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MEMORANDUM

TO:	**Nechako Water Engagement Initiative *Technical Working Group***
FROM:	**Susan Johnson, Ph.D., Rachel Chudnow, Ph.D., R.P.Bio., Isabelle Girard, M.Sc., R.P.Bio., P.Biol., and Jayson Kurtz, R.P.Bio., Ecofish Research Ltd.**
DATE:	**September 21, 2023**
FILE:	**1316-15**
RE:	**Issue #3: Fish Access to Nechako Reservoir Tributaries – V2**

1. INTRODUCTION

During Nechako Water Engagement Initiative (WEI) Main Table and Technical Working Group (TWG) meetings, concerns were raised about potential effects of Rio Tinto (RTA; formerly Alcan) operations on fish populations within the Nechako Reservoir. One priority is to better understand how reservoir drawdown impacts fish access to tributaries. The TWG asked Ecofish Research Ltd. (Ecofish) to review literature and summarize the status of current knowledge regarding this potential concern and develop recommendations for WEI consideration. This memo provides an overview of potential drawdown related impacts on fish access to tributary habitats within the Nechako Reservoir and offers practicable recommendations to inform water management decisions and minimize the negative effects of operations on fish access to these habitats.

2. BACKGROUND

2.1. Nechako Reservoir Hydrology

The Nechako Reservoir is located approximately 200 km west of Prince George, British Columbia (BC) and was created to provide water for RTA's Kemano Hydroelectric Project, which was constructed in the 1950s to provide energy to operate an aluminium smelter in Kitimat, BC. The reservoir was formed by the construction of Kenney Dam on the Nechako River (at the east end of the reservoir), which inundated a chain of six major lake and river systems (Ootsa, Whitesail, Knewstubb, Tetachuck, Natalkuz, and Tahtsa, ~420 km total length; Map 1). The remainder of this subsection provides an overview of Nechako Reservoir hydrology, with further details regarding Nechako watershed hydrology more broadly provided in a separate Ecofish memo (Beel *et al.* 2022).

Nechako Reservoir has a surface area of ~910 km^2 with a normal annual drawdown range of ~ 3 m (10'); annual minimum reservoir levels occur in late spring and annual maximum water levels occur in late summer. Water levels in Nechako Reservoir vary among years, but they generally follow a similar seasonal trend (Figure 1). Based on data from 1987 – 2020 inclusive (the years analyzed with complete records), the annual range in reservoir level varied from 1.20 m to 3.33 m, with a median annual range of 1.90 m (Figure 1). Generally, reservoir levels increase rapidly in spring (April – May) and peak in summer, reaching a mean maximum of 852.74 m in ~July, before steadily declining during the fall through to the following spring to minimum levels (mean minimum = 850.94 m) in ~April – July, prior to freshet.

There are two reservoir outflows. On Tahtsa Lake, an intake to the Kemano hydroelectric station diverts ~70% of the annual reservoir inflow 16 km west into the Kemano River watershed. The Skins Lake Spillway on Ootsa Lake diverts the remaining flow (~60 m^3/s mean annual discharge) from the surface of the lake ~80 km through the Cheslatta watershed, before discharging into the Nechako River at Cheslatta Falls. There is no discharge facility at the Kenney Dam.

