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MEMORANDUM

TO: **Nechako Water Engagement Initiative**

FROM: **Heidi Regehr, Ph.D., R.P.Bio. and Jayson Kurtz, B.Sc., R.P.Bio, P.Biol, Ecofish Research, Ltd.**

DATE: **January 19, 2022**

FILE: **1316-07**

RE: **Potential Effects of Nechako Reservoir Operations on Wildlife**

1. INTRODUCTION

During Main Table and Technical Working Group meetings of the Nechako Water Engagement Initiative (WEI), concerns were raised regarding potential effects of Rio Tinto operations of the Nechako Reservoir on nesting birds and more generally on wildlife and wildlife habitat. Ecofish Research Ltd. was asked by the WEI Technical Working Group to identify and evaluate wildlife issues related to operations of the Nechako Reservoir and make recommendations regarding next steps that could be taken to address identified potential effects.

This document summarizes available information about wildlife species in and around the reservoir, identifies data gaps, evaluates and prioritizes pathways of effects for species/species group, and identifies actions that could be taken to address identified potential effects. Although caribou (*Rangifer tarandus*) are included in this memo at a high level, a separate memo (Regehr *et al.* 2021a) details effects for this species.

2. METHODS

Information was obtained from multiple sources to identify and evaluate potential effects to wildlife resulting from Nechako Reservoir operations and make recommendations regarding actions that could be taken to address identified potential effects or further our understanding when data are limited. The approach taken to locating and compiling information, categorizing and evaluating potential effects of reservoir operations on wildlife, assessing data availability, prioritizing issues, and making recommendations is described below.

Reports from the 1980s environmental assessment of the Kemano Completion Project were not available to review; however, a report documenting baseline wildlife studies (Environmental studies associated with the proposed Kemano Completion Hydroelectric Development. Volume 10: Wildlife resources; issued in 1984 by Envirocon Limited) has been requested which may provide additional information in the future.

2.1. Identifying Potential Interactions Between Wildlife and Reservoir Operations

Information on the presence of wildlife species in the watershed that have the potential for interaction with reservoir operations was obtained from provincial websites and reference documents and reports or assessments specific to the watershed. Specifically, a search of wildlife species potentially occurring in the area was created through the BC CDC (2021) search engine, and this was supplemented with information from key reference documents (e.g., Campbell *et al.* 1990a, 1990b, 1997, 2001, Matsuda *et al.* 2006, Hatler *et al.* 2008) and websites (e.g., BC CDC 2021, Davidson *et al.* 2015, eBird 2021, E-Fauna BC 2021). However, potential presence of species was primarily evaluated at the level of the species group (described below), with examples of key species potentially present identified for each group.

Identification of interactions between wildlife and reservoir operations was based on studies and assessment completed for other reservoir systems in BC (e.g., Campbell Lake reservoirs, Kinbasket and Arrow lakes reservoirs), input of local resource professionals, and professional experience conducting wildlife studies, environmental effects assessments, and reviews of studies and monitoring programs for hydroelectric developments. Resources consulted for this review, including meetings and correspondence with local resource professionals, are listed in Appendix A.

Wildlife issues were identified by species group. This involved organizing species potentially present that may interact with reservoir operations into groups depending on life history characteristics, habitat occupied, and the pathways of effects identified (i.e., the mechanisms of impact). For example, aquatic-breeding amphibians were identified as one species group because amphibian species have similar life history characteristics (e.g., aquatic egg and larval phases) and habitat requirements (i.e., wetlands), and the same pathways of effects were identified (i.e., reservoir water level fluctuations have the potential to affect breeding success through impacts on breeding habitat) (as described in Section 3.1). In contrast, bird species were grouped into several groups because different pathways of effects were identified (Section 3.2). Mammal species were also grouped into separate groups, two of which were single species that were not logically combined with others (Section 3.3). Additionally, one species group was created for a specific habitat type (riparian habitat) for which the pathways of effects apply to multiple classes of wildlife (Section 3.4).

2.2. Evaluating Potential Effects

For each species group, the magnitude of identified potential effects was evaluated and ranked as high, moderate, or low based on the potential impacts of reservoir operations on habitat, behaviour, productivity, survival, and population status. Categorization was guided by guidelines produced by the BC Environmental Assessment Office (EAO) on effects assessment (EAO 2013). Magnitude was rated as high when reservoir operations are anticipated to affect productivity, survival, and population status in excess of what would be observed within the range of natural variation. Magnitude was rated as moderate if operations are anticipated to cause some changes in behaviour and habitat and may

have small impacts on productivity and/or survival, but effects are not anticipated to affect population status. Magnitude was rated as low if operations are anticipated to have little or no effect on behaviour, productivity, survival, or habitat (effects are within the range of natural variation) and are not anticipated to affect population status. Conservation status was also considered when evaluating magnitude of potential effects because impacts on survival and productivity are more likely to be biologically significant for vulnerable populations. As the objective of this review was to identify and evaluate potential effects of reservoir operations on wildlife at high level, detailed analyses of potential effects were not completed.

For many wildlife issues identified, the timing and magnitude of reservoir water level fluctuations were an important consideration when identifying pathways of effects and evaluating the magnitude of potential effects. Thus, during the identification and evaluation of potential effects related to water level fluctuations, a Nechako Reservoir hydrograph[1] was consulted to determine average annual timing and magnitude of water level fluctuations and generally relate these to key annual events of wildlife species (e.g., breeding, migration).

