Relationships to large-scale environmental drivers. ***30th Congress of the International Association of Theoretical and Applied Limnology* (SIL)*.*** *Montréal, QC, Canada. August 12-18. Oral Presentation.*

Gregory-Eaves, I., **Selbie D.T.**, Chen, G., Finney, B.P., Foster-West, C., Schindler, D.E. and P.R. Leavitt. 2007. What can long-term paleolimnological records of sockeye salmon dynamics tell us? ***Ecological Society of America (ESA)-Society for Ecological Restoration (SER) Joint Meeting.*** *San Jose, CA, USA. August 5-10. Oral Presentation.*

Selbie, D.T., Bunting, L., Chen, G., Gregory-Eaves, I., Leavitt, P.R., Schindler, D.E., and B.P. Finney. 2007. Mid to late Holocene trends in northern Pacific salmon production. ***Canadian Conference for Fisheries Research (CCFFR) / Society of Canadian Limnologists (SCL) Conference***. *Montréal, QC, Canada. January 4-6. Oral Presentation.*

Chen, G., **Selbie, D.T.**, Gregory-Eaves, I., Finney, B.P., Bunting, L., Leavitt, P.R., and D.E. Schindler. 2007. Tracking the history of Pacific salmon populations and related trophic dynamics over the past ~ 5,000 yrs using multi-proxy paleolimnological techniques. ***Canadian Conference for Fisheries Research (CCFFR) / Society of Canadian Limnologists (SCL) Conference***. *Montréal, QC, Canada. January 4-6. . Poster Presentation.*

Selbie, D.T., Gregory-Eaves, I., Barto, D., Chen, G., Finney, B.P., Leavitt, P.R., and D.E. Schindler. 2007. Constraining Pacific salmon paleo-reconstructions: Landscape and climatic controls on sedimentary stable isotopic signatures and carbon to nitrogen (C/N) ratios in nursery lakes of western North America. ***Groupe de Recherche Interuniversitaire en Limnologie*** **(GRIL)** ***17th Annual Conference*****.** *Harrington, QC, Canada. March 1-3. Poster Presentation.*

Selbie, D.T., Chen, G., Finney, B.P., Leavitt, P.R., Schindler, D.E., Krümmel, E., Blais, J., and I. Gregory-Eaves. 2006. Establishing past southern Canadian Pacific salmon production variability and influences on stock dynamics: Sockeye of the Fraser River, British Columbia. ***19th International Diatom Symposium***. *Irkutsk, Russia. August 28-September 3. Oral presentation.*

Selbie, D.T., Finney, B.P., Thomson, D.J., Kim, J.H., and J.P. Smol. 2006. Towards understanding environmental drivers of Pacific salmon production: millennial-scale paleolimnological evidence. ***10th International Paleolimnology Symposium***. *Duluth, MN, USA. June 25-30. Oral presentation.*

Selbie, D.T., Finney, B.P., Thomson, D.J., and J.P. Smol. 2006. Multi-centennial cyclical variability in Canadian Pacific salmon production: Insight into the influence of large-scale environmental forcing mechanisms. ***Groupe de Recherche Interuniversitaire en Limnologie (GRIL) 16th Annual Conference*****.** *Saint-Ferdinand, QC, Canada. March 2-4. Poster presentation.*

Selbie, D.T., Finney, B.P., and J.P. Smol. 2005. Multi-centennial cyclicity in Canadian sockeye salmon (*Oncorhynchus nerka*) production: A window into large-scale environmental forcing mechanisms. ***IGBP-PAGES (International Geosphere-Biosphere Programme – Past Global Changes) 2nd International Open Science Meeting: Paleoclimate, Environmental Sustainability and Our Future***. *Beijing, China. August 10-12. Poster presentation.* **** Awarded best student presentation.***

Selbie, D.T., Finney, B.P., and J.P. Smol. 2005. ~6,000yr record of Pacific salmon production in British Columbia: A paleolimnological reconstruction of sockeye salmon (*Oncorhynchus nerka*) population dynamics in Tahltan Lake, BC. ***Canadian Conference for Fisheries Research (CCFFR) / Society of Canadian Limnologists (SCL) Conference***. *Windsor, ON, Canada. January 6-9. Oral Presentation.*

Selbie, D.T., Lewis, B., Finney, B.P., and J.P. Smol. 2004. Paleolimnological approaches for inferring long-term sockeye salmon (*Oncorhynchus nerka*) population dynamics. ***American Fisheries Society (AFS) 4th World Fisheries Congress*****.** *Vancouver, BC, Canada. May 2-6. Oral Presentation.*