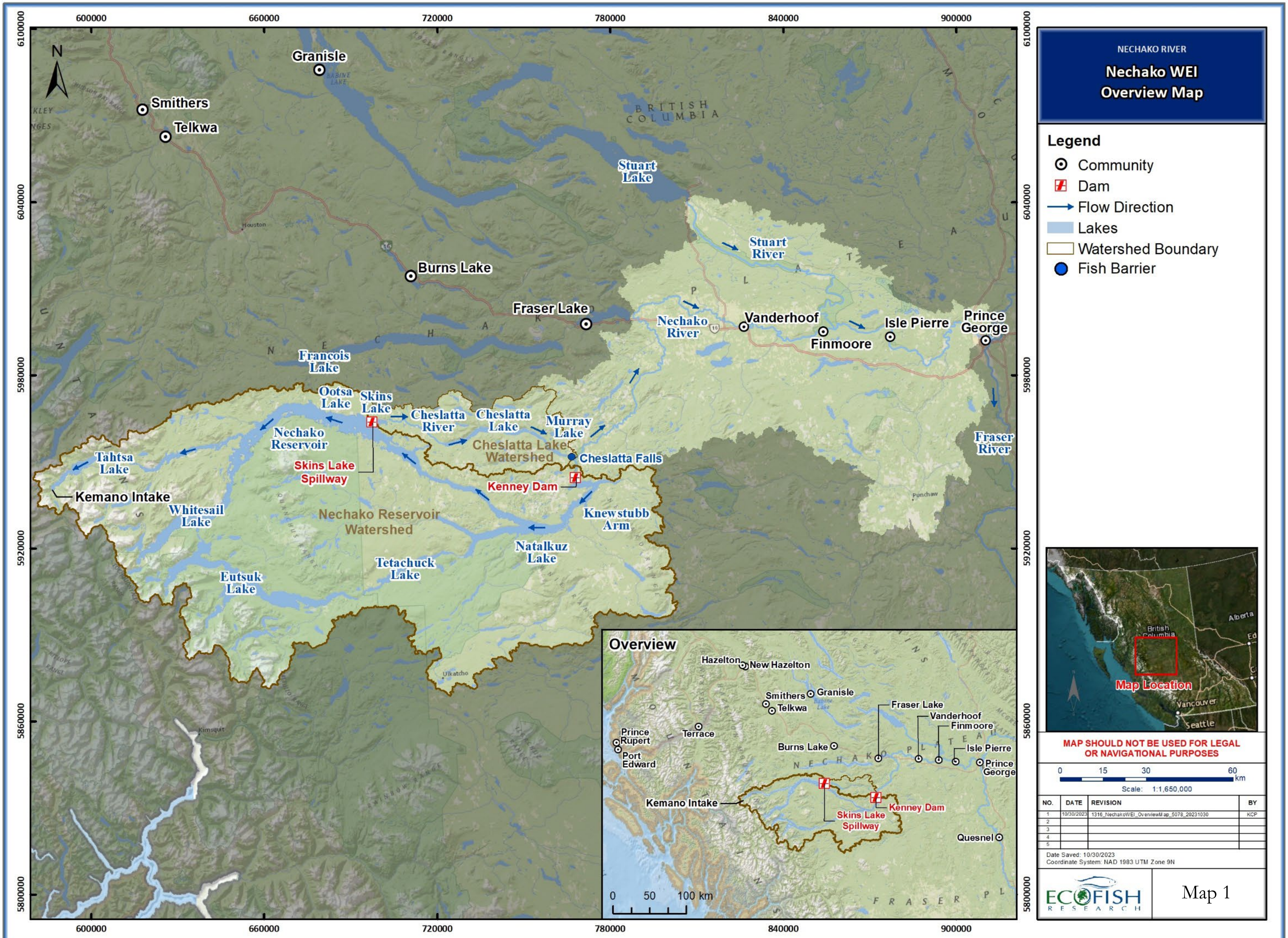

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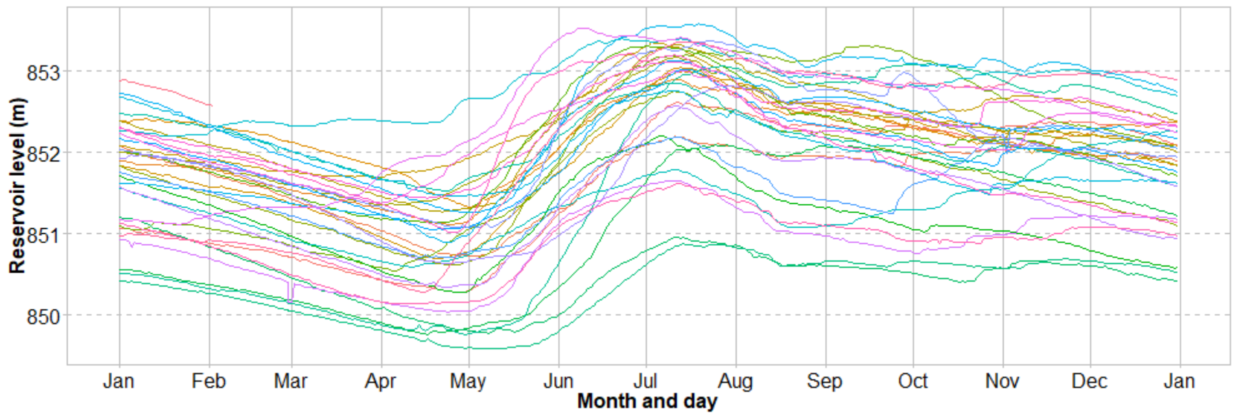
Figure 1. Plots showing daily reservoir water levels in Nechako Reservoir coloured by year (1987 – 2021).