2.3. Data Availability/Certainty

Data availability was assessed and categorized by species group and was used to inform priority ranking and recommendations because data gaps typically must be addressed before management actions can be identified. Data availability was considered at the spatial scale of the watershed and was ranked as high, moderate, or low by species group depending on the amount and relevance of the data found. Data availability was categorized within three areas that differ by data amount and type: 1) potential habitat presence; 2) species presence; and 3) species abundance/population status. As an example, evaluation of data availability for potential habitat presence for the aquatic-breeding amphibian species group would have considered data on wetland presence regardless of known amphibian occupancy; evaluation of data availability for species presence would have considered presence/not detected data on amphibian occurrences; and evaluation of data availability for species abundance/population status would have considered amphibian abundance or population status data, potentially over an extended time frame. An overall data availability rating (high, moderate, or low) was also generated. It should be noted that because the review was high level, sources of information may exist that were not found during the time allotted for the review; thus data availability classified as low should be considered preliminary based on limited effort.

[1] https://nechako.riotintoflowfacts.com/#reservoir.

Only data relevant to the identified pathways of effects were considered when assessing data availability. For example, when assessing data availability for potential habitat presence for amphibians for which potential effects of reservoir operations were associated with breeding, only amphibian breeding habitat was considered. Similarly, when assessing availability of species presence data for waterbirds for which potential effects of reservoir operations were associated with nesting, only occurrence data for breeding waterbirds was considered (e.g., not for migrating waterbirds).

2.4. Prioritization of Issues

Priority of wildlife issues in relation to consideration for reservoir operational management was ranked based on the magnitude of potential effects and overall data availability, the latter of which was indicative of the certainty in our assessment. As illustrated in the matrix below (Table 1), priority of the species group in relation to reservoir operational management was ranked as low, moderate, or high based on a combination of magnitude of potential effects and data availability/certainty. This matrix indicates that the assigned priority category was the same as the anticipated magnitude of potential effects if magnitude of potential effects was high or low; however, priority was conservatively increased relative to magnitude for a moderate magnitude potential effect if data certainty was low, given that inadequate data may be available to provide confidence in the assessment.

Table 1. **Priority of wildlife issues in relation to consideration for reservoir operational management as evaluated from the magnitude of identified potential effects and data availability.**

		Magnitude of Potential Effects[1]		
		High	**Moderate**	**Low**
Data Availability / Certainty[2]	**High**	High	Moderate	Low
	Moderate	High	Moderate	Low
	Low	High	High	Low

[1] High: reservoir operations are anticipated to affect productivity, survival, and population status in excess of what would be observed within the range of natural variation; Moderate: operations may cause changes in behaviour and habitat, and may have small impacts on productivity and/or survival, but effects are not anticipated to affect population status; Low: operations are anticipated to have little or no effect on behaviour, productivity, survival, or habitat (effects are within the range of natural variation) and are not anticipated to affect population status.

[2] High: data exist with which to adequately evaluate species presence and abundance in locations and time periods where interaction with reservoir operations may occur; Moderate: some data exist with which to evaluate species presence and abundance in locations and time periods where interactions with reservoir operations may occur, but they may be limited in scope or are not recent; Low: few data exist with which to evaluate species presence and abundance in locations and time periods where interactions with reservoir operations may occur.

2.5. Recommendations

To address identified potential effects by species group, recommendations were made for all issues ranked moderate or high in priority and for some issues ranked low in priority. These recommendations considered the need to obtain more information (e.g., of species and habitat presence, habitats occupied, timing and locations of interactions) for improving our understanding of the interaction between reservoir operations and potential effects, because adequate information is required before potential effects can be assessed, management actions can be identified, or specific water level management recommendations can be made. Recommendations also included specific management action when sufficient information existed to allow identification of such actions.

3. RESULTS

Potential interactions between wildlife and reservoir operations were identified for several wildlife species groups. For amphibians, birds, and aquatic mammals, potential pathways of effect were related to reservoir water level fluctuations because these can alter habitat or affect the survival of vulnerable life stages. For other species, reservoir water level fluctuations or drawdown may have the potential to impact shoreline or riparian areas, potentially causing movement difficulties or reducing habitat suitability. Many of the interactions identified were associated with specific life history stages, such as breeding or migration. In many cases, data availability was poor (Table 2), which limited our ability to prioritize issues for management action. Prioritization may therefore change once data gaps are addressed. Results for identified species groups are summarized in Table 3 and are discussed in the sections below. Additional detail on habitat, pathways of effects, data availability, magnitude of potential effects, and recommendations are provided in Appendix B.

Table 2. Availability of data for the watershed ranked as low, moderate, or high for habitat presence, species presence, and species abundance/population status, by identified wildlife species groups.

Class	Species Group	Life History Period of Pathways of Effects	Availability of Data for the Watershed[1]			
			Potential Habitat Presence[2]	Species Presence	Species Abundance/ Population Size & Trend	Overall
Amphibian	Aquatic-breeding amphibians	breeding	Low	Low	Low	Low
Bird	Waterbirds	nesting	Low	Moderate	Low	Low
	Near-ground nesting passerines	nesting	Low	Moderate	Low	Low
	Near-water cavity-nesting birds	nesting	Low	Moderate	Low	Low
	Water-associated raptors	breeding	Moderate	Moderate	Moderate	Moderate
	Aquatic predatory birds	breeding	Moderate	Low	Low	Low
Mammal	Ungulate - Caribou	calving/migration	High	High	High	High
	Ungulate - Moose	year-round	High	High	Moderate	Moderate
	Aquatic mammals	breeding/wintering	Low	Moderate	Low	Low
Multiple	Riparian-associated species	year-round	Low	Moderate	Low	Low

[1] Only data relevant to evaluation of interactions with reservoir operations are considered (e.g., data availability for species presence for birds during migration are not considered when the pathway of effects is related to nesting); assumes access to all resources potentially available (e.g., mapping of wetlands, existing reports, existing databases). See Appendix B for additional information on data availability.