Selbie, D.T., Lewis, B., Finney, B.P., and J.P. Smol. 2004. Paleolimnological records of nutrient dynamics associated with sockeye salmon (*Oncorhynchus nerka*) production in sub-arctic and sub-alpine nursery lake environments. ***34th International Arctic Workshop*****,** *Boulder, CO, USA. March 10-13. Poster Presentation.*

Selbie, D.T., Finney, B.P., and J.P. Smol. 2003. Paleolimnology as a tool for assessing long-term population dynamics and anthropogenic contamination of sockeye salmon (*Oncorhynchus nerka*) in northern British Columbia and Yukon Territory, Canada. ***Association of Canadian Universities for Northern Studies (ACUNS) Student Conference - Breaking the Ice: Transcending Borders through Collaboration and Interdisciplinary Research*****.** *Edmonton, AB, Canada. October 24-26. Oral Presentation.*

Selbie, D.T., Lewis, B., Finney, B.P., and J.P. Smol. 2003. A multi-proxy paleolimnological assessment of long-term population dynamics in endangered snake river sockeye salmon (*Oncorhynchus nerka*) returning to Redfish Lake, Idaho. ***Canadian Conference for Fisheries Research (CCFFR) / Society for Canadian Limnologists (SCL) Conference.*** *Ottawa, ON, Canada. January 3-5. Poster Presentation.*

Selbie, D.T., Clerk, S., and J.P. Smol. 2002. Nutrient impacts on freshwater lacustrine systems from cage and hatchery aquaculture. ***American Society of Limnology and Oceanography (ASLO) Conference*****.** *Victoria, BC, Canada. June 9-14. Oral Presentation.*

Selbie, D.T., Gregory-Eaves, I., Finney, B.P., and J.P. Smol. 2001. It's as clear as mud: Inferences of sockeye salmon (*Oncorhynchus nerka*) population dynamics from lake sediment cores. ***American Fisheries Society (AFS) Nutrient Conference: Restoring Nutrients to Salmonid Ecosystems***. *Eugene, OR, USA. April 24-26. Poster Presentation.*

Gregory-Eaves, I., **Selbie, D.T**., Finney, B.P., and J.P. Smol. 2001. Inferences of salmon population dynamics from lake sediment cores. ***Canadian Conference For Fisheries Research (CCFFR) / Society for Canadian Limnologists (SCL) Annual Conference***. *Toronto, ON, Canada. January 4-6. N Poster Presentation.*

Workshop, Conference and Formal Scientific Review Participation:

2013 **Water Quality and Eurasian Watermilfoil (*Myriophyllum spicatum*) Workshop - Cultus and Nicola Lakes** *Chilliwack, BC, Canada. February 18.*

2012 **Risk-Based Assessment of Climate Change Impacts and Risks on the Biological Systems and Infrastructure within Fisheries and Oceans' Mandate – Pacific Large Aquatic Basin - Canadian Science Advisory Secretariat (CSAS) Review** *Nanaimo, BC, Canada. November 28-29.*

Applications of Ocean-Colour Radiometry for the Study of Marine Ecosystems Including Fisheries – Fisheries Applications of Remotely-Sensed Ocean (FARO) Workshop *Nanaimo, BC, Canada. March 20-22.*

Aquatic Climate Change Adaptation Services Program *Vancouver, BC, Canada. February 5.*

2011 **Identification of Critical Habitat for Cultus Pygmy Sculpin - Canadian Science Advisory Secretariat (CSAS) Review** *Nanaimo, BC, Canada. October 12.*

Fisheries Think-Tank: An Inland Fisheries Research Centre Development Workshop *Quesnel River Research Centre, University of Northern British Columbia, Likely, BC, Canada. February 23-25, 2011.* ****Invited Advisor.***

Species at Risk Act (SARA) Technical Workshop on Identification of Critical Habitat for the

2011 **Threatened Cultus Lake Pygmy Sculpin,** *University of British Columbia, Vancouver, BC, Canada. February 8.* ****Invited Technical Advisor.***

Shuswap Lakes Integrated Planning Process (SLIPP) Water Quality Monitoring Planning Workshop, *Chase, BC, Canada. February 2.* ****Invited Technical Advisor***

2010 **Stock Assessment of Fraser River Sockeye Salmon (Including Wild Salmon Policy Benchmarks) Basin - Canadian Science Advisory Secretariat (CSAS) Review** *Nanaimo, BC, Canada. November 15-18.*

Stock Assessment of Nass River Sockeye Salmon - Canadian Science Advisory Secretariat (CSAS) Review *Nanaimo, BC, Canada. November 15-18.*

Fisheries and Oceans Canada Regional Science Forum, *Victoria, BC, Canada. April 6-8.*

2009 **Kootenay Lake and Arrow Lakes Nutrient Restoration Workshop,** *Kelowna, BC, Canada. January 16-17.* ****Invited Technical Advisor***