2.2. Nechako Reservoir Fish Community

The Nechako Reservoir provides habitats for a diverse assemblage of 14 fish species (Table 1). Information regarding species specific population distribution and habitat use is highly limited (see Section 2.3), however, reconnaissance level stream inventories have identified at least six species in Nechako Reservoir tributaries (i.e., Burbot, Kokanee, Lake Chub, Prickly Sculpin, Rainbow Trout, and whitefishes) (BCUC 1993; Hatfield 1997, 1998; KCB 2013; SKR 1999, 2002a, 2002b, 2003; RTA 2013; Winsby *et al.* 1997, 1998). In addition, populations of all remaining species contributing to the Nechako Reservoir fish community are generally known to use tributary habitats for spawning or rearing (Table 2). Therefore, it is possible that tributary habitats are also important to populations of these species within the Nechako Reservoir. Herein, we limit our discussion of tributary habitat use to only the species that have been explicitly identified in Nechako Reservoir tributaries. Additional discussion of habitat use for all additional species is provided in Chudnow and Kurtz (2022), which also provides a summary of the native distribution, conservation status, population trends, and life histories of all species identified within the Nechako Reservoir.

All Nechako Reservoir salmonids excluding Rainbow Trout (i.e., Kokanee, Mountain Whitefish, and Umam) are fall spawning, with emergence and early juvenile rearing occurring in spring (Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007). In contrast, Rainbow Trout are spring spawning, with early juvenile rearing occurring primarily in tributary habitats before individuals begin recruiting to lacustrine habitat as parr (McPhail 2007). Both Burbot and Prickly Sculpin spawning begins in winter with spawning and early juvenile rearing extending through spring and early summer, respectively (Scott and Crossman 1973; Roberge *et al.* 2002; McPhail 2007). Finally, Lake Chub spawning and rearing occurs throughout late spring and summer (McPhail 2007).

Table 1. Nechako Reservoir fish community.

Family	Common Name	Scientific Name[1]
Burbots	Burbot	*Lota lota*
Minnows	Brassy Minnow	*Hybognathus hankinsoni* [2]
	Lake Chub	*Couesius plumbeus* [3]
	Northern Pikeminnow	*Ptychocheilus oregonensis*
Salmonids	Kokanee	*Oncorhynchus nerka*
	Mountain Whitefish	*Prosopium williamsoni*
	Umam	*Prosopium* sp. [4]
	Rainbow Trout	*Oncorhynchus mykiss*
Sculpins	Prickly Sculpin	*Cottus asper*
	Slimy Sculpin	*Cottus cognatus* [3]
Suckers	Bridgelip sucker	*Catostomus columbianus*
	Largescale Sucker	*Catostomus macrocheilus*
	Longnose Sucker	*Catostomus catostomus*
	White Sucker	*Catostomus commersonii* [3]

[1] Species presence sourced from: Hatfield 1997, 1998; Winsby *et al.* 1998; Envirocon 1989; Triton 2000a, 2000b, 2005; SKR 2002a, 2002b, 2003; BCUC 1993; RTA 2013; BC MOE 2021a, 2021b; Robertson, pers. comm. 2021.

[2] Observations in Skins Lake Spillway plunge pool indicate species could be entrained from Nechako Reservoir (Triton 2005).

[3] Species observed in tributaries of the Nechako River (Triton 2000a, 2000b, 2005) and could potentially use Nechako Reservoir lacustrine habitats.

[4] Species' taxonomic classification is unclear. This fish is important to the Cheslatta Carrier Nation, and it is unclear if the rough translation ("pygmy" whitefish; Triton 2008) relates to a common translation (i.e., "small" whitefish) or refers to *Prosopium coulterii*. The Nation is undertaking ongoing work to better understand whitefish populations in the basin (Triton 2008; Robertson, pers. comm. 2021).

Table 2. Spawning timing for species that may use tributary streams for spawning and incubation.

Family	Species	Spawning Timing
Lings	Burbot	Dec - Mar
Minnows	Brassy Minnow	Jun - Aug
	Lake Chub	May - Aug
	Northern Pikeminnow	May - Jun
Salmonids	Kokanee	Sep - Nov
	Mountain Whitefish	Oct - Nov
	Umam	Sep - Jan
	Rainbow Trout	Apr - Jun
Sculpin	Prickly Sculpin	Feb - Jul
	Slimy Sculpin	Apr - Jun
Suckers	Bridgelip Sucker	Apr - Jun
	Largescale Sucker	Apr - Jul
	Longnose Sucker	Apr - Jun
	White Sucker	May - Jun

Grey cells indicate fall spawning (i.e., spawning occurs at high reservoir level minimzing tributary access issues).