[2] Evaluates whether data exist on the presence of habitat that has the potential to support the species group, although occupancy of the habitat by the species group may not be documented (e.g., wetlands have been documented that amphibians are likely to use for breeding, but species presence has not been documented).

Table 3. Summary of wildlife issues related to operations of the Nechako Reservoir by species group. See Appendix B for additional information.

Species Group	Pathways of Effects	Priority[1]			Recommendations
		Data Availability/ Certainty	Magnitude of Potential Effects	Priority Rating	
Aquatic-breeding amphibians	Breeding: water level fluctuations caused by reservoir operations may cause adverse changes in the suitability of breeding wetland habitat for survival, growth, and development of egg and larval stages (e.g., changes in water levels may lead indirect effects through changes in key habitat characteristics, such as water temperature and water depth, and to direct adverse effects on eggs and larvae, such as desiccation or inundation)	Low	Moderate	High	• Address data gaps for habitat presence and species occupancy: identify potentially suitable habitats for amphibian breeding that can be affected by reservoir operations and determine which amphibian species are present • Use data on habitat, occurrence, and life history characteristics (e.g., timing of breeding) to evaluate potential impacts of reservoir water level fluctuations on amphibian breeding habitat and breeding success
Waterbirds & Near-ground nesting passerines	Nesting: reservoir water levels are generally rising during the bird breeding season; thus rising water levels may flood nests, drowning immobile or relatively immobile life stages (eggs, nestlings, fledglings)	Low	Moderate	High	• Address data gaps for habitat presence and species occupancy: identify potentially suitable habitats for breeding and determine which species are present and locations where interactions between active bird nests and reservoir operations could occur • Use data on habitat, occurrence, and life history characteristics (e.g., nest site characteristics, developmental strategy, timing of nesting) to evaluate potential impacts of reservoir water level fluctuations on breeding success

Table 3. Continued (2 of 4).

Species Group	Pathways of Effects	Priority[1]			Recommendations
		Data Availability/ Certainty	Magnitude of Potential Effects	Priority Rating	
Near-water cavity-nesting birds	Nesting: reservoir water levels are generally rising during the bird breeding season; thus rising water levels may flood nests, drowning immobile or relatively immobile life stages (eggs, hatchlings)	Low	Moderate	Low	• Address data gaps for habitat presence: confirm absence of nesting habitat adjacent to the reservoir and wetlands affected by the reservoir, especially for Barrow's Goldeneye and Bufflehead
Water-associated Raptors	Breeding: nests sites may be inundated or lost due to reservoir flooding/water level fluctuations and prey species (fish) and foraging habitat may be affected	Moderate	Low	Low	• No recommendations
Aquatic predatory birds	Breeding: foraging habitat may be adversely affected by impacts to flow or water quality which can affect prey abundance (fish, aquatic invertebrates) and foraging success	Low	Low	Low	• No recommendations

Table 3. Continued (3 of 4).

Species Group	Pathways of Effects	Priority[1]			Recommendations
		Data Availability/ Certainty	Magnitude of Potential Effects	Priority Rating	
Ungulate - Caribou	Calving and migration: woody debris along reservoir shorelines disrupts movement pathways during migration and when accessing calving islands; reservoir drawdown creates land bridges to calving islands and can affect shoreline access	High	High	High	• Collaborate in restoration of caribou habitat and monitoring through management of woody debris as per recommendations and priorities developed by BC FLNRORD (Cichowski *et al.* 2020) • Consider the impacts of drawdown in May on calving island isolation (and therefor availability for calving by caribou) when evaluating trade-offs during the structured decision-making water use planning process • Investigate the extent to which reservoir drawdown affects caribou access to the reservoir
Ungulate - Moose	Year-round/seasonal: reservoir may cause movement disruption when accessing or crossing over the reservoir due to drawdown zone shoreline characteristics or woody debris accumulations	Moderate	Low	Low	• Investigate documented moose movements that cross portions of the reservoir to evaluate potential for interaction with reservoir operations and use remote camera monitoring results from the Whitesail Reach Woodland Caribou Habitat Restoration Project (Lee and Flowers 2021) to investigate potential moose shoreline access issues

Table 3. Continued (4 of 4).

Species Group	Pathways of Effects	Priority[1]			Recommendations
		Data Availability/ Certainty	Magnitude of Potential Effects	Priority Rating	
Aquatic mammals	Breeding and wintering: rising water levels during the breeding season may flood dens and dropping water levels during winter may cause exposure of underwater den entrances and freeze-up of the water column which can limit underwater movement and prevent access to resources	Low	Moderate	High	• Address data gaps for habitat presence and species occupancy: identify potentially suitable habitats for aquatic mammals that can be affected by reservoir operations and determine which species are present • Use occurrence data to identify potential interactions with reservoir operations and evaluate potential impacts of reservoir water level fluctuations on behaviour, survival, and reproduction
Riparian-associated species	Year-round/breeding (depending on species): reservoir operation causes drawdown zone banks (riparian habitats) to become impoverished which adversely affects riparian habitat values	Low	Moderate	High	• Address data gaps for species occupancy: compile information on species presence and distribution • Investigate the potential for enhancing habitat along drawdown zone shorelines through physical works and/or water level management

[1] See Table 1 (Methods) for categorization of priority and Appendix B for details on data availability and magnitude of potential effects.