2006 **American Geophysical Union Annual Meeting,** *San Francisco, CA, USA. December 11-15.*

2003 **Relations Between Traditional Knowledge and Western Science Conference,** *NSERC Northern Chair, Canadian Polar Commission, Royal Canadian Geographic Society, Association of Canadian Universities for Northern Studies. Ottawa, ON, Canada. March 7.*

Canadian Climate Impacts and Adaptation Research Network Workshop: Impact and Adaptation Responses of Fish and Fisheries to Climate Change, *Ottawa, ON, Canada. January 5-6.*

2000 **8th International Paleolimnology Symposium**, *Kingston, ON, Canada. August 20-24.*

Formal Solicited Science Advice & Expert Witness Testimony:

2012-Present **BC Hydro Site C Hydroelectric Project,** *Fisheries and Oceans Canada, Ecosystems Branch;* Productive capacity changes to fish habitat associated with Site C development.

Taseko Mines Inc. New Prosperity Copper-Gold Project, *Fisheries and Oceans Canada, Oceans and Ecosystems Branch;* Effects of mining on aquatic ecosystem productivity and integrity.

2011-Present **Shuswap Lakes Integrated Planning Process (SLIPP)**, *SLIPP Technical Advisory Team;* Water quality monitoring framework for Shuswap and Mara lakes.

2011 **Regional Advisory Process (RAP), Centre for Scientific Advice, Pacific Region**, *Fisheries and Oceans Canada;* The identification of critical habitat for Coastrange Sculpin (Cultus Population, Cottus sp.).

2010 **Regional Advisory Process (RAP), Centre for Scientific Advice, Pacific Region**, *Fisheries and Oceans Canada;* Fraser sockeye (Oncorhynchus nerka) Wild Salmon Policy evaluation of stock status: state and rate; Status of Nass River sockeye salmon (Oncorhynchus nerka).

Canadian Environmental Assessment Agency (CEAA) Hearings, Expert Witness Testimony *Fisheries and Oceans Canada, Oceans, Habitat and Enhancement Branch, Taseko Mines Inc. Prosperity Copper-Gold Project;* Effects of mining on aquatic ecosystem productivity and integrity.

2009-2011 **Taseko Mines Inc. Prosperity Copper-Gold Project (Fish Lake),** *Fisheries and Oceans Canada, Oceans, Habitat and Enhancement Branch;* Effects of mining on aquatic ecosystem productivity and integrity.

2009 **Kootenay Lake and Arrow Lakes Nutrient Restoration Workshop,** *British Columbia Ministry of Environment;* Exploration of lake fertilization options for kokanee enhancement in Kootenay and Arrow reservoirs.

Invited Public and Private Lectures and Research Seminars:

2013 **Pacific Salmon Commission,** *Vancouver, BC, Canada*; *Long-term freshwater habitat changes in the Fraser River: Connections to sockeye salmon fisheries production in Quesnel, Shuswap and Chilko lakes.*

2012 **Shuswap Lakes Integrated Planning Process (SLIPP) All Committee Meeting,** *Chase, BC, Canada; A 25-year perspective on lake productivity in Shuswap and Mara lakes.*

2011 **University of the Fraser Valley, Faculty of Science Discovery Lecture,** *Abbotsford, BC. Canada; Long-term perspectives on Pacific salmon production variability and nursery ecosystem dynamics.*

Soowahlie Longhouse Celebration, *Chilliwack, BC, Canada; Cultus Lake under stress: Threats and solutions to interactive stressors.*

2009 **Cultus Lake Aquatic Stewardship Strategy (CLASS),** *Cultus Lake, BC, Canada; Cultus Lake, British Columbia: Potential aquatic stressors and research opportunities.*

Simon Fraser University, School of Resource and Environmental Management, *Burnaby, BC, Canada; Long-term perspectives on salmon production variability and nursery ecosystem dynamics in Pacific North America.*

2007 **McGill University, Department of Biology,** *Montreal, QC, Canada; Large-scale natural and anthropogenic population drivers on Pacific salmon and ecosystem interactions through time: a paleoenvironmental perspective.*

Queen's University, Department of Biology, *Kingston, ON, Canada; Large-scale exogenous forcing of Pacific salmon population and ecosystem dynamics in western North America.*

2006 **McGill University, Department of Biology,** *Montreal, QC, Canada; Constraining Pacific salmon reconstructions: Landscape, climatic and ecosystem controls on sedimentary stable isotopes and C/N ratios.*

2005 **Rotary International,** *Haliburton, ON, Canada; Eyes on the past, understanding today and the future: paleolimnology as a tool for understanding long-term environmental change.*