2.3. Current Level of Knowledge

Data regarding tributary habitat use by members of the Nechako Reservoir fish community comes primarily from reconnaissance level stream inventories for forestry operations in Tahtsa and Ootsa lakes (see Sections 4.2.1 to 4.2.7 below). These reports provide fish species presence, stream classification, habitat characterization, and physical habitat descriptions by tributary reach. Significantly less information is available regarding tributaries of Whitesail, Natalkuz, Eutsuk, and Tetachuck lakes. While across the reservoir, data regarding the influence of reservoir draw down on tributary fish access is highly limited. A single report written prior to reservoir inundation (Dominion-Provincial Board 1950) indicated that "all lakes had excellent spawning habitat in their tributary streams" and predicted that rivers connecting the lakes would lose all spawning habitat following reservoir inundation. Available data suggests fish passage issues may exists for a subset of tributary streams, but in many cases reporting identified barriers to fish passage occurring upstream of the tributary confluence (i.e., within the tributary mainstem or sub-watershed) which were not directly affected by reservoir water level. Generally, these reports did not explicitly consider connectivity at tributary mouths. Further, most surveys that visited Nechako Reservoir tributaries occurred in late summer and fall, when reservoir water elevations were moderate to high. Therefore, the ability of past work to identify barriers to fish passage at tributary mouths was limited.

3. METHODS

3.1. Literature and Information Review

A literature review and data search were conducted to locate all known information on the influence of Nechako Reservoir drawdown on fish access to reservoir tributaries since the commencement of RTA operations. Literature was considered regarding the potential effects of reservoir water level operations on tributary connectivity generally, as well as specifically in the Nechako Reservoir. This information was then used to define potential pathways of effect, which were evaluated in the context of watershed-specific information.

Literature was identified by consulting the provincial Ecological Reports Catalogue (EcoCat; Province of BC 2022) and other online databases (e.g., Nechako Environmental Fund, NEEF 2022 and the Northern BC Archives and Special Collections, UNBC 2022). Specific efforts were undertaken to review British Columbia Utilities Commission (BCUC) and Kemano Completion Project (KCP) reports as well as key watershed-specific studies including fish habitat assessments (e.g., Hatfield 1998; Winsby *et al.* 1998; SKR 1999, 2002a, 2003; RTA 2013).

3.2. 2022 Reconnaissance Surveys

Ecofish completed two reconnaissance field surveys of the Nechako Reservoir: spring low water survey (May 31 and June 1, 2022) and summer high water survey (July 26 and July 28, 2022), reported in Regehr *et al.* (2023). At the time of the spring survey water elevation was 2,795’, which is ~2’ above low water level and 4’ to 5’ below full pool. While during the summer survey, water elevation was ~2,800’, which was ~0.3' (10 cm) below full pool.

In total, nine tributaries were investigated during the field surveys (spring survey: six tributaries, summer survey: three tributaries). Tributary mouth barrier assessments were only conducted during the spring survey because water levels during the summer survey were too high for this assessment. Detailed survey results are provided in Regehr *et al.* (2023).

4. RESULTS

4.1. Overview of Potential Pathways of Effects

Here, we identify key pathways through which RTA operations could potentially effect Nechako Reservoir fish access to tributaries. Based on available evidence potential pathways of effect can be summarized as:

1. Tributary mouth dewatering;
2. Debris and sediment deposition; and
3. Barrier exposure.

Each pathway has the potential to effect multiple species and/or life history stages and are described separately in further detail below. It is important to note that the relative importance of tributary habitats to some fish populations is variable (i.e., for those species capable of spawning in both fluvial and lacustrine habitats). For these species, density dependent inter- and intra- species dynamics play a role in determining population distribution and tributary habitat use. For example, when abundance is high, more individuals may access tributary habitat for spawning than would be expected when population abundance is low (i.e., habitat is not a limiting factor).

4.1.1. Dewatering

When reservoir water elevation is low, channel braiding can occur in low gradient tributary mouths or drawdown zones. This could result in sub-surface flow or water levels that are to too shallow to provide fish access to tributaries.

4.1.2. Debris and Sediment Deposition

Multiple processes can increase woody debris and sediment deposition along reservoir shorelines which can create access barriers to fish if they block tributary mouths. For example, initial reservoir inundation submerged nearby forested terrain (Dominion-Provincial Board 1950), leading to tree mortality as the result of prolonged submersion or waterlogging. Over time, this has led to substantial woody debris accumulation along some reservoir shorelines. Reservoir inundation and subsequent water level management has also increased bank erosion (Lawson 1985; Tamminga *et al.* 2021). Erosive processes can uproot shoreline trees and other vegetation, introducing sediment and additional woody debris to the reservoir which can later be deposited along shorelines by wave and wind action and repeated inundation and dewatering. Further, drawdown zone erosion and resultant tributary downcutting can also increase sediment transport within tributaries, which can result in sediment and/or debris accumulation at tributary mouths (NHC 2000; Hamilton and Schmidt 2005).