3.1. Aquatic-Breeding Amphibians

Nechako Reservoir operations have the potential to affect amphibians through impacts to their wetland breeding habitat. Specifically, if water levels in the reservoir fluctuate due to operations, water levels may also fluctuate within wetlands used for breeding that are affected by the reservoir through surface or subsurface flows. Amphibians may also breed within the reservoir itself if suitable habitat exists along the shorelines, such as in shallow, low gradient bays. Such permanent or ephemeral aquatic habitat in wetlands or reservoir margins may be altered by reservoir water level fluctuations, affecting suitability for amphibian breeding. For example, increases or decreases in water level may cause water temperatures to change (which affects growth and development of eggs and larvae) and can cause eggs that are attached to substrates to become sub-optimally positioned in the water column or to become exposed (which affects egg survival and development). Changes in water level may also cause mortality of amphibian eggs or larvae, such as if wetlands dry out when water levels drop or if predatory fish are introduced when water from the reservoir floods into previously isolated ponds. Water levels are typically decreasing in the reservoir in the early part of the amphibian breeding season when early egg laying occurs, and they are typically rising later in the spring when egg and/or larvae are developing. However, assuming that amphibians are present in aquatic habitat affected by the reservoir (see below), the actual impacts of reservoir water level fluctuations on amphibian eggs and larvae will depend on species-specific characteristics (such as timing of breeding, type of habitat preferred, and behavioural flexibility of amphibians), as well as the characteristics of the aquatic habitat (e.g., elevation, depth, substrate, water sources other than the reservoir) which affect the extent to which they are influenced by reservoir water level fluctuations. Potential effects of reservoir operations on amphibians can be complex, and studies have been implemented in other reservoir systems to identify and quantify such effects (e.g., Hawkes *et al.* 2015, BC Hydro 2018, Regehr *et al.* 2021b).

Few data were found during this review on amphibian presence in the watershed (Table 2) and given that the potential for operational effects is contingent on amphibian presence, this limits certainty in the identification and evaluation of this wildlife issue. Although the range of several amphibian species encompasses the watershed, and two species have been recorded present in the watershed (Western Toad (*Anaxyrus boreas*) and Columbia Spotted Frog (*Rana luteiventris*) have been documented between Eutsuk Lake and Ootsa Lake; E-Fauna BC 2021), no records were found for amphibians in wetlands likely to be affected by reservoir operations. Further, although some data are available on habitats potentially available for amphibian breeding within the reservoir's operational footprint, these data are limited in scope. A desktop wetlands assessment (Wright *et al.* 2021) provided information on the presence of wetlands within the reservoir footprint and identified only one marsh that overlaps with (is affected by) the reservoir. This wetland, which is ~4.7 ha in size, is most affected when reservoir elevations are between 852.5 m and 853.44 m (2797 and 2800 ft), and up to ~1.2 ha (26%) of this marsh can be affected by water level fluctuations (Wright *et al.* 2021). However, the wetland assessment was purely a GIS desktop exercise based on contour data provided by

Triton Environmental Consultants (Warburton, pers. comm. 2021), the Freshwater Atlas (FWA) (GeoBC 2021) (which is based on the province's 1:20,000 scale topographic base maps – the Terrain Resource Information Management (TRIM) series), and reservoir water elevation data provided by Rio Tinto (Wright *et al.* 2021). Other habitats likely exist within the drawdown zone of the Nechako Reservoir that are suitable for amphibian breeding and that were not identified in the wetlands assessment because they are not classified as wetlands by the FWA (e.g., seasonal shallow waters such as small ponds and pools) or not depicted in TRIM wetland data (which is considered less accurate in depicting the amount, distribution, and type of wetlands within a region compared to other modelling and mapping methods; see Wright *et al.* 2021). Such drawdown zone habitats can provide important amphibian breeding habitat (Boyle 2012, Hawkes *et al.* 2015, Swan *et al.* 2015, Regehr *et al.* 2021b).

The magnitude of potential effects of reservoir operations on aquatic-breeding amphibians was assessed as moderate because, although the effects of reservoir operations on wetlands were assessed to be small within the wetlands assessment (Wright *et al.* 2021), this was a desktop assessment based on limited data, and breeding by amphibians within aquatic habitats affected by the reservoir is considered likely. Moreover, operationally influenced water level fluctuations have the potential to adversely affect habitat suitability of amphibian breeding habitat which may, in turn, affect growth and survival of aquatic life stages (Table 3, Appendix B). Because overall data availability was rated as low, priority was ranked as high. Recommendations include addressing data gaps on species occupancy and habitat availability and evaluating potential impacts of reservoir operations on amphibian breeding success based on species-specific and habitat-specific characteristics (Table 3, Appendix B). Once data gaps on habitat and amphibian presence have been addressed and potential impacts are evaluated based on improved knowledge of amphibian occupancy and habitat, priority can be reassessed and identified interactions with reservoir operations could be incorporated into water management planning in accordance with priority.

3.2. Birds

3.2.1. Waterbirds and Near-Ground Nesting Passerines

Waterbirds (loons, grebes, waders, swans, geese, ducks, mergansers, gulls, shorebirds) and near-ground nesting passerines for which nesting is associated with proximity to water (e.g., Common Yellowthroat (*Geothlypis trichas*), Northern Waterthrush (*Parkesia noveboracensis*), Wilson's Warbler (*Cardellina pusilla*), Song Sparrow (*Melospiza melodia*)) may be impacted by reservoir operations if nests made close to the ground near water, or over water, become inundated due to rising reservoir water levels. Water levels are generally rising in the reservoir during the bird nesting season; thus the flooding of nests could cause mortality of eggs or nestlings, potentially adversely affecting breeding success. Birds potentially impacted by reservoir operations may breed in or adjacent to wetlands that are affected by the reservoir

through surface or subsurface flows, or within or adjacent to the reservoir itself (e.g., on stumps, rocks, or islands within the reservoir, or along the reservoir shorelines).