Queen's University, Department of Biology, *Limnology and Aquatic Ecology Course, Kingston, ON, Canada; Field sampling in limnology and the aquatic sciences.*

2004-2006 **Paul Smith's College** *Paleoenvironmental Studies Course, Kingston, ON, Canada; Paleoenvironmental methods for reconstructing long-term fisheries records.*

2004 **Queen's University Biological Station (QUBS),** *Chaffey's Locks, ON, Canada; Long-term changes in sockeye salmon (Oncorhynchus nerka) population dynamics in pristine and impacted North American stocks.*

2004 **Queen's University, Department of Biology,** *Behaviour, Ecology and Evolution Seminar Series, Kingston, ON, Canada; A fishy, muddy voyage through time: Long-term records of salmon-derived nutrient dynamics in human-impacted and pristine nursery environments.*

2001-2006 **Queen's University, Department of Biology**, *Departmental Showcase Poster, Kingston, ON, Canada; It's as clear as mud: inferring long-term trends in sockeye salmon populations*

Queen's University, Department of Biology, *Kingston, ON, Canada; Numerous invited presentations on fisheries and aquaculture.*

2001 **Queen's University, Department of Biology,** *Kingston, ON, Canada; Paleolimnological approaches for tracking fisheries and aquaculture practices*

Field Research:

My field experience has involved extensive campaigns to recover limnological, fisheries and sediment samples in remote northern and wilderness regions. This research has required ensuring the supervision and safety of sizeable field crews, working with a variety of fixed wing aircraft and helicopters, watercraft, amphibious and all-terrain vehicles, the negotiation of in-kind and logistical support, and the acquisition of research permits. I have experience in forming and maintaining research partnerships with universities and provincial, territorial, federal and international governments. I have employed a full complement of limnological and paleolimnological sampling and analytical equipment as well as have experience in a diversity of methods for capturing juvenile and adult fish in freshwater.

2013-2014 **Research Team Leader,** *Shuswap Lake, British Columbia, Canada*
Fisheries hydroacoustic/trawl and seine net sampling; Mechanisms regulating juvenile growth and survival of Shuswap Lake sockeye salmon; Fisheries and Oceans Canada, Science Branch; Research team of 7-10 people.

2013-2014 **Research Team Leader,** *Babine Lake, British Columbia, Canada*
Limnological and fisheries hydroacoustic/trawl sampling; Babine Lake productive capacity, ecological status, and juvenile sockeye salmon abundance. Fisheries and Oceans Canada, Science Branch; Research team of 6 people.

2011-2013 **Research Team Leader,** *Shuswap Lake, British Columbia, Canada*
Limnological sampling; Assessing the effects of large escapements on Fraser River sockeye salmon freshwater habitat and productivity; Fisheries and Oceans Canada, Science Branch; Research team of 6 people.

2009-Present **Research Team Leader,** *Chilko Lake, British Columbia, Canada*
Limnological sampling; The role of changing freshwater habitat in the record production of Fraser River sockeye salmon; Fisheries and Oceans Canada, Science Branch; Research team of 6 people.

2009-Present **Research Team Leader,** *Cultus and Chilliwack lakes, British Columbia, Canada*
Limnological and fisheries hydroacoustic/trawl sampling; Assessing the role of freshwater habitat on endangered sockeye salmon freshwater survival; Nutrient loading and source modeling for the Cultus Lake watershed; Fisheries and Oceans Canada, Science Branch; Research team of 6-10 people.

2009-2010 **Research Team Leader,** *Yukon Territory, Canada (2 Field Campaigns)*
Paleolimnological and limnological sampling; Assessing the role of glaciers and ice fields in the regulation of regional atmospheric and freshwater responses to climate change; McGill University, Queen's University, Parks Canada, Champagne-Aishihik First Nation; Field crew of 2-5 people.

2009 **Research Team Leader,** *Cultus and Chilliwack lakes, Southern and Central British Columbia, Canada*
Limnological and fisheries sampling; Assessing fisheries productivity and lake ecosystem structure and functioning; Fisheries and Oceans Canada; Field crew of 2-3 people.

2008 **Research Team Member** *Cultus Lake, Fraser Valley, British Columbia, Canada*
Paleolimnological sampling; Long-term limnological and fisheries productivity of interior and coastal British Columbia sockeye salmon lakes; Fisheries and Oceans Canada, McGill University, University of Washington, Idaho State University, University of Regina; Field crew of 7 people.

2007 **Research Team Leader,** *Northwestern British Columbia, Canada and southeastern Alaska, USA*
Paleolimnological and limnological sampling; Holocene Pacific salmon population variability and climatic drivers; McGill University, University of Washington, Idaho State University, University of Regina; Field crew of 3 people.