4.1.3. Barrier Exposure

Several types of depth mediated barrier exposure have the potential to affect fish access to Nechako Reservoir tributaries. When reservoir elevation is low, barriers in the drawdown zone may be exposed that reduce or eliminate connectivity between the reservoir and its tributaries (e.g., waterfalls, cascades, steep gradient, sediment/gravel shelves or berms, woody debris, etc.). Tributary morphology is affected by several dynamic processes that also play significant roles in determining upstream fish access. Several factors can expose access barriers throughout tributaries, including at their mouths. Specifically, drawdown zone erosion and resultant tributary downcutting (i.e., as tributaries adjust to changes in reservoir water elevation) can result in increased tributary gradient or the formation of drops or falls (NHC 2000; Hamilton and Schmidt 2005).

4.2. Nechako Reservoir Lake Area Specific Tributary Access

4.2.1. Tahtsa Lake Area Tributaries

Several Tahtsa Lake and Tahtsa Reach area tributaries have been identified as containing important fish habitat and may be, or historically have been significant contributors to Rainbow Trout and/or other species production (e.g., Kasalka Creek, Rhine Creek, and Whiting Creek). Although literature review found no evidence of fish access issues at tributary mouths visited during past surveys, no surveys identified during the review specifically considered fish access within their methodology and most occurred at moderate to high reservoir water elevation (e.g., BCUC 1993; Hatfield 1998; Jedrzejczyk 2004; KCB 2013; RTA 2013; SKR 1999, 2002a, 2002b, 2003; Winsby *et al.* 1998). One author (Hatfield 1998) recommended that Tahtsa Lake area tributary mouths be revisited at low reservoir water levels to assess potential fish migration concerns.

The 2022 reconnaissance survey visited one Tahtsa Lake tributary (i.e., Blue Creek) on July 26, 2022. Given that the survey visit occurred during high reservoir water elevation, and the survey vessel did not observe the creek upstream of full pool, assessment of potential fish access barriers was not possible. However, the survey did observe several unidentified salmonids within the creek and identified potentially suitable rearing habitat for juvenile salmonids (Figure 2; Regehr *et al.* 2023).

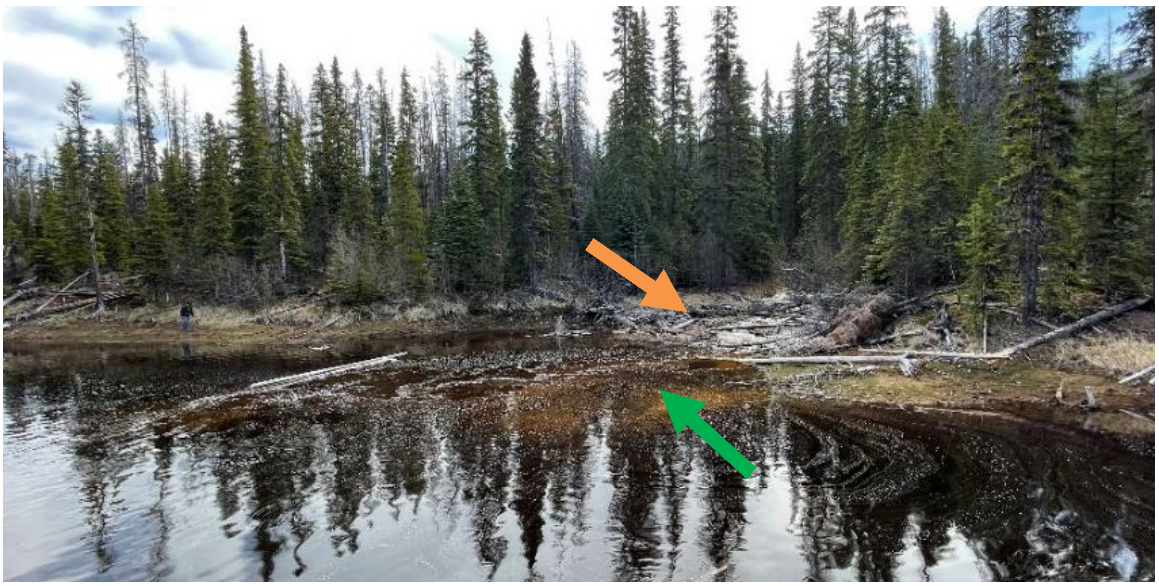
Figure 2. Lower reach of Blue Creek. Photographed on July 26, 2022.