The risk of impacting breeding success of waterbirds and passerines that nest near water on or near the ground, or over water, if present, will vary by species, depending on factors such as timing of nesting, nest site preference (nest height over ground or water, nest proximity to shoreline), and life history characteristics such as developmental strategy (altricial or precocial young) and length of vulnerable developmental periods (egg incubation period, nestling and post-nestling periods for some species). Available data indicate that reservoir water levels may rise ~11 to 13 ft (~3.4 to 4 m) from mid-April to July (based on data in the last 10 and 20 years, respectively) (Wright *et al.* 2021); thus, only nests built within ~3 to 4 m from the ground (or over water) could be at risk of flooding. However, water levels will typically not rise that much during the vulnerable period of most species because vulnerable periods (e.g., incubation periods for species with precocial young that can swim shortly after hatch, or incubation and nestling periods combined for species with altricial young or semi-precocial young that cannot swim at hatch) typically do not extend from April to July. For example, the vulnerable period of most waterfowl is the incubation period (which is typically about one month long) because the young are precocial and can swim shortly after hatch, whereas for many passerines it is the incubation and nestling periods combined (also often about one month long) because the young are altricial. However, for some species the vulnerable period may be much longer. For example, the combined incubation and nestling period for the Herring Gull (*Larus argentatus*) (which have semi-precocial young that are not able to swim) is ~ 80 days. For such species, risk would also be dependent on nest site habitat (i.e., whether the nest is on a rock or islet that is entirely flooded or whether there is opportunity for the terrestrially mobile young to move away from advancing water). Species that nest directly over water in emergent vegetation or on stumps or logs protruding above the water surface (e.g., loons, grebes, some waders, ducks, and gulls), may be at greatest risk of nest flooding even if young are precocial because only a small water level increase may be required to flood nests during the approximately one-month incubation period. Studies in other reservoir systems have been implemented to identify and quantify potential effects of reservoir water level fluctuations on nesting birds (e.g., van Oort *et al.* 2017).

In general, few data were found during this review on the presence of bird species that could be affected by nest flooding in the watershed. Although some data exist on species presence within the watershed (Table 2), and for several species (e.g., Common Loon (*Gavia immer*), Canada Goose (*Branta canadensis*), Green-winged Teal (*Anas crecca*), Mallard (*Anas platyrhynchos*), Herring Gull, Common Yellowthroat, Northern Waterthrush, Song Sparrow) breeding records have been reported for National Topographic System (NTS) grids that encompass portions of the reservoir (Campbell *et al.* 1990a, 1990b, E-Fauna BC 2021), it could not be determined if such breeding records can be linked to aquatic habitat affected by the reservoir without access to specific databases (e.g., Biodiversity Centre for Wildlife Studies 2021, eBird 2021, Atlas of Breeding Birds of BC

(Davidson *et al.* 2015)). As discussed for amphibians above (Section 3.1), this lack of specific data limits certainty in the identification and evaluation of this issue. Further, although the desktop wetlands assessment (Wright *et al.* 2021) documented that effects of reservoir operations on wetlands are expected to be small, this assessment was limited to wetlands classified by the FWA. Moreover, some bird species are likely to breed within the reservoir itself. Given these considerations and because rising water levels during the bird nesting season have the potential to affect survival of relatively immobile life stages and therefore productivity, the magnitude of potential effects was evaluated as moderate (Table 3, Appendix B). However, owing to low overall data availability, a high priority was assigned. Recommendations include addressing data gaps on species occupancy and habitat presence and, following this, re-evaluating potential impacts of reservoir operations on breeding success and priority based on species occupancy and species-specific characteristics such as breeding habitats, nest site characteristics, timing of nesting, and life history characteristics such as developmental strategy and length of vulnerable breeding periods (Table 3, Appendix B).

Cormorants were a group of species of concern mentioned during Main Table and Technical Working Group meetings of the Nechako WEI that could also be included among waterbirds potentially affected by reservoir operations through nest flooding if breeding occurs within the reservoir, or in wetlands affected by reservoir water level fluctuations. Double-crested Cormorants (*Phalacrocorax auritus*) are the only cormorant that breeds inland, and this species can nest on stumps, pilings, trees, or rocks, over water (Campbell *et al.* 1990a); thus nests could be affected by rising water levels during the vulnerable nesting period (which would include both incubation and nestling periods). Some Double-crested Cormorant occurrence records have been reported for Ootsa Lake and the vicinity of the Nechako Reservoir (eBird 2021), and a local resident has reported a sighting of cormorants in the reservoir that could potentially be nesting; however, breeding was not confirmed, and no breeding records for Double-crested Cormorants within or adjacent to the Nechako Reservoir were found during this review. To date, breeding has only been confirmed in the interior of BC at two locations: Leach Lake in the Kootenay River valley and Stum Lake in the Cariboo (Davidson *et al.* 2015). However, these colonies were first reported relatively recently (in 2003 and 1993, respectively) and since then sightings have suggested potential breeding in Swan Lake in the Peace River lowlands. Thus, breeding in the Nechako Reservoir is a possibility, and it is also possible that breeding could begin here in the future.

