Review of the Prosperity Mine Aquatic Impact Assessment

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Executive Summary

The application by Taseko Mines Ltd. to develop the Prosperity Project would severely affect fisheries and aquatic habitats in the Fish Creek watershed. A Tailings Disposal Facility and the mine pit would eliminate Fish Lake and Little Fish Lake in Upper Fish Creek and stream habitats in Middle Fish Creek. An artificial lake, Prosperity Lake, is proposed as compensation for the elimination of Fish Lake. This compensation proposal is inadequate and does not account for differences in littoral habitat area between Fish and Prosperity Lakes, time lags in artificial lake functionality, inherently lower trout production in Prosperity Lake and predicted reduction in Prosperity Lake productivity over time. When these factors are considered, the compensation ratio (compensation habitat: affected habitat) is 0.23:1, suggesting that Prosperity Lake would need to be 4-5 times larger than proposed to meet the “no net loss” principle of the DFO Policy for the Management of Fish Habitat. Further, the Fisheries Compensation Plan does not address the loss of rainbow trout stream habitats in Middle Fish Creek.

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1. Introduction

MiningWatch Canada has a mandate to ensure that mining ventures in Canada and elsewhere are carried out responsibly and in the best public interest. The organization scrutinizes new projects to ensure that relevant environmental regulations are enforced and that projects are designed with minimal environmental impacts. MiningWatch is presently evaluating the Prosperity Project that has been proposed by Taseko Mines Ltd. as a copper-gold mine located 125 km from Williams Lake, BC. The proposed project will be subject to public review in 2009 under a harmonized Federal/Provincial environmental review process.

The Prosperity Project, if pursued, would profoundly alter aquatic ecosystems in the vicinity of the project. A Tailings Storage Facility (TSF) would be created that would inundate Fish Lake and Little Fish Lake. An artificial lake, Prosperity Lake, would be constructed along the southern margin of the TSF to compensate for rainbow trout habitat losses. Flows from the Fish Creek watershed would be diverted into Prosperity Lake and from there downstream into Wasp Lake, Beece Creek and the Taseko River. Middle Fish Creek stream habitats would be permanently lost and replaced by the TSF and the mining pit. The compensation plans that address these impacts must satisfy the DFO No Net Loss criteria and provide assurance that fish habitats will be successfully compensated.

This report was prepared for MiningWatch to review the aquatic components of the Prosperity Environmental Impact Statement (EIS) that deal specifically with immediate impacts at the mine site. Downstream impacts, particularly in regards water quality impacts related to acid rock drainage and metal leaching, are also highly relevant for fisheries impact assessment and are being addressed by other investigators. Sections of the EIS that were analyzed include chapters and appendices related to the Project Description, the Physical and Biotic Environments, and the Fisheries Compensation Plan. The report begins with a description of the proposed aquatic habitat alterations and then considers the fisheries and aquatic impact assessment. Next, the proposed Fisheries Compensation Plan is summarized.

Canadian experience with the implementation of fisheries compensation is reviewed in reference to reports authored by DFO habitat managers.
The report concludes with a critique of the proposed Fisheries Compensation Plan.

2. Aquatic Habitat Alterations

The proposed project would involve the re-routing of surface flows and the impoundment of Fish Lake and Little Fish Lake aquatic habitats (Figure 1) to form a Tailings Storage Facility (TSF). Prosperity Lake would be situated to the east of Wasp Lake and south of the TSF and would be constructed by building a water retention dam and filled via a 10.8 km headwater channel and spring snowmelt runoff.

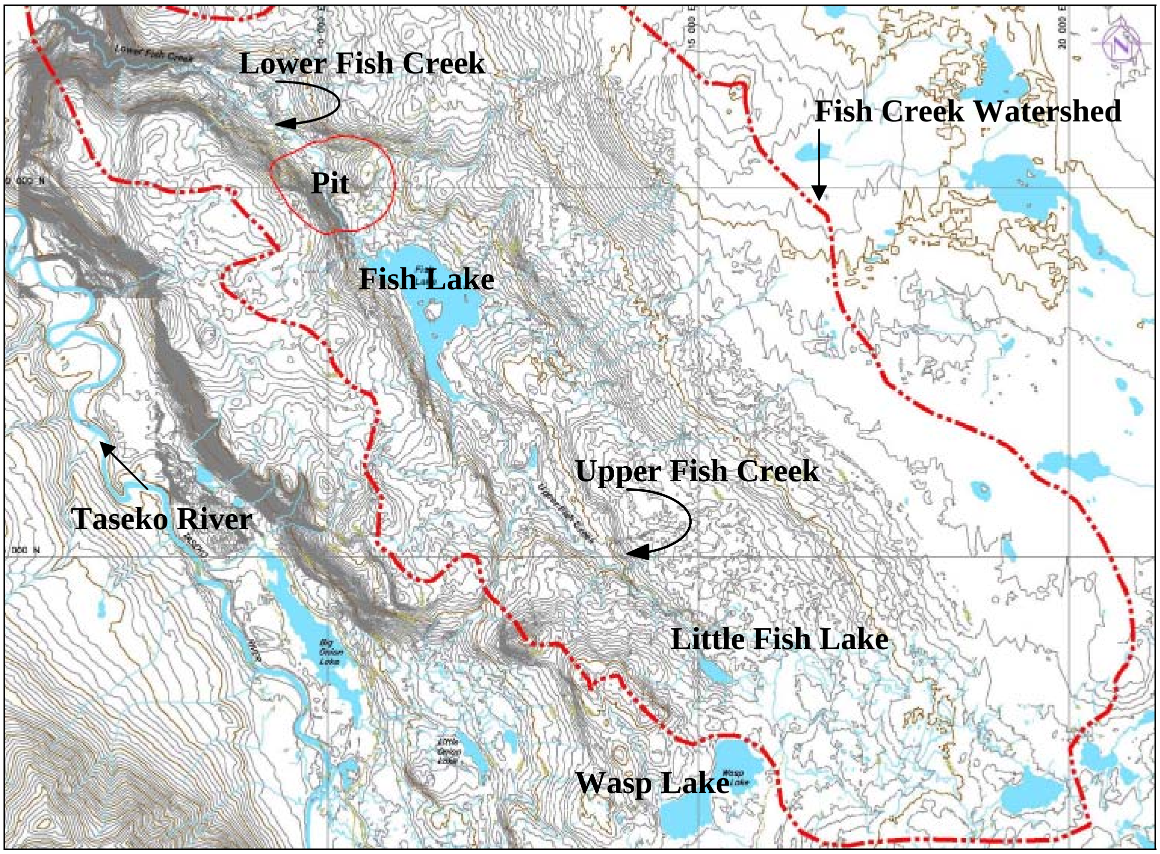


Figure 1. Aquatic habitats in, and adjacent to, the Fish Creek watershed.