4.2.2. Ootsa Lake Area Tributaries

Most Ootsa Lake tributaries surveyed by past reconnaissance work were first order tributaries that were described as ephemeral (Hatfield 1997; Winsby *et al.* 1997; Triton 1998, 2000a, 2000b). Multiple tributaries were found to potentially provide Rainbow Trout spawning and/or rearing habitat within their lowest reaches, with both juvenile and adult trout observed in many locations Hatfield 1997; Winsby *et al.* 1997). One Ootsa Lake tributary (i.e., Andrews Creek) was identified as Kokanee spawning habitat; however, it was not determined whether observed fish were part of the Nechako Reservoir population or had migrated from other lakes in the Andrews Creek watershed (Hatfield 1997). Rainbow Trout were the most abundant species captured in lower tributary stream reaches in addition to Northern Pikeminnow, sculpins, and White Sucker. No access barriers were identified at the mouths' of any surveyed Ootsa Lake area tributaries. However, most work occurred during moderate to high reservoir water elevation.

Regehr *et al.* (2023) visited five Ootsa Lake area tributaries in spring 2022. Of these, two were found to have potential access barriers at their mouths. Both tributaries were located in relatively more exposed areas compared to tributary mouths without observed potential access issues (i.e., both fed into small, exposed bays whereas other tributaries visited were protected by longer, narrower, often curved bays). The first tributary (unnamed tributary #1) is located in a small, exposed bay on the southern shore of Ootsa Lake across the reservoir from Little Andrew's Bay. The tributary mouth was observed to flow over a submerged sediment shelf and to contain a mix of embedded and unembedded woody debris (Figure 3). Since the survey occurred at reservoir water levels that were approximately two metres above low water, it is possible that the sediment shelf could be exposed at low water and become a barrier to fish passage. The presence of embedded large woody debris may also pose an access barrier to fish passage across a range of flows.

Figure 3. Unnamed tributary #1 flowing into the head of a bay located on the southern shore of Ootsa Lake, across from Little Andrew's Bay. The creek and sediment shelf are indicated with orange and green arrows, respectively. Photographed on May 31, 2022.



The second tributary (unnamed tributary #5) is located on the northern shore of Ootsa Lake approximately 2 km east of Brewer's Creek (unnamed creek 180-7934). The tributary was ephemeral and found dewatered approximately 100 – 200 m upstream (Figure 4). Observed potential barriers to fish passage included an elevated berm composed of a combination of large woody debris and gravel located at the reservoir interface (Figure 5) and large woody debris throughout the lowest tributary reach (Figure 6). Given the ephemeral nature of the tributary, it likely does not provide valuable fish habitat.

Figure 4. Unnamed tributary #5 flowing into Ootsa Lake, at the northwest corner of the reservoir across from Little Andrew's Bay, showing embedded woody debris and tributary dewatering. Photographed on June 1, 2022 during the 2022 spring reconnaissance survey.

Figure 5. **Unnamed tributary #5 flowing into Ootsa Lake, at the northwest corner of the reservoir across from Little Andrew's Bay, showing large, elevated gravel berm and substantial woody debris accumulation at tributary mouth. Photographed on June 1, 2022.**

Figure 6. **Unnamed tributary #5 flowing into Ootsa Lake, at the northwest corner of the reservoir across from Little Andrew's Bay, showing substantial woody debris accumulation at tributary mouth. Photographed on June 1, 2022.**

4.2.3. Whitesail Lake and Whitesail Reach Area Tributaries

Fish and fish habitat surveys in Whitesail Lake and Whitesail Reach have classified most first order tributaries as non-fish-bearing due to their ephemeral nature and lack of suitable fish habitat (Winsby *et al.* 1997; SKR 1999, 2003). Notable exceptions include Coles Creek, Gibbons Creek, Fish Lake Creek, Lucy Creek, Michel Creek, Storm Creek, and unnamed creeks WSC 180-943000 and WSC 180-938700, which were found to contain salmonids (i.e., Kokanee and/or Rainbow Trout) or to have good fish rearing and/or spawning habitat in their lower reaches (Winsby *et al.* 1997; SKR 1999, 2003). Although previous surveys of Whitesail Lake and Whitesail Reach tributaries did not specifically consider fish access issues, no such issues were noted for any of the tributaries surveyed. In addition, Regehr *et al.* (2023) visited one Whitesail Lake area tributary in spring 2022, located approximately 22 km northeast of the Eutsuk Lake portage (unnamed tributary #3). No access barriers were observed at the time of survey; however, many extensive nearshore areas where dead trees remained standing and/or where substantial woody debris had accumulated on shorelines were observed (Figure 7).