3.2.2. Near-Water Cavity Nesting Birds

Similar to waterbirds, some cavity nesting birds nest near water, and nest sites could potentially become inundated by water if reservoir water levels rise. The cavity nesting species potentially present in the watershed, which include Wood Duck (*Aix sponsa*), Barrow's Goldeneye (*Bucephala islandica*), Common Goldeneye (*Bucephala clangula*), Bufflehead (*Bucephala albeola*), and Hooded Merganser (*Lophodytes cucullatus*), nest in cavities in trees (live or dead) along the borders of forested wetlands. Thus, these species could potentially nest in forested habitat or snags adjacent to the reservoir or

wetlands affected by the reservoir because water levels are typically rising in the reservoir during the nesting season (described in Section 3.2.1). The hatchlings in this species group are precocial and able to swim soon after hatch, and incubation periods are of approximately one month during which eggs could be vulnerable to flooding. Overall data availability was ranked as low although some information on breeding records for the watershed is available (Table 2).

Although cavity nests can be vulnerable to flooding if built close to the ground and the shoreline, cavity nest sites for three of the five identified species are typically far enough off the ground to remain above maximum reservoir water level rise during the breeding season, especially during the one-month time span needed for incubation of eggs. For Wood Duck, Common Goldeneye, and Hooded Merganser, cavity nests are typically greater than ~3 to 4 m off the ground[2]; thus, because water levels would not rise that much during a 30-day period in spring[1], risk of nest flooding for these species is small. However, there may be greater risk of nest flooding for Barrow's Goldeneye and Bufflehead given that these species nest closer to the ground[2]. Breeding records exists for both Barrow's Goldeneye and Bufflehead in the vicinity of the east and north sides of Ootsa Lake (Campbell *et al.* 1990a); thus, if suitable nesting habitat exists immediately adjacent to the reservoir or wetlands affected by the reservoir for these species, there is some potential risk of nest flooding. However, the desktop wetlands assessment (Wright *et al.* 2021) documented that only one wetland defined by the FWA interacts with the reservoir (see Section 3.1) and it is likely that suitable nesting habitat (relatively large trees with cavities) is lacking within the reservoir drawdown zone. Thus, although the two cavity-nesting species most likely to be affected by reservoir operations (Barrow's Goldeneye and Bufflehead) have been documented breeding near Ootsa Lake, risk of reservoir operations affecting cavity nesting birds through nest flooding was considered low based on: 1) typical nest height in relation to potential water level rise within an approximately one month incubation period in spring/early summer; 2) limited wetland habitat affected by reservoir that could provide potential nesting habitat for cavity nesting species; 3) the small likelihood of suitable nesting habitat (relatively large trees with suitable cavities) existing within the drawdown zone. Thus, the magnitude of potential effects and priority rating were assessed as low (Table 3, Appendix B). Nevertheless, it would be prudent to confirm the absence of suitable nesting habitat for cavity nesting waterfowl adjacent to the reservoir or wetlands affected by the reservoir, potentially through desk-top and/or field assessment (Appendix B). This could be conducted coincident with the evaluation of nesting habitat for waterbirds (Section 3.2.1).

[2] Distances of nests from ground (Campbell *et al.* 1990a): Wood Duck – 5 to 25 m (n=9); Common Goldeneye – 3.5 m to 15 m, with most 3.5 to 5.5 m (n=14); Barrow's Goldeneye – ground level to 18 m with 51% between 2 and 3 m (n=87); Bufflehead – 60 cm to 14 m, with 61% between 60 cm and 3 m (n=218); Hooded Merganser – 4 m to 15 m, with 7 between 6m and 9 m (n=7).

3.2.3. Water-Associated Raptors - Osprey

Three pathways of effect were identified for Osprey (*Pandion haliaetus*): 1) loss of tree nest sites within or adjacent to areas flooded by the reservoir due to erosion or salvage of timber that was flooded during reservoir impoundment; 2) flooding of nest sites over water if water levels rise during the breeding season; and 3) effects to food supply (fish) and aquatic foraging habitat (water quality) from water level management.

Overall data availability was evaluated as moderate for Osprey (Table 3) because previous studies were conducted on Osprey presence/occupancy and nesting habitat; however, this work was not recent (1980s and 1990s) and the reports (Lloyd 1998, Greinger 2004) are not readily available (Appendix B). No timber salvage is currently occurring, and a nest platform program was implemented in the past to offset loss of nest trees over time; thus potential effects on tree nest site availability are considered low. Further, the management of prey (fish) and water quality are directly addressed through ongoing management for fish. However, flooding of nests could occur in some cases because water levels are rising in the reservoir during the Osprey breeding season (described in Section 3.2.1), the vulnerable period for Osprey during which mortality of eggs and nestlings could occur due to flooding is relatively long (incubation and nestling periods combined are ~85 to 95 days), and some nests may be low enough to become flooded[3,4]. Nevertheless, nests are typically located far enough off the ground (or above water)[3] to remain above maximum reservoir water levels, thus nest flooding throughout the vulnerable period is unlikely. Based on these considerations, the magnitude of potential effects and priority were assessed as low and no recommendations were made (Table 3, Appendix B).

3.2.4. Aquatic Predatory Birds

Flow management decisions can alter the foraging habitat of aquatic predatory birds (e.g., herons, kingfishers, eagles, gulls, mergansers, cormorants) through impacts to water quality and prey (fish, aquatic invertebrates). However, as discussed for Osprey above (Section 3.2.3), these potential effects are directly addressed through ongoing management for fish. Thus, potential effects and priority were assessed as low and no recommendations were made (Table 3, Appendix B).

3.3. Mammals

3.3.1. Ungulate – Caribou

Three potential pathways of effects were identified through which caribou could be impacted by reservoir operations: 1) accumulation of shoreline woody debris obstructs caribou movements during migration and when accessing calving islands; 2) exposure of land links to caribou calving islands during reservoir drawdown improves predator access and therefore reduces suitability for calving; and

[3] Height of Osprey nests (Campbell *et al.* 1990b): 1 to 61 m, with 59% between 9 and 18 m (n= 381).