A system of headwater channels would be constructed along the eastern side of the site in the Upper Fish Creek watershed. The headwater channel system would consist of both south and north flowing channels. The north flowing channel would connect with Lower Fish Creek to maintain partial flow in the lower watershed. These flows would represent 35% of present flows. The south flowing channel would connect to a Headwater Channel Retention Pond (Figure 2) southeast of Prosperity Lake. This water would be regulated and diverted into Prosperity Lake via an engineered spawning channel. From Prosperity Lake, the water would flow into Wasp Lake and from there to Beece Creek over the life of the operation. Post-closure, the water from Prosperity Lake would be diverted to the TSF and then to the open pit (Figure 3). Once the open pit filled (up to 27 years post-closure) water flows would be re-established to Lower Fish Creek.

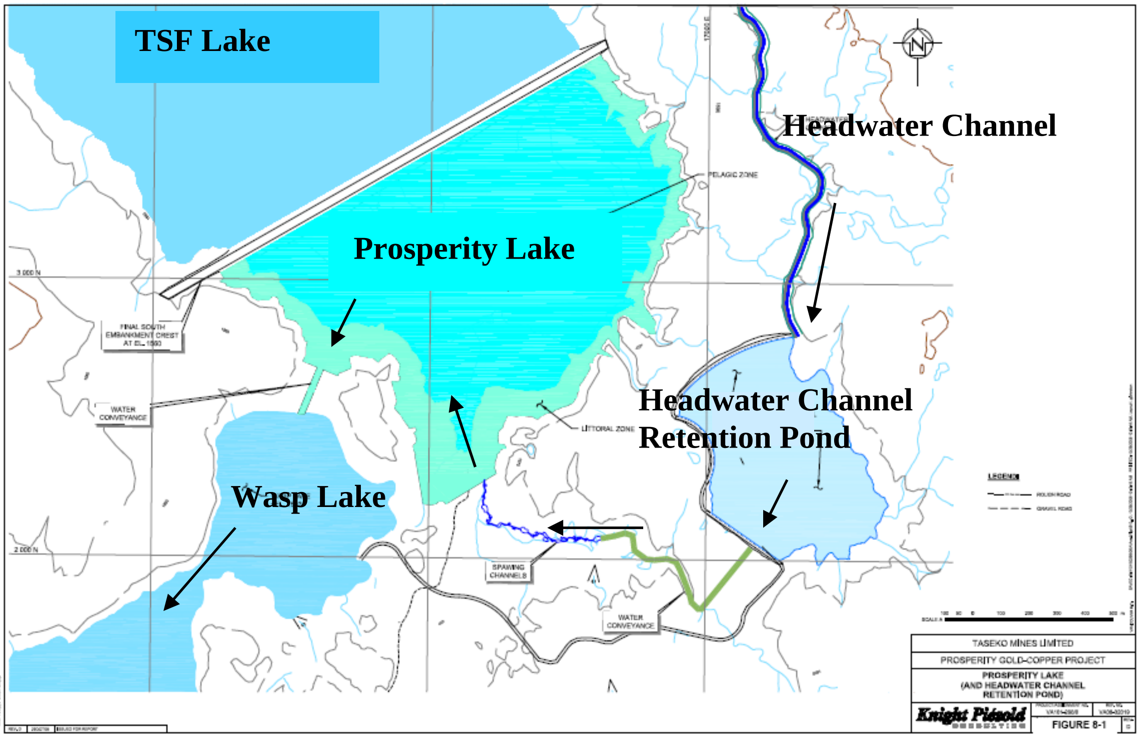


Figure 2. Prosperity Lake water inflows and outflows during operations.