Research Team Member, *Kodiak Island, Alaska, USA*
Paleolimnological and limnological sampling; Holocene Pacific salmon population variability and climatic drivers; McGill University, University of Washington, Idaho State University, University of Regina; Field crew of 4 people.

2007 **Research Team Leader,** *Upper Klamath Lake & surrounding area, Southern Oregon, USA*
Paleolimnological sampling; Investigation of possible Late-Glacial period Pacific salmon southern refugia; McGill University, University of Washington, Idaho State University, University of Regina; Field crew of 3 people.

2004 **Research Team Member,** *Experimental Lakes Area (ELA), ON, Canada*
Limnological and paleolimnological sampling; Long-term climate variability in NE North America; Queen's University; Field crew of 5 people.

2003 **Research Team Leader,** *Kodiak Island, Alaska, USA*
Fisheries, limnological and paleolimnological sampling; Past salmon productivity, lake food-web dynamics and nutrient flow modeling; Queen's University, University of Alaska, Fairbanks; Field crew of 2 people.

2003 **Research Team Leader,** *Northwestern British Columbia, Canada*
Fisheries and Oceans Canada partnership; Limnological and paleolimnological sampling; Assessment of limnological and food-web changes associated with the compounding influences of climate change and salmon introductions; Queen's University, Fisheries and Oceans Canada; Field crew of 2 people.

2002-2003 **Research Team Leader,** *Yukon Territory, Canada (3 field campaigns)*
Champagne-Aishihik First Nations partnership; Limnological and paleolimnological sampling; Regional salmon population reconstructions; Validation of oral history and assessment of past human-salmon interactions; Queen's University; Field crews of 3-6 people.

2001 **Research Team Leader,** *Central Idaho, USA*
Limnological and paleolimnological sampling; Endangered salmon population reconstruction, assessment of food-web dynamics and factors responsible for population decline; Queen's University, University of Alaska, Fairbanks; Field crew of 2 people.

2000 **Research Team Leader,** *Northern Michigan, USA*
Limnological and paleolimnological sampling; Assessment of downstream freshwater impacts from Pacific salmon hatchery effluents; Queen's University; Field crew of 3 people.

Skilled Personnel Training and Research Supervision:

2011-2013 **Annika Putt,** *Masters of Resource Management (MRM) Candidate, School of Resource and Environmental Management, Simon Fraser University*
M.R.M. Thesis: A surface hydrological nutrient loading and source model for the Cultus Lake, BC watershed: Environmental context for habitat degradation of species at risk

2009-2013 **Katie Griffiths,** *Ph.D. Candidate, Department of Biology, Queen's University*
Ph.D. Thesis: Heterogeneity in northern climate trends and freshwater resources: the influence of glacial modulation

2008-2011 **Dr. Guangjie Chen** *Post-Doctoral Fellow (completed), Department of Biology, McGill University*
Post-Doctoral Research: Assessing the influence of the cryosphere on climate change and variability in Pacific North America

2008-2009 **Katherine Velghe**, *Undergraduate Thesis (completed), Department of Biology, McGill University*
Research: Reconstructing paleoproductivity of Pacific salmon at maximum spawner densities: Red Lake, AK

2005-2006 **Jennifer Bondy**, *Undergraduate Thesis (completed), Department of Biology, Queen's University*
BScH Thesis: Assessing past salmon presence in relation to oral history in sub-arctic Howard Lake, YT

2002-2003 **Allison Daley**, *Undergraduate Thesis (completed), Department of Biology Queen's University*
BScH Thesis: Verifying native oral traditions: The history of sockeye salmon in Little Klukshu Lake, YT, Canada

2001-2002 **Laura Stewart**, *Undergraduate Thesis (completed), Department of Biology Queen's University*
BScH Thesis: Paleolimnological reconstruction of long-term sockeye salmon fisheries productivity on Saltery and Afognak Islands, Alaska, USA

Teaching and Administration:

2007 **Lecturer,** *Limnology and Aquatic Ecology, Department of Biology, McGill University (selected lectures)*

Field Instructor, *Limnology and Aquatic Ecology, Department of Biology, McGill University*

2002-2006 **Laboratory Coordinator,** *Limnology and Aquatic Ecology, Department of Biology, Queen's University*

2002-2005 **Instructor,** *Aquatic Ecology Mini-Course, School of Enrichment Studies, Queen's University*

2000-2006 **Teaching Assistant,** *Department of Biology and School of Environmental Studies, Queen's University*
Various courses: Limnology and Aquatic Ecology, Aquatic Ecology Field Course, Ecosystem and Community Ecology, Botany, Zoology, Introductory Biology, Wildlife Issues in a Changing World

Additional Training:

2013 **Hydroacoustic Assessment Training,** *Biosonics Inc., Seattle, WA, USA.*
Theory and practical applications of hydroacoustics to fisheries and habitat science.