Figure 7. Accumulated shoreline woody debris in Whitesail Lake. Photographed on May 31, 2022.

4.2.4. Natalkuz Lake Area Tributaries

Limited information is available on fish and fish habitat in Natalkuz Lake area tributaries. Triton (2000c) inventoried multiple unnamed tributary streams in the lower Nechako Reservoir in Ootsa and Natalkuz lakes. However, reporting did not distinguish tributaries by lake. These surveys found multiple first order tributaries were ephemeral and unlikely to support fish (Triton 2000c). Fish species captured in second order tributaries or larger included Rainbow Trout, sculpins, and White Sucker, with Rainbow Trout the most abundant species captured and found mainly in lower tributary reaches (Triton 2000c). No issues with fish access to tributaries were noted in the surveys, except for barriers upstream of tributary mouths that would not be affected by reservoir water levels. Tributaries in the area were not visited by Regehr *et al.* (2023).

4.2.5. Knewstubb Lake Tributaries

Fish and fish habitat data for Knewstubb Lake area tributaries is highly limited. Big Bend Creek has been found to contain Rainbow Trout and suckers (BC MOE 2022). While an unnamed tributary in the area was also described as containing Rainbow Trout (BC MOE 2022). Regehr *et al.* 2023 visited Enhorn Creek in summer of 2022 during a period of high-water elevation. Although fish access barriers could not be assessed at the time of survey, the tributary was found to contain suitable salmonid rearing habitat (Figure 8).

Figure 8. Enhorn Creek mouth and associated wetland habitat. Photographed on July 28, 2022.

4.2.6. Tetachuck Lake and Euschu Reach Area Tributaries

Literature review did not identify information regarding Tetachuck Lake or Euschu Reach tributary access. However, the Tetachuck River was noted by the Cheslatta Carrier First Nation as having good spawning habitat for fish (Winsby *et al.* 1997). Regehr *et al.* (2023) visited the Entiako River in summer of 2022 during a period of high water elevation. Although the time of survey precluded assessment of tributary access, suitable salmonid spawning and rearing habitat was observed (Figure 9). Given the prevalence of bedrock landforms in the vicinity of the tributary (Figure 10), it is possible that barriers may exist within the drawdown zone.

Figure 9. Entiako River mouth. Photographed on July 28, 2022.

Figure 10. Exposed bedrock observed "downstream" of the Entiako River. Photographed on July 28, 2022.

4.2.7. Eutsuk Lake Area Tributaries

Literature review identified four reports (Lyons and Larkin 1952; Inventory Operations Unit 1982; DeGisi 2002) regarding Eutsuk Lake tributaries. No fish access barriers were identified at any tributary mouth visited (e.g., Bone Creek, Chezko River, St. Thomas River, several unnamed tributaries). The area was not visited by Regehr *et al.* (2023).

5. DISCUSSION

5.1. Potential Limiting Factors

Three pathways of effect were identified that relate to the potential for reservoir elevation to impact fish access to Nechako Reservoir tributaries. Each pathway is summarized separately, although interactions and trade-offs between the pathways should be considered when evaluating reservoir management alternatives.

- ***Dewatering*** – Literature review and the 2022 reconnaissance survey (Regehr *et al.* 2023) do not provide evidence that low reservoir water levels expose low slope tributary channel braiding at stream confluences. However, reservoir level during previous surveys was not consistently reported and only a subset of known tributaries have been surveyed. Therefore, because many Nechako Reservoir tributaries surveyed to date have been described as low gradient (see Section 4.2), they are therefore prone to channel braiding and potential dewatering when reservoir water levels and/or stream flow is low. Remaining uncertainties preclude elimination of this pathway as a potential mechanism affecting fish access to tributaries within the Nechako Reservoir.