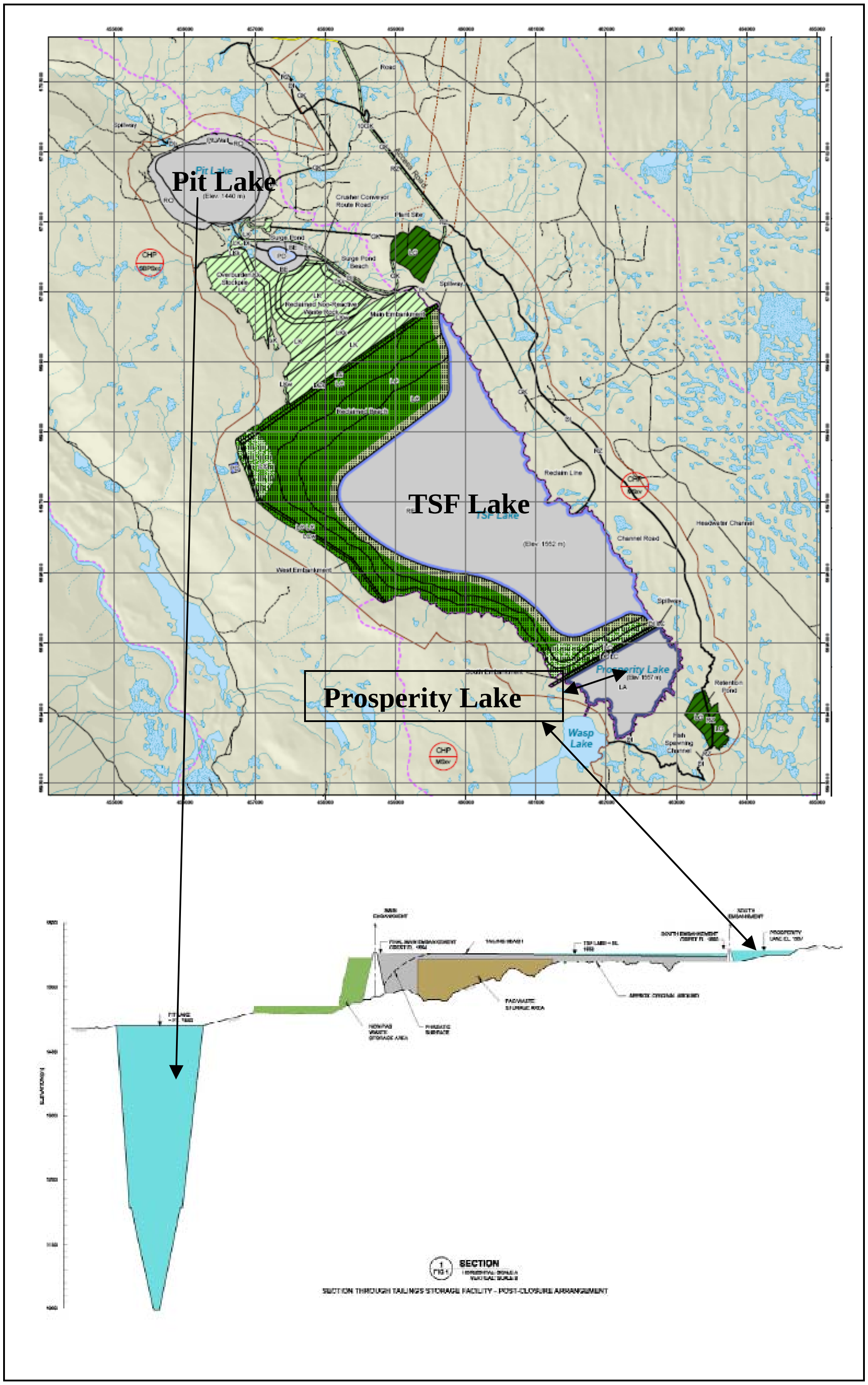


Figure 2. Reclamation plan layout and longitudinal section at post-closure abandonment.

3. Fisheries and Aquatic Impact Assessment

Hydrology

Fish Creek and its tributaries are characterized by high spring flows due to snowmelt and rainfall combined with snowmelt. Low flows occur in late summer/early fall and winter. Most smaller creeks are frozen over for extended periods during the winter.

Project-related water diversions would permanently alter the baseline hydrology of the Fish Creek watershed. These changes include the complete removal of Fish Lake and Little Fish Lake. There would be an estimated 65% decrease in surface water streamflow during the operating period in the Fish Creek watershed, following a 72% decrease in watershed area. The annual flow into Lower Fish Creek would be 1.25 Mm^3 over the life of the mine. After closure, flows would be re-routed from Prosperity Lake into TSF Lake and from there to Pit Lake. After Pit Lake has filled, baseline flow conditions would be re-established in Lower Fish Creek. In Beece Creek, there would be an increase in streamflow during operations (3.8%), reflecting a 14% increase in watershed area. After closure the proponent predicts that there would be a small decrease in watershed area (-1.4%) and only minor streamflow changes from baseline.

A Headwater Channel of 10.8 km (Figure 2) would be designed to have bi-directional flow capability and would direct water either north into Lower Fish Creek, or south into Prosperity and Wasp Lakes. About 2.3 Mm^3 per year would be directed into Prosperity Lake. An Optional Diversion Channel would allow the mine to divert water either north or south, depending on operational requirements. The Headwater Channel would reduce the Fish Creek catchment area by up to 29 km^2, about one third of the entire Fish Creek drainage (94.1 km^2).

Proposed mitigation measures for effects on hydrology include:

- Water diversion channel that during operations diverts 1.25 Mm^3 annually to Lower Fish Creek;

- Restoration of flows in Lower Fish Creek post closure. This would be undertaken by constructing a spillway in the Main Embankment crest of the TSF to allow the TSF supernatant pond to overflow and contribute to the surface water runoff to Lower Fish Creek via the open pit.

The EIS concludes that, with the proposed mitigation measures, the effect of the Project on Fish Creek surface water hydrology, and groundwater quantity is predicted to be adverse until the post-closure period when flows are re-established in Lower Fish Creek. This flow re-establishment would involve a time lag of up to 27 years as the pit fills up and reaches full pool.

Water Quality

Water quality parameters in Prosperity Lake were addressed via modeling, with parameter values compared to sampling site "W1" upstream of Fish Lake, several adjacent lakes (Wasp, Fish, Little Fish, Slim and Vick), and BC as well as Canadian water quality guidelines. The following parameters were evaluated:

- Total dissolved solids
- pH
- Hardness
- Overwintering dissolve oxygen
- Chloride
- Fluoride
- Sulphate
- Nitrate
- Nitrite
- Ammonia
- Phosphorus
- Nitrogen to phosphorus ratio
- 27 different metals in their total and dissolved forms

All metals were predicted to be below their respective guideline with the exception of total and dissolved iron and total cadmium. Total iron was well above the water quality guidelines, and the high concentration was attributed to the fact that iron is naturally present in high concentrations in the Fish Lake watershed. Likewise total cadmium was predicted to be elevated above water quality guidelines. Nevertheless the predicted concentration was 3.1 times lower than the "lowest observed effect level" for *Daphnia magna*, reducing concern about cadmium toxicity for rainbow trout.

A mercury model was used to predict mercury levels in rainbow trout following Prosperity Lake impoundment and potential mercury mobilization during Prosperity Lake creation. The model suggested that mercury levels in Prosperity Lake would be similar to those presently existing in Fish Lake. Prosperity Lake fish were predicted to be safe for consumption by humans and wildlife.

The water quality assessment predicted insignificant effects from post-closure diversions into Fish Creek, Wasp Lake and Beece Creek, and from TSF seepage water either directly to the Taskeo River or moving with groundwater to Big Onion Lake. Post-closure discharge of pit water was predicted to result in moderate magnitude water quality changes in lower Fish Creek and low magnitude changes in the Taseko River downstream. The need for treatment of this contaminated water would be assessed via monitoring programs during operations and the 27 years of pit filling during closure. The EIS states that current technologies are capable of achieving the necessary load reductions to meet water quality guidelines.

Fisheries

The majority of the Local Study Area (brown line on Figure 3) is comprised of the Fish Lake watershed which contains a monoculture population of rainbow trout with about 85,000 resident in Fish Lake and 5,000 in Little Fish Lake. The trout utilize about 6.4 km of associated inlet and outlet streams for spawning and seasonal juvenile rearing. Annual angler fishing effort, measured as part of the environmental assessment, ranged from 388 to 548 angler-days with a total annual harvest of 4100 – 4900 rainbow trout ranging in size from 20 to 34 cm.