Values, Integrity & Conflict Resolution (VICR) Training for Managers, *Fisheries and Oceans Canada, Vancouver, BC, Canada.* Maintaining integrity and ethics in the Public Service.

Collaborative Arrangement Development Training, *Fisheries and Oceans Canada, Vancouver, BC, Canada.* Development of Collaborative Arrangements in the Public Service with external partners.

Environmental Emergency Response Training, *Fisheries and Oceans Canada, Cultus Lake, BC, Canada.* Emergency environmental response protocols for environmental spills and releases.

2012 **Data Exploration, Regression, General Linear Modeling and General Additive Modeling**, *Highland Statistics Inc., Banff, AB, Canada.* Theory and application of statistical methods in R platform.

Radiation Safety Recertification, *Simon Fraser University, Burnaby, BC. Canada.*
Recertification in the theory and practical training on the safe use of radioisotopes in research.

Firearms Training and Bear Defense Requalification, *Fisheries and Oceans Canada, Hope, BC, Canada.* Proficiency recertification for firearms use in Fisheries and Oceans Canada.

Workplace Hazardous Materials Information System (WHIMIS), *Fisheries and Oceans Canada, Cultus Lake, BC, Canada.* Orientation to WHIMIS for supervisors.

2011 **Firearms Training and Bear Defense Requalification**, *Fisheries and Oceans Canada, Hope, BC, Canada.* Proficiency recertification for firearms use in Fisheries and Oceans Canada.

Wilderness First Aid (Explorer) Training, *Wilderness Alert, Vancouver, BC, Canada.*
Remote location first aid certification

2010 **Staffing Sub-Delegation Training**, *Fisheries and Oceans Canada, Vancouver, BC, Canada.*
Essentials of staffing positions within Fisheries and Oceans Canada.

Staffing: A Resourcing Tool for Managers, *Canada School of the Public Service, Edmonton, AB, Canada.* Essentials of staffing positions in the Public Service.

Firearms Training and Bear Defense Requalification, *Fisheries and Oceans Canada, Hope, BC, Canada.* Proficiency recertification for firearms use in Fisheries and Oceans Canada.

Cardiopulmonary Resuscitation (CPR) Requalification, *St. John's Ambulance*
CPR certification with Automated External Defibrillator (AED) training

2009 **Leading Scientific Teams,** *Canada School of the Public Service, Ottawa, ON, Canada.*
Leadership competencies and team building and maintenance techniques.

Essentials of Managing in the Public Service, *Canada School of the Public Service, Vancouver, BC, Canada.* Accountability, policies, human resources, information management,, finance, procurement.

Occupational Health and Safety Training, *Fisheries and Oceans Canada, Cultus Lake, BC, Canada.* Responsibilities and liability, task hazard analysis, workplace inspections, investigation and reporting, safety in materials and services management.

Transportation of Dangerous Goods Training, *Fisheries and Oceans Canada, Cultus Lake, BC, Canada.* Protocols and regulations for transportation of dangerous goods, radioactive substances transport.

Performance Measures Training, *Fisheries and Oceans Canada, Nanaimo, BC. Canada.* Approaches for setting and assessing performance criteria in science and human resources.

Firearms Training and Bear Defense Training, *Fisheries and Oceans Canada, Hope, BC. Canada.* Certification in bear behaviour assessment and safe firearms use with Fisheries and oceans Canada.

2009 **Radiation Safety Training***, Simon Fraser University, Burnaby, BC. Canada.* Theory and practical training on the safe use of radioisotopes in research.

2008 **Orientation to the Public Service,** *Canada School of the Public Service, Vancouver, BC., Canada.* Structure, culture, policies, procedures, values, ethics and accountability in the Public Service of Canada.

MATLAB Recipes for Earth Sciences, *Dr. Martin Trauth, University of Potsdam, Munich, Germany.* Time series analyses, spectral analyses, wavelet analyses, signal processing, spatial analyses, geospatial analyses, multivariate statistics, image processing.

2004 **Animal Care Certification,** *University of Western Ontario, London, ON, Canada.*

Selected Volunteer Involvement and Outreach:

2007 **Field Instructor,** *Limnology and Aquatic Ecology Course*, *McGill University Department of Biology.*

2004-2005 **Instructor, Mentor**, *Boy's and Girls Club of Kingston, ON, Canada.*

2001-2006 **Instructor**, *Queen's University Goju Ryu Karate Dojo, Kingston, ON, Canada.*

Instructor, *Tallack Martial Arts and Fitness Center, Kingston, ON, Canada.*

1998-1999 **Vice-President,** *Queen's Goju Ryu Karate Club Executive Committee, Kingston, ON, Canada.*