- ***Debris and sediment deposition*** – Literature review did not provide explicit evidence that debris results in tributary fish access issues within the Nechako Reservoir (e.g., sediment, woody debris). However, the 2022 reconnaissance surveys (Regehr *et al.* 2023) identified woody debris deposition and/or the presence of a sediment berm as potentially impacting fish access to two of six tributaries visited at low reservoir elevation. At least one of these tributaries was not expected to provide valuable fish habitat due to channel dewatering as the result of low tributary flow. Given the limited evidence that this mechanism affects fish access to at least some tributaries, and because many previous tributary surveys have not explicitly considered fish access at tributary mouths, remaining uncertainties preclude elimination of this pathway as a potential mechanism affecting fish access to tributaries within the Nechako Reservoir.
- ***Barrier exposure*** – Literature review provided no evidence that depth mediated barrier exposure at tributary stream confluences occurs within the Nechako Reservoir. While the 2022 reconnaissance survey showed evidence that one of six tributaries visited contained a potential depth mediated barrier to upstream fish migration (i.e., sediment shelf at tributary confluence that was inundated at the time of the survey but could be exposed at lower water levels; Regehr *et al.* 2023). Uncertainty remains as reservoir water levels during most previous Nechako Reservoir tributary surveys were moderate to high, and many surveys did not explicitly consider access barriers at tributary mouths. Further, Hatfield (1998) suggested that Tahtsa Lake tributary mouths should be examined at low reservoir water levels for potential fish migration concerns.

Restriction or loss of tributary access for the Nechako Reservoir fish community could inhibit migration to spawning and rearing habitats and reduce recruitment of stream spawning species to the reservoir. While various fish species may use tributary habitats for different life history stages (e.g., spawning or rearing; see Table 2), the seasonal patterns of each species' tributary habitat use have implications for how reservoir elevation affects their ability to access these habitats. Generally, Nechako Reservoir elevation is lowest in the spring and highest in fall. Therefore, fall spawning species such as Kokanee and Whitefish that access tributaries during a period of high reservoir elevation likely encounter limited potential access issues. In contrast, Rainbow Trout spawning occurs in spring when reservoir levels are low. Thus, this and other spring spawning species may experience tributary access issues that would not be expected to affect spawning Kokanee or whitefish (Table 2). Similarly, if juvenile out-migration occurs in spring or early summer, fish would be expected to encounter access issues that may not affect fish outmigrating during seasons when reservoir elevation is high.

The degree to which fish recruitment to the reservoir affects reservoir fish community abundance has not been directly investigated. However, it is possible that tributary habitats are an important source of population abundance for some species. For example, Rainbow Trout captured in reservoir embayments in 1996 had two years of slow fish scale growth indicating stream residence for multiple years prior to recruitment to the reservoir (Winsby *et al.* 1998). This highlights the potential importance of tributary stream habitat for Nechako Reservoir fish recruitment with low recruitment resulting from tributary access issues having the potential to result in population level effects (i.e., reductions in overall fish abundance).

5.2. Data Gaps

Studies to date provide useful information regarding tributary habitat associated with the Nechako Reservoir (e.g., Hatfield 1997, 1998; Winsby *et al.* 1998; SKR 1999, 2002a, 2003; RTA 2013). However, data on potential fish access issues at tributary mouths and contemporary analysis is limited. Generally, past surveys di not explicitly considered fish access to tributaries. While the 2022 reconnaissance survey was only able to visit six tributaries in spring (i.e., during low reservoir water elevation; Regehr *et al.* 2023). This survey noted two tributaries with potential fish access issues at low reservoir elevation as the result of woody debris and sediment deposition. The tributaries surveyed by Regehr *et al.* 2023 provide only a snapshot of a small proportion of all Nechako Reservoir tributaries, and available information is not sufficient to determine if reservoir drawdown is impacting fish access to tributary streams. Therefore, no preliminary performance measures are recommended at this time.

Given existing data gaps, collecting contemporary information is of high importance since performance measure development for this issue (i.e., Issue #3: Fish Access to Nechako Reservoir Tributaries) has been identified as a WEI priority. Past research by Hatfield (1998) which visited several Tahtsa Reach tributaries during late summer and early fall recommended tributaries be revisited at low reservoir water elevation to examine potential fish migration issues. Given that most past surveys of Nechako Reservoir tributaries occurred during moderate to high reservoir water elevation and the age of most existing work (i.e., occurring prior to 2000), we recommend future surveys revisit all tributaries previously identified as capable of supporting fish. Further, given the lack of available data for some reservoir areas (e.g., Tetachuck or Eutsuk area tributaries) we recommend future reconnaissance survey work focus efforts in these areas. With a more complete understanding of fish habitat and access to key tributaries that are important for fish recruitment to the Nechako Reservoir, meaningful PM development may be possible.

6. CONCLUSION/CLOSURE

This memo has reviewed the potential for changes in the Nechako Reservoir water level to affect access for fish to tributary habitat. Outcomes of the review are used to identify data gaps are identified that could be addressed with further study. No performance measures for the WEI are recommended at this time due to data gaps identified.

Yours truly,

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Disclaimer:

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