Fisheries assessment indicated that the Fish Lake rainbow trout population consisted of 36,000 juveniles, 22,000 sub-adults, and 27,000 adults. During the development of the project, BC MOE agreed with Taseko that the estimated upper limit for the Fish Lake trout population of 85,000 would suffice for fisheries compensation planning purposes.

In the Upper and Middle Fish Creek stream habitat, rainbow trout were roughly estimated as 74,000 fish, the majority of which (96%) are young-of-the-year (age 0+ years). Ages 2+ and 3+ rainbow trout were most abundant in mainstem Reach 5 (Figure 3). Collectively, Reaches 5 and 6 supported the majority (75%) of rainbow trout stream production in the Fish Creek watershed.

The total Fish Lake and Fish Creek rainbow trout population was estimated at 165,000 individuals, of which 85,000 resided in Fish Lake and 80,000 resided in Fish Creek. The Fish Lake population consisted of age classes 0+ to 6+ fish. Based on the: 1) Fish Lake population estimate, 2) mean fish weight by life-stage (juvenile, sub-adult and adult fish), and 3) Fish Lake surface area, rainbow production in Fish Lake was estimated at 24.1 kg/ha/y.

Fish and fish habitat conditions along the Taseko Lake and 4500 Road, as well as the 2.8 km mine access road, were evaluated during a survey of road stream crossing sites between July 16-21, 2006. A total of 64 sites were assessed.

Proposed construction activities, including dewatering of Fish Lake, starter dam construction and water diversion around the Project site would result in fish habitat destruction via the loss of Fish Lake and the eventual inundation of Little Fish Lake. Reduction of downstream flows together with the loss of mainstem, tributary and riparian habitats would adversely affect rainbow trout populations in Fish Creek. The main fisheries impacts of concern include:

- Elimination of Fish and Little Fish Lakes as a result of mine construction activities;
- Loss or alteration of in-stream habitat in Fish Creek as a result of mine operations water management;
- Elimination of First Nations fish harvesting opportunities in Fish Lake and Little Fish Lake;
- Elimination of Fish Lake recreational angling opportunities.

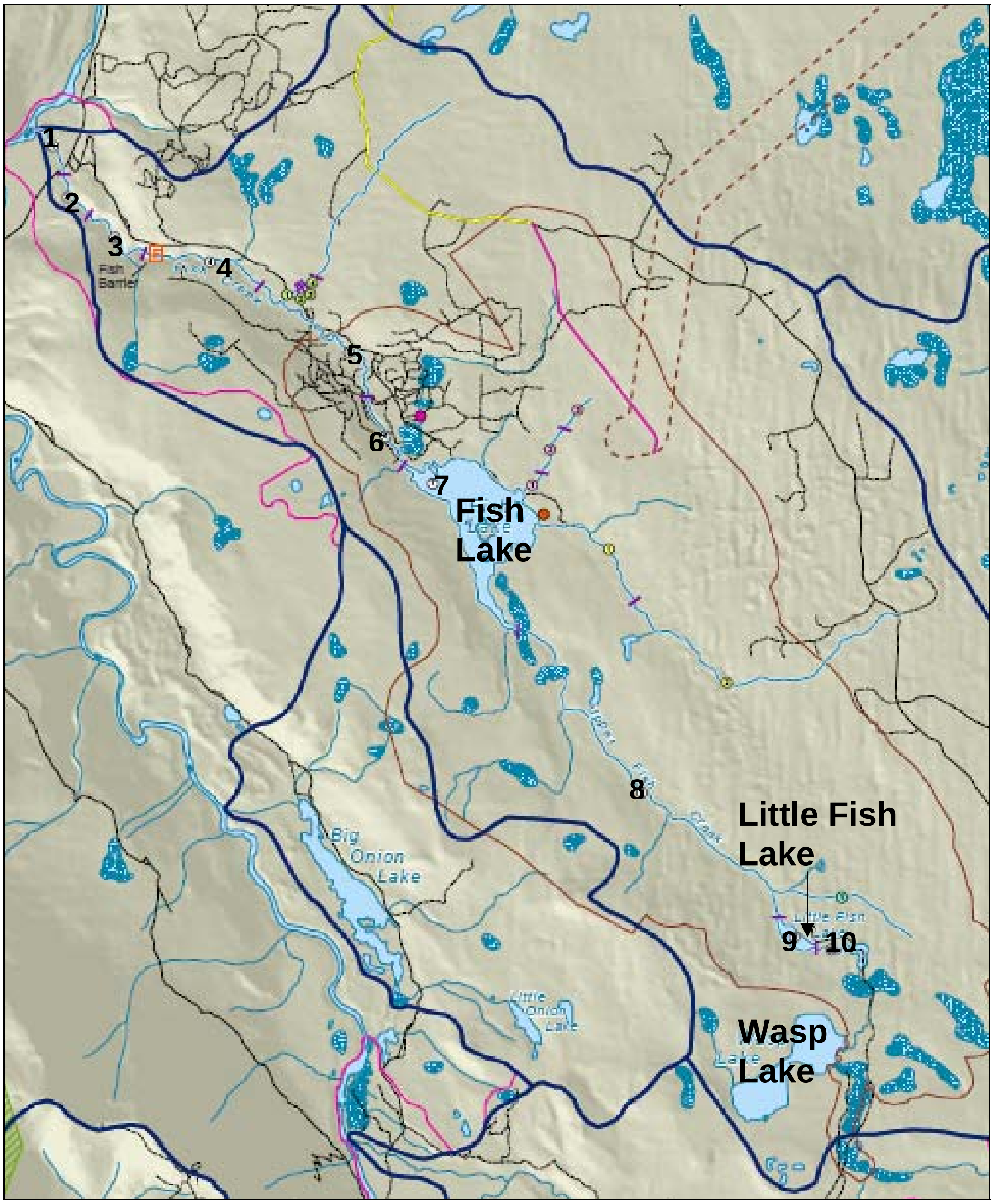


Figure 3. Fish sampling reaches 1-10 in the Fish Creek Watershed.