[4] Osprey nest just above water documented at https://www.getinvolvednechako.ca/wei/maps/wewanttohearfromyou.

3) exposure of shorelines during reservoir drawdown affects caribou access to the reservoir. These potential effects, and associated recommendations, are described in detail in a separate document (Regehr *et al.* 2021a). This separate document (Regehr *et al.* 2021a) provides detailed descriptions of the potential effects of shoreline woody debris accumulations on caribou as well as the physical works and monitoring programs that are being implemented to address these effects (e.g., Cichowski *et al.* 2020, Lee and Flowers 2021). It also includes an analysis conducted to evaluate the relationship between reservoir water level elevations in spring and the isolation of calving islands, the results of which indicated that reservoir operations affect the isolation of some calving islands during the calving period (which affects their suitability as calving habitat), and some potential exists for reservoir water level management to increase the availability of caribou calving islands.

Data availability for caribou in the watershed was categorized as high given that studies, including telemetry, survival, and productivity studies, have been ongoing (e.g., Cichowski and MacLean 2005, Cichowski 2015, Cichowski *et al.* 2020, Lee and Flowers 2021) (Table 2). The magnitude of potential effects was also rated high given that there is substantial concern that the caribou migration route through Whitesail Lake could be abandoned due to movement obstruction, the loss of access to calving islands due to movement obstruction has the potential to impact calf survival, and populations are federally and provincially at risk and have been identified as having high management a priority (Table 3, Appendix B; see also Regehr *et al.* 2021a). Recommendations include collaboration in the restoration of shorelines impacted by woody debris in accordance with recommendations and priorities developed by BC FLNRORD (Cichowski *et al.* 2020), incorporating the effect of drawdown during the caribou calving period on the isolation of calving islands into the evaluation of trade-offs during the structured decision-making water use planning process, and investigating the extent to which reservoir drawdown affects access to the reservoir for caribou by evaluating drawdown zone bank characteristics within caribou movement pathways during caribou movement time periods and evaluating potential options and benefits of shoreline and riparian enhancements (Appendix B). However, as discussed in Regehr *et al.* (2021a), there are challenges associated with some of the recommendations, such as our limited understanding of how reservoir operations affect the amounts and locations of woody debris accumulations along shorelines and how drawdown affects shoreline areas. In addition, calving islands have been prioritized for restoration based on their use by caribou, which is likely to be at least partly related to their isolation during the calving period (i.e., islands ranked as lower in priority may increase in value if water levels were managed to increase the probability of their isolation in spring). As discussed in Regehr *et al.* (2021a), it would be helpful for structured decision making and water use planning to obtain more information on the benefits of increasing calving island isolation in spring, some of which will likely emerge from ongoing research and monitoring (e.g., Lee and Flowers 2021).

3.3.2. Ungulate – Moose

Studies on moose (*Alces americanus*) are being conducted in the watershed, and data are therefore available on moose movements and habitat use that provide some information on the potential for interactions between moose and reservoir operations (Table 2). Specifically, an ongoing BC FLNRORD study was initiated in 2013 in response to landscape changes that followed pine beetle infestation with the objective of increasing our understanding of moose population dynamics in the watershed (Schindler, pers. comm. 2021). This study, which has involved radio-collaring and monitoring adult female moose (~100 females have been monitored to date and ~30 are actively monitored each year), has been focused on habitat selection and linking landscape features to causes of, or susceptibility to, moose mortality. Results from this study to date have not identified effects on moose that can be directly linked to reservoir operations. Collared female moose have been found to have relatively small home ranges (~12 to 40 km^2) but, although seasonal migrations are observed for some individuals such as movements to specific secluded areas for calving, these movements have been documented to occur overland, and no regular movements that overlap with the reservoir have been observed. However, although some collared females have been observed to cross the reservoir, analyses have not been conducted that allow linking of such movements with factors potentially relevant to reservoir operations (e.g., time of year, location of crossing). Potential effects to moose, if present, are likely to be associated with movement obstructions, similar to those identified for caribou above (Section 3.3.1). While it is also possible that reservoir operations indirectly affect moose by impacting important habitat (e.g., wetlands), there is currently little evidence for such effects because the monitored adult females have not been specifically associated with habitats adjacent to the reservoir that could be affected by water level fluctuations (Schindler, pers. comm. 2021).

Given results from this study to date, little interaction between moose and reservoir operations has been identified. However, as described above, limitations exist for interpretation of the data in relation to reservoir operations. Also, existing data for the watershed are limited to adult females, which are likely the population demographic that is least mobile and therefore has the lowest potential to be affected by movement obstruction issues associated with reservoir operations. Males may have larger home ranges (e.g., Cederlund and Sand 1994) and juveniles may have highest dispersal rates (e.g., Hundertmark 1998). In addition, data on movements by adult females that cross the reservoir have not been analyzed with the objective of identifying potential effects of reservoir operations on moose (Schindler, pers. comm. 2021). Based on these considerations, data availability was evaluated as moderate and the magnitude of potential effects and priority were assessed as low (Table 3, Appendix B).

Although a low priority rating was assigned to moose, opportunity exists for increasing our understanding of potential interactions between moose and reservoir operations. Additional effort could be expended to investigate documented moose movements that cross portions of the reservoir with the objective of evaluating whether the timing and locations of such movements can be linked

to potential reservoir operational effects, such as those identified for caribou (e.g., shoreline accessibility). Additionally, moose are included as a focal species in remote camera monitoring targeting caribou use of the islands and shorelines of Whitesail Reach as part of the Whitesail Reach Woodland Caribou Habitat Restoration Project[5] (Lee and Flowers 2021); thus monitoring results from this project may also help to determine whether shoreline access issues that have been identified for caribou also apply to moose.