1993-1999 **Ground and Water Searcher,** *Haliburton Highlands Search and Rescue Unit, Haliburton, ON, Canada.*

1994-1997 **Walleye Spawning Habitat Rehabilitation,** *Ontario Ministry of Natural Resources and Haliburton Highlands Outdoors Association, Haliburton, ON, Canada.*

Analytical and Software Familiarity:

Limnological and aquatic ecological experimental design, univariate and multivariate statistical analyses of environmental and biological datasets (e.g. ordination techniques, multiple regression, information theoretic models, clustering and similarity/dissimilarity analyses, construction of quantitative paleolimnological inference models) using a variety of statistical packages including (e.g. Systat, Canoco, R, Matlab, Excel), spreadsheet and database construction and management, Geographic Information Systems (GIS) (e.g. ArcGIS), time series and spatial analyses, 2D and 3D graphical representation of data and statistical relationships using a variety of programs (e.g. Sigmaplot, C2, Adobe Photoshop, Matlab, R, CorelDraw), Microsoft Office

Professional Membership:

Society of Canadian Limnologists (SCL)
American Society of Limnology and Oceanography (ASLO)
International Paleolimnology Association (IPA)
International Geosphere-Biosphere Program - Past Global Changes Research Network (IGBP-PAGES)
Dai Nippon Butoku Kai (Japan Martial Virtues Association)

Licensure and Certification:

Restricted Radio Operator Certificate, *Canadian Power and Sail Squadron*
Staffing Sub-Delegation, *Government of Canada*
Management (RC Centre) Sub-Delegation, *Government of Canada*
Wilderness First Aid and CPR (40 hr course) – *Wilderness Alert*
Radiation Safety Certification – *Simon Fraser University*
Spill Response Certification – *Fisheries and Oceans Canada*
Small Vessel Operator Proficiency (SVOP), *Canadian Coast Guard – Commercial Vessels*
Small Non-Pleasure Vessel Basic Safety (MED A3), *Canadian Coast Guard*
Dangerous Goods Transportation Certification
BreatheSafe Canada Respirator Certification
Pleasure Craft Operator Accreditation, *Canadian Coast Guard*
Workplace Hazardous Materials Information System Training (WHIMIS)
Open Water Diver Certification - *American-Canadian Underwater Councils (ACUC)*
Canadian Firearms Possession and Acquisition License (PAL)
British Columbia Class III Driver's License (Heavy Truck)
Shodan Grade (Black Belt, 1st Degree) – Goju Ryu Meitoku-ha Karate-do – *Dai Nippon Butoku Kai*

Brenda Rotinsky

Summary of Qualifications

- Experienced in the environmental industry: government, private, and industrial sectors.
- Varied experiences leading to broad based knowledge in environmental management.

Professional Experience

2009 - Present | Fisheries and Oceans Canada | Vancouver, BC

Senior Fisheries Protection Biologist

- Overall project direction and oversight of Fisheries Protection Biologists responsible for meeting the Department's responsibilities under the *Fisheries Act* for small hydro projects in the Pacific Region.
- Delegation and assignment of responsibilities to staff and provide guidance and advice on regional and national policies and protocols.

Team Leader (8 month assignment)

- Overall project direction and oversight of Habitat Biologists and Environmental Assessment Analysts responsible for meeting the Department's responsibilities under the *Canadian Environmental Assessment Act* and for administering the habitat protection provisions of the *Fisheries Act* for major projects.
- Delegation and assignment of responsibilities to staff and provide guidance and advice on regional and national policies and protocols.

Habitat Monitoring Biologist (5 month assignment)

- Monitoring Yukon and Transboundary projects for compliance with the *Fisheries Act* and conditions of authorizations and letters of advice.

Environmental Assessment Analyst

- Leading the management of environmental assessment for major projects by providing scientific advisory and coordination services in the development and implementation of the environmental assessment component of the Habitat Management Program to support the Department's compliance to applicable environmental assessment legislations and regulations.
- Responding to enquiries from and lead consultations with First Nations representatives, community interest groups, members of the public, and the media on various environmental assessment issues.
- Providing expert advice on fish and fish habitat resources and possible effects resulting from major projects.
- Working with proponents and their representatives to ensure projects are consistent with DFO's National Policy for the Management of Fish Habitat.
- Drafting *Fisheries Act* authorizations for major projects.
- Monitoring major projects for compliance with the *Fisheries Act* and conditions of authorizations.