The main fisheries impacts are associated with water flow diversions, physical disturbance of fish habitats, site clearing and preparation for project development. The impacts of the Project on rainbow trout in-stream habitat in middle and upper Fish Creek would be greatest during the pre-construction and construction phases.

Project activities associated with pre-construction, construction and operation phases, including Fish Lake dewatering, TSF starter dam construction and water diversion, would be expected to eliminate flows and rainbow trout habitat. Collectively, mine facilities and operation, and the headwater diversion channel would create a closed mine site which would restrict the local flow of water, thereby eliminating a large proportion of stream and lake fish habitat in the Middle and Upper Fish Creek watershed.

Of the 47,600 m^2 of fish-bearing in-stream habitat that would be affected in Fish Creek, 34,800 m^2 (73%) would be permanently lost when portions of Reach 5, all of Reaches 6 and 8, and 2 Fish Lake tributaries become part of the Tailings Storage Facility or Pit after closure. Thus, a total of 34,800 m^2 of fish-bearing and 53,400 m^2 of non fish-bearing habitat would be permanently lost as part of Project activities. This amount includes 9,160 m^2 of spawning habitat and 29,100 m^2 of fish-bearing habitat during the critical low flow period. These habitat alterations would occur during the life of the mine as a result of upstream water diversion and Project dewatering activities.

An estimate of Fish Lake productive capacity showed that Fish Lake had higher than average productivity (TDS 130 mg/l), capable of supporting a substantial standing crop of trout (85,000 fish, approximately 700 fish/ha). Stream habitats in the Fish Lake system are also productive. Stream habitats below Fish Lake, and above the falls (Reaches 4-6 on Figure 3), were estimated by BC MOE to produce 18,000+ one year old rainbow trout or equivalents.

4. Fisheries Compensation Proposal

The overall goal of fisheries compensation is to provide lake and stream habitats of similar or better productive capacity for trout as provided by the Fish Lake system now, and a trout fishery of at least similar character to what is supported by Fish Lake under current conditions. BC MOE requires that the compensation measures be effective for at least the period of time that the fishery is eliminated due to mining activities or that replacement habitat is not fully functional to support a fishery. The rationale for constructing Prosperity Lake is to re-establish a lake and stream ecosystem to replace the Fish Lake complex (like-for-like under the habitat policy).

Proposed compensation for the loss of Fish Lake would be accomplished via creation of Prosperity Lake and the Headwater Channel Retention Pond (HCRP - Figure 4).The HCRP would be non fish-bearing, but is predicted to contribute nutrients and organic materials to downstream fish habitats.

Prosperity Lake would be a 113 ha water body formed upslope of the south embankment of the Tailings Storage Facility (Figure 4). Six existing rainbow trout lake creation projects constructed in the end pits of coal mines in Alberta (Hartman and Miles 2001) are considerably smaller than the proposed Prosperity Lake, covering areas between 6-16 ha.

Prosperity Lake would consist of 49 ha of shoal habitat and 64 ha of pelagic area: 43% shoal and 57% pelagic. The shoal habitat (also called littoral area) is defined as the area between the lake outline and the 6 m (20 foot) contour lines. Approximately 2 km of inlet stream would be complexed to provide spawning habitat for about 50 pairs of rainbow trout and summer rearing habitat for approximately 30,000 fry (Figure 4). Instream and lake habitats would be designed to support a managed population of 20,000-25,000 fish in Prosperity Lake. The lake is predicted to have a rainbow trout productivity level of approximately 15 kg/ha/y, based on the results of the Primary Productivity model in the EIS.

Prosperity Lake would replace 49 ha or about 54% of the affected Fish and Little Fish lakes littoral habitats (90.1 ha) and 64 ha (a greater than twofold increase) of the affected pelagic habitats. The fish compensation plan states:

> "Although there will be a decrease in shoal habitat, Prosperity Lake will have sufficient shoal areas and water quality to support the target fish population to maintain the genetic composition of rainbow trout from the upper watershed."

There are time lags involved in proposed compensation project development. The proponent states that a temporal reduction in fish productivity from one to four years is predicted to occur as design capacity is reached in the various compensation elements. It would take at least 2 years to fill Prosperity Lake after land clearing activities have been completed. Prior to the first freshet, the area

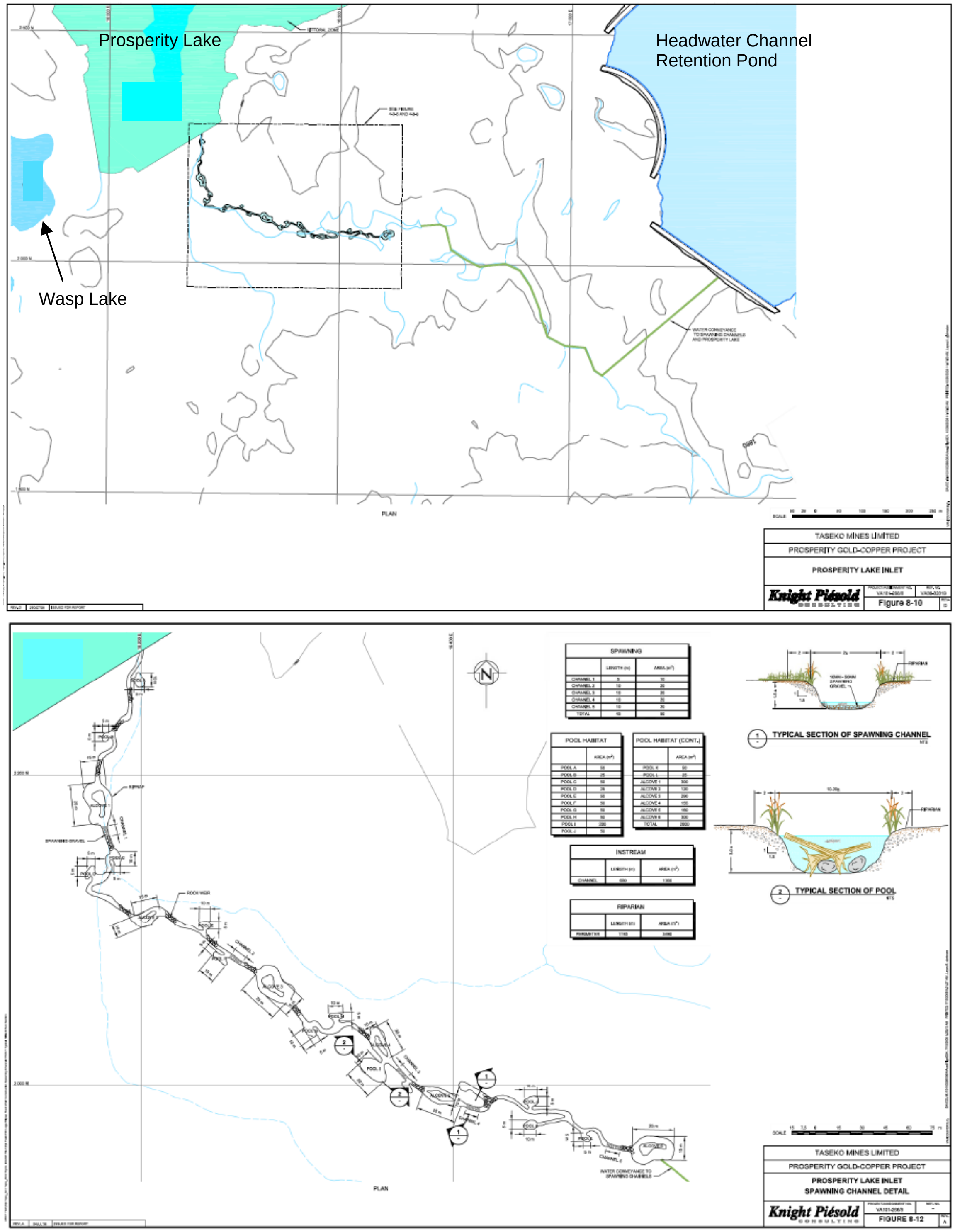


Figure 4. Upper: Location of engineered spawning channel that would inflow into Prosperity Lake. Lower: Spawning channel details.

that would be flooded by about 50% of the volume of the lake would be stripped of vegetation and soil. Prior to the second freshet, the full area to be flooded by Prosperity Lake would be stripped of vegetation and soil. There would be a further time lag of about 4 years between stocking of rainbow fry, and their recruitment to the fishery at age 4+.

During year one, several candidate lakes in the Chilcotin would be stocked with mature and immature rainbow trout salvaged from Fish and Little Fish lakes and in-stream habitats. The fish would be salvaged prior to lake dewatering activities during the pre-construction period.

Fish culture activities are proposed as an important component of the proposed compensation plan to maintain the genetic integrity of Fish Lake rainbow trout. The BC MOE Hanceville Hatchery was identified as one of several possible sites for rainbow hatchery production. Rainbow hatchery fry additions into Prosperity Lake would be required until such time as monitoring demonstrated that the constructed lake and the associated spawning channel provides a suitable replacement fishery for Fish Lake.

A letter from Dr. Eric Taylor, UBC to Dr. Tom Watson, Triton on June 27, 2008 provides the results of DNA testing of Fish Lake rainbow trout and comparison with 54 other populations. Fish Lake rainbow trout are not genetically distinctive within the context of a large number of BC populations. They are considered “typical” in terms of their close phylogenetic affinity to other interior BC populations.

In addition to hatchery outplants to Prosperity Lake, back-up gene pools of Fish Lake rainbows would also be maintained via annual outplants to Slim, Blue and Koster Lakes and Lake 6267 at an individual lake size of about 3000 fish.

The EIS draws the following overall conclusions about the fish compensation plan:

> “However, as environmental effects will be mitigated or compensated for, there will be no adverse combined environmental effects of the Project on rainbow trout or habitat in middle and upper Fish Creek…In general, the Project effects after implementation of the Compensation Plan will result in an increase of lake habitat within the Fish Creek watershed, and a decrease of stream habitat.”

This conclusion is further evaluated in Section 6.

5. Effectiveness of Fisheries Habitat Compensation in Canada

Since the release of the DFO Policy for the Management of Fish Habitat in 1986, there have been many hundreds of fisheries compensation projects in Canada and there is a large amount of experience with policy implementation. This section of the report considers several studies which have retrospectively analyzed the successes and failures of the DFO policy.

The BC MOE fisheries program goal - to conserve wild fish and their habitat - includes protection, maintenance and restoration management activities. Those activities related to fish stocks are classed as mitigation, and those associated with habitat restoration or enhancement are classed as compensation.

The DFO Policy for the Management of Fish Habitat is a cornerstone for salmon habitat protection in Canada, and is a major driver during the environmental assessment of mining projects and other industrial developments. The “No Net Loss” (NNL) principle guides the policy and seeks to balance unavoidable habitat losses with habitat replacement in order to prevent reductions to Canada's fisheries resources. One of the metrics under this principle is “productive capacity” which has been defined by DFO as:

> “The maximum natural capability of habitats to produce healthy fish, safe for human consumption, or to support or produce aquatic organisms upon which fish depend.”

Evaluations of net gain or net loss in productive capacity are central to the evaluation of the acceptability of a project. Where projects have adverse impacts on productive capacity, proponents are required to undertake mitigation to alleviate such impacts. Mitigation has been defined by DFO as actions taken during the planning, design, construction and operation of works to compensate for potential adverse effects on the productive capacity of fish habitats. Fisheries mitigation procedures are integral components of mining projects that identify, design and construct compensation projects to meet NNL criteria.

Retrospective studies have been carried out to evaluate the effectiveness of Canadian fish habitat compensation projects in achieving the conservation goal of no net loss of productive capacity. Harper and Quigley (2005A) evaluated 103 projects and found that only 64% of the projects were determined to have achieved NNL. In another study, determinations of NNL could only be made for 17 out of 84 HADD (harmful alteration, disruption, and destruction of fish habitat) authorizations as a result of poor proponent compliance with monitoring requirements (Harper and Quigley 2005B). At 16 habitat compensation sites where habitat productivity was measured, 63% of the projects resulted in net losses in habitat productivity (Quigley and Harper 2006). These projects were characterized by mean compensation ratios of 0.7:1, indicating a failure to achieve NNL. Increasing compensation ratio requirements to 2:1 was insufficient to achieve NNL for all projects, suggesting that the ability to replicate ecosystem function is clearly limited. Where there is a time lag between development activities and compensation actions, it is necessary to increase compensation ratios to account for the time lags. Delaying compensation actions while incurring losses early in a project increases the levels of compensation required. In these circumstances, compensation ratio values of 2:1 or higher may be necessary to ensure the achievement of NNL (Minns 2006).