Fall 2006 - 2009 | Peter Kiewit Sons Co. | Vancouver, BC

Environmental Manager/Coordinator

- Environmental Management for the East Toba & Montrose Hydroelectric Project including establishing the environmental program for compliance documentation and coordinating the environmental team.
- Environmental Management and quality control of environmental aspects of construction for the Sea to Sky Highway Improvement Project (North of Squamish to Whistler).
- Environmental Management for the Whistler Natural Gas Pipeline Project (Squamish to Whistler).
- Provided instruction, guidance, advice, and technical assistance to project construction and environmental staff.
- Developed partnerships between government, industry, Aboriginal Groups, and stakeholders on a variety of environmental management issues including wildlife and fisheries mitigation/compensation.

- Coordinated equipment, labour, and supplies for compliance with environmental permits and approvals.
- Created and provided training for Managers, Engineers, construction crews, and other environmental staff.
- Compiled data and information for Environmental Management Plans, Sediment and Drainage Plans, Construction Environmental Plans, and permit acquisition.

2004 - 2006 Cascade Environmental Resource Group Ltd Squamish, BC

Field Biologist

- Completed reports including land tenure applications, government permit applications for in-stream work and CEAA review, summary documents of field inventories or background studies, Initial Environmental Reviews and environmental assessments for development proposals, habitat balances, Spill Response Plans, Water Quality Management Plans, Sediment and Drainage Management Plans, and compliance monitoring reports.
- Reviewed development proposals and providing advice to clients on how to protect fish habitat including buffer recommendations, design (re-design) considerations, construction mitigation, and compensation design.
- Conducted field work including fish inventory/salvage, fish habitat assessments, wildlife inventory/salvage, aquatic invertebrate sampling, Terrestrial Ecosystem Mapping, wetland habitat assessments, riparian areas assessments, water/soil quality sampling/monitoring, and monitoring of construction in environmentally sensitive areas.
- Conducted laboratory analysis including water quality testing and aquatic invertebrate identification for various assessments and long term monitoring projects.

2002 - 2004 Canadian Wildlife Service, Env Canada Delta, BC

Research Technician

- Compiling, analyzing, and summing data for publication/conference presentations including conducting data quality checks.
- Preparing data reports for the CWS Technical Report Series.
- Training field volunteers to conduct waterfowl surveys.

2003 Garibaldi Springs Management Ltd Squamish, BC

Field Biologist

- Implementing habitat compensation plan including field design, coordinating riparian planting, and managing staff while acting as field liaison between the developer and environmental consultant.

2001 Ministry of Forests (sub-consultant) Comox, BC

Field Biologist

- Tracking seabird nesting habits along the northern BC coast while conducting seabird radar surveys.

1999 - 2000 Center for Wildlife Ecology-SFU/CWS Delta, BC

Research Assistant

- Monitoring abundance and habitat use of wintering/migrating Brant while conducting radio telemetry surveys and behavioural studies.
- Band reading, abdominal profiles, and observations for activity budgets.
- Nesting and breeding surveys of cavity nesting ducks, nasal disk tagging and banding, adult and brood observations/handling, aquatic invertebrate sampling and analysis.

1999 FishFor Contracting Ltd Port McNeil, BC

Biological Technician

- Conducting Forest Practices Code stream classifications and RISC Standards reconnaissance level fish and fish habitat assessments throughout the BC coast.

Education

2003 Simon Fraser University Burnaby, BC

Bachelor of Science Degree

- Biological Sciences

1999 BC Institute of Technology Burnaby, BC

Diploma of Technology

- Renewable Resources: Fisheries, Wildlife, and Recreational Land Management

1996 University of Victoria Victoria, BC

Bachelor of Arts Degree

- Political Science

Additional Training and Professional Development

- Canadian Aquatic Bio-monitoring Network (CABIN) training, 2011
- Coast Guard Small Craft Operators training, 2011
- Instream Flow Incremental Methodology and System for Environmental Flow Analysis, 2011
- Wilderness Survival and Wilderness First Aid training, 2011
- Aviation Egress and Occupational Helicopter Safety Technician training, 2011
- Engaging and Consulting with Aboriginal Groups in EA, 2010
- Fish Habitat Assessment Method training, 2010
- Becoming Leaders Workshop, 2009
- Swift-water Rescue training, 2009
- Erosion and Sediment Control - Application of BMPs training, 2008
- Supervisory and Management training, 2008
- Columbia Mtn Institute Conference – Environmental Impacts of Linear Developments, 2007
- Erosion and Sediment Control, International Erosion Control Association Certified, 2007
- ISO 14001 Environmental Management Systems training, 2007
- WCB Level 1 First Aid Certification with Spinal Immobilization Techniques and Transportation Endorsement and CPR (Level C), 2006
- Interactive Spill Response training, 2005
- Riparian Areas Regulation, QEP Certified, 2005
- Environmental Monitoring for Construction Projects, 2004
- Electro-fishing Crew Supervisor training, 2000
- Eligible for membership in the Association of Professional Biologist of BC and College of Applied Biology