It is evident that Canada has had a mixed track record with achieving NNL. It cannot be assumed that mining project mitigation and compensation projects will function as designed. To be conservative, it is necessary to apply a compensation ratio of 2:1 (minimum) and where practical, to develop compensation projects in advance of mining activities. Post-project effectiveness surveys are also required at regular intervals after project completion to ensure that mitigation projects are fully functional. Where they do not, then alternate approaches will be required. In view of the uncertainty of many fisheries mitigation projects to achieve NNL, contingency plans are required to predetermine responses to mitigation projects which don’t function as intended.

6. Critique of the Prosperity Fisheries Compensation Proposal

This section of the report provides a critical analysis of the proposed fisheries compensation plan. In particular, it evaluates the following statements in the EIS:

> "In regards to the productive capacity in the Fish Lake system, the plan provides for on-site like for like compensation of lake habitat with the development of Prosperity Lake, the Headwater Channel and the Headwater Channel Retention Pond. In general, the project effects after implementation of the Compensation Plan will result in an increase of lake habitat within the Fish Creek watershed, and a decrease in stream habitat. After closure, the policy objective of net gain will be met…."

From a fisheries perspective, there are a number of reasons why Prosperity Lake does not adequately compensate for the loss of Fish Lake and Little Fish Lake. They include:

- Inadequate compensation for littoral habitats;
- No compensation to account for time lags in artificial lake functionality;
- Inherently lower trout production in Prosperity Lake; and
- Predicted reduction in Prosperity Lake productivity over time.

The critique also considers the uncompensated net decrease in stream habitat in Middle and Upper Fish Creek as a consequence of project activities.

<u>Inadequate compensation for littoral habitats</u>

Much higher aquatic productivity occurs in littoral (also called shoal) habitats in lakes than pelagic habitats. This occurs because of the growth of rooted aquatic plants and associated periphyton (algae that grows on plants and the bottom), tight nutrient and organic carbon recycling and strong light penetration. Rainbow trout productivity is higher in littoral habitats, reflecting the higher biological production, compared to the pelagic zone. These differences are reflected by the BC MOE Small Lake Stocking Model that is referenced in the EIS:

> "Shoal area is considered to be ten times more productive than deep water areas in terms of carrying capacity for fish stocking."

During the environmental review for the Kemess Project, DFO suggested the use of a compensation ratio (compensation area:impacted area) for littoral areas of 2:1 to reflect the higher productivity of littoral areas of Amazay Lake.

Comparison of littoral habitat areas in Prosperity and Fish/Little Fish Lakes (Table 1) shows that Prosperity is relatively deeper lake than Fish, and has more of its area as pelagic habitat. Fish and Prosperity Lakes are comprised of 77% and 43% littoral habitat respectively.

Table 1. Comparison of Fish Lake/Little Fish Lake and Prosperity Lake littoral areas and rainbow trout productivity.

Parameter	Impacted			Compensation
	Fish Lake	Little Fish Lake	Total	Prosperity Lake
Lake Area (ha)	111	6.6	**117.6**	**113**
Littoral Area (ha)	83.5	6.6	**90.1**	**49**
Pelagic Area (ha)	27.5	-	**27.5**	**64**
% littoral	75%	100%	**77%**	**43%**
Rainbow Trout Population	85,000	5,000	**90,000**	**20,000 – 25,000 (managed population)**
Spawning and Rearing Habitat (km)	6.4		**6.4**	**2 (spawning channel)**
Fish Production (kg/ha/yr)	24.1	24.1	**24.1**	**15 (primary productivity model)**
Fish Production (kg/yr)	2675	159	**2834**	**1695**

The EIS states:

> "There has been a deliberate decision to construct Prosperity Lake with less shoal habitat than Fish Lake so as to influence a change in fish size distribution. The deeper waters of Prosperity Lake combined with a lesser proportion of spawning habitat are expected to produce larger fish. While overall fish biomass per unit area is predicted to be less in Prosperity Lake than Fish Lake, the trout population is anticipated to produce a better angling experience and facilitate achieving regional objectives for fisheries enhancement."

The predicted outcome of larger fish in the deeper waters of Prosperity Lake is questionable. Prosperity Lake is proposed as a monoculture population of rainbow trout and there would be no forage fish available in the pelagic zone to promote faster fish growth. Rainbow trout production in Prosperity Lake would more likely depend on littoral zone habitat capacity which is greatly reduced compared to Fish/Little Fish Lake.

To evaluate the relative productivity of the 2 lakes, Lake Production Units (LPUs) were assigned a value of 2/ha for littoral areas and 1/ha for pelagic areas. Fish/Little Fish and Prosperity Lakes have values of 208 LPUs and 162 LPUs respectively. This reflects a compensation ratio of 0.78:1, leaving out other considerations.

No compensation to account for time lags in artificial lake functionality

There are a number of time lags involved before Prosperity Lake would equilibrate and function as rainbow trout habitat. Shoreline vegetation stripping and land clearing will take place over 2 years, with the lake reaching full pool after 2 years of runoff. Thereafter stocking of juvenile rainbow from a fish culture facility would commence. There would also be an unknown time lag as the littoral zone aquatic community develops over a number of years. The hatchery fish would likely recruit into the fishery at Age 4, reflecting a 3-year fish growth time lag. Between lake construction, filling, littoral zone development and growth of hatchery fry there would be a minimum time lag of 6 years before Prosperity Lake functionality was fully established.

The compensation ratios needed to offset timing effects of losses and gains to achieve no net loss of productive capacity of fish habitat were evaluated by Minns (2006). As reviewed on page 14, compensation ratios of 2:1 or higher may be necessary to ensure attainment of NNL when time lags occur.

Inherently lower trout production in Prosperity Lake

Lower trout production in Prosperity Lake, compared to Fish Lake, is documented in the EIS. Table 1 indicates lower production rates in Prosperity compared to Fish, 15 vs. 24.1 kg/ha/y respectively. On an annual basis, Fish/Little Fish produces 2834 kg rainbow trout/y compared to predicted production in Prosperity of 1695 kg/y. This is a ratio of 0.6: 1.

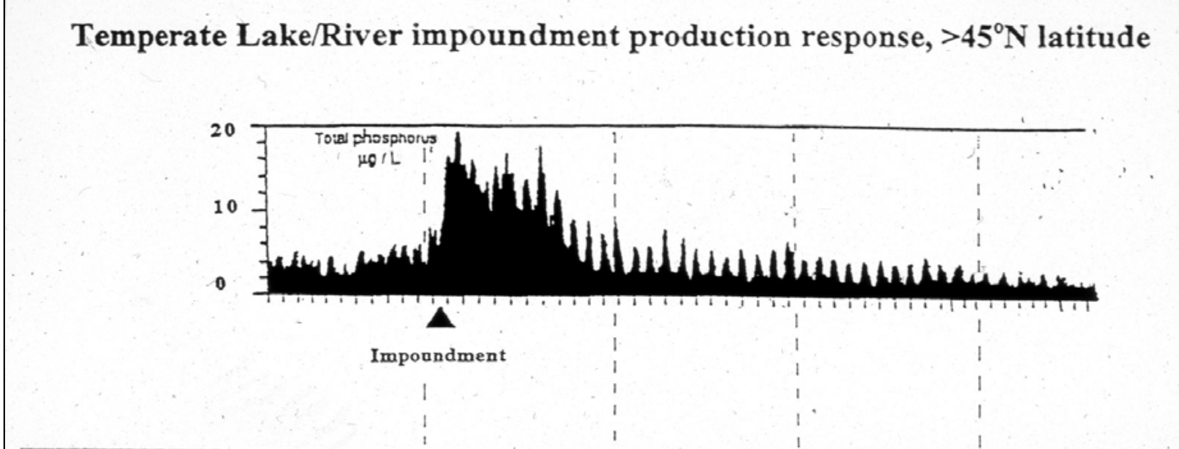
There would also be differences in rainbow trout population size (Table 1). Fish and Little Fish Lakes support 90,000 trout (all age classes) whereas the managed rainbow population in Prosperity would number 20,000 – 25,000. There would also be large discrepancies in rainbow trout spawning and rearing habitat: 6.4 km adjacent to Fish Lake compared to 2 km in the proposed spawning channel adjacent to Prosperity Lake.

Predicted reduction in Prosperity Lake productivity over time

Although Prosperity Lake is considered a “lake” it is actually a reservoir according to the following definition:

> “A natural or artificial pond or lake used for the storage and regulation of water.”

Experience has shown that reservoir productivity fluctuates over time. Following the creation of a reservoir there is a 5-year duration “trophic upsurge” due to land-based nutrient contributions creating a boom phase when productivity is high. After about 5 years, the reservoir goes into a transition phase which is then followed by a bust phase and eventually a post-phase where nutrients, productivity, and fish production are very low (Figure 5).



Phase	Pre-	'Boom'	Transition	'Bust'	Post-
Year		1-5	5-8	8-15	perpetuity
Production ($gC \cdot m^{-2} y^{-1}$)	50-70	100-120	80-100	40-60	30-50
Total P	2-4	10-14	6-8	2-4	1-3
Trophic state	oligotrophic	mesotrophic	oligotrophic	ultra-oligotrophic	ultra-oligotrophic
Fish prod.	low	moderate	low	very low	very low
Transparency	high	low	moderate	high	very high

Figure 5. A schematic production time series for a north temperate reservoir following impoundment. Source: Stockner et al. (2000).

If/when Prosperity Lake is constructed, it will likely become meso-eutrophic (i.e. moderately productive) in the short-term (1-5 years post-impoundment). Thereafter productivity will decrease down to potentially low levels. It is difficult to predict the magnitude of the productivity decrease, making it challenging to specify the lake habitat compensation implications. Nevertheless, this effect necessitates a conservative approach to habitat compensation planning.

<u>Stream habitat decreases</u>

A total of 73% (34,800 m^2) of fish-bearing in-stream habitat in Fish Creek will be permanently lost when portions of Reach 5, all of Reaches 6 and 8, and 2 Fish Lake tributaries (Figure 3) become part of the Tailings Storage Facility or Pit. Reaches 5 and 6 are the most productive stream habitats for rainbow trout in the Fish Lake watershed, accounting for about 75% of the population.

The EIS does not propose compensation to offset stream habitat loss in the productive Middle and Upper Reaches of the Fish Creek Watershed. This is inconsistent with the NNL principle of the DFO Habitat Management Policy.

Following closure, the Pit would fill up over a 27 year period and flows would be re-established to Lower Fish Creek. However this flow re-establishment would not benefit Middle and Upper Fish Creek which would be transformed irreversibly into TSF Lake and Pit Lake.

This filling period for the Pit after closure also introduces another time lag during which adverse effects due to flow reduction would continue to occur in Lower Fish Creek.

7. Conclusions

Table 2 summarizes the relative impact of the above fisheries considerations on habitat compensation ratios. Where there is uncertainty i.e. reduced productivity over time, the factor is removed from the comparison. The comparison suggests that the compensation ratio for the proposed lake component of the project would be 0.23: 1. These values represent the product of the columns in Table 2. This implies that a compensation lake for Fish Lake would need to be 4-5 times larger than the proposed Prosperity Lake to achieve NNL.

Table 2. Effect of different biological production elements on compensation ratios represented by Prosperity Lake.

	Prosperity Lake	**Fish Lake**
Littoral habitat compensation	0.78	1
Time lags	0.5	1
Rainbow trout production	0.6	1
Reduced biological productivity over time	?	1
Combined	**0.23**	**1**

The stream habitats in Middle and Upper Fish Creek would be permanently destroyed by the mine development. They represent a net loss to the ecosystem and compensation strategies are not included in the EIS. Habitat losses include 34,800 m^2 of fish-bearing habitat encompassing Reaches 5 and 6 which are the most productive stream habitats for Fish Creek rainbow trout, accounting for about 75% of rainbow trout population in Lower and Middle Fish Creek.

The precautionary principle is an approach to uncertainty, and provides for action to avoid serious or irreversible environmental harm in advance of scientific certainty of such harm (Cooney 2004). This principle needs to be adopted as a key feature of decision-making around the Prosperity Mine and its impacts on fish habitats adjacent to the proposed mine site and downstream in the Taseko and Chilko Rivers.

8. References

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