3.3.3. Aquatic Mammals

Reservoir operations may affect aquatic mammals (American Beaver (*Castor canadensis*), Common Muskrat (*Ondatra zibethicus*), North American River Otter (*Lontra canadensis*), American Mink (*Neovison vison*)) by causing water level fluctuations that have the potential to impact denning conditions, behaviour, survival, and productivity. Specifically, rising water levels in spring have the potential to flood dens, and dropping water levels during winter may cause exposure of underwater den entrances and freeze-up of the water column, which can limit underwater movement and prevent access to food supplies. Winter drawdown in reservoirs has been linked to altered behaviour and reduced body condition in American Beavers (Smith and Peterson 1991). Impacts due to water level fluctuations may occur in wetlands that are affected by the reservoir (described in Section 3.1) or within the reservoir itself, although some species (e.g., Common Muskrat) are unlikely to occur within the reservoir because fluctuating water levels tend to eliminate required food supply (littoral zone plants; BC CDC 2021).

Few data were found on potential habitat or species presence/occurrence in the watershed, especially related to aquatic habitat affected by the reservoir, or on management concerns for aquatic mammal species other than American Beaver, and overall data availability was rated low (Table 2). However, some information for species presence in the watershed may be available in reports and databases (e.g., Hattler 1998; occurrence data from museum and harvest records for some species (E-Fauna BC 2021)). The magnitude of potential effects was evaluated as moderate based on the potential for water level fluctuations to affect behaviour, survival, and productivity of aquatic mammals and on previous identification of American Beaver as a focal species group for water management (Rio Tinto 2018). Given low overall data availability, priority was ranked as high (Table 3, Appendix B). Recommendations include addressing data gaps on species occupancy and, following this, re-evaluating potential impacts of reservoir operations on behaviour, productivity, and survival based on occurrence information (e.g., locations and habitats in relation to the potential for interaction with reservoir operations) (Appendix B).

[5] https://sernbc.ca/projects/Whitesail-Reach-Woodland-Caribou-Habitat-Restoration-Project.

3.4. Riparian-Associated Species

Reservoir operations can cause drawdown zone banks to become scoured, which adversely affects riparian habitat values for wildlife species associated with riparian areas (e.g., Fisher (*Pekania pennanti*), bats, aquatic mammals, some bird species). Few data were found during the review on occurrences of riparian associated wildlife species in the watershed (Table 2), although additional information may be available in specific data bases (discussed in Sections 3.2.1 and 3.3.3). However, some of the shorelines of the Nechako Reservoir are affected by accumulations of woody debris (see Section 3.3.1), and because vegetation communities along the shorelines of reservoirs tend to become impoverished due to water level fluctuations (Hill *et al.* 1998), reservoir operations are likely to impact productivity, survival, and/or behaviour for species associated with riparian areas. Thus, although data are lacking, the magnitude of potential effects was conservatively evaluated as moderate. Given low data availability, a high priority was assigned (Table 3, Appendix B). Recommendations include addressing data gaps on presence and distribution of riparian-associated birds and mammals, identifying potential interactions with reservoir operations, and investigating the potential for enhancing habitat along drawdown zone shorelines through physical works and/or water level management, similar to approaches taken in other reservoir systems (Ballin *et al.* 2018, Miller and Hawkes 2020) (Appendix B).

4. SUMMARY

Potential wildlife issues related to Nechako Reservoir operations have been identified for wildlife (amphibians, birds, and mammals) by identifying species groups that have the potential to interact with reservoir operations, evaluating the magnitude of potential effects identified, and ranking data availability and priority of issues in relation to reservoir operational management. Most pathways of effects identified are associated with reservoir water level fluctuations that can alter habitat or affect productivity and survival of wildlife species occupying habitats within wetlands affected by the reservoir or within the reservoir itself. Other pathways of effects include impacts to the movement pathways of ungulates, especially caribou, across the shorelines of the reservoir and calving islands which may be cluttered with woody debris or affected by drawdown. Drawdown has also been identified as potentially reducing the isolation of caribou calving islands during the calving period due to the formation of land links between the islands and the mainland (discussed in greater detail in Regehr *et al.* 2021a). In general, few data were found to evaluate wildlife species and habitat presence in the watershed, especially for locations potentially affected by reservoir operations, which limits certainty in the identification and evaluation of identified issues. As such, priority for several species groups was conservatively rated high. Priority for issues identified for caribou was rated high in spite of high data availability owing to substantial conservation concern for this species in the watershed (related to migration route use and access to calving islands).

For most wildlife species groups for which priority was ranked as moderate or high, recommendations were made to first fill identified data gaps and then re-evaluate the magnitude of potential effects and management priority because increased understanding of occupancy and habitat use is needed before potential effects of reservoir operations can be meaningfully considered during water use planning. As an exception, recommendations were made to implement management action for caribou because adequate work has been done to allow identification of effects and prescription of mitigation measures that will directly address those effects. For some species groups ranked low in priority, recommendations were also made to address uncertainties or assumptions.

Yours truly,

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REFERENCES

Ballin, L., T. Gower, M. Bayly, M. Hocking, M. Sloan, H. Regehr, and D. Lacroix. 2018. JHTWORKS-3: Upper Campbell Reservoir Drawdown Zone Revegetation Treatment Report – Year 1. Draft V2. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessments Ltd. Partnership and Ecofish Research Ltd., January 12, 2018.

BC CDC (BC Conservation Data Centre). 2021. BC Species and Ecosystems Explorer. Government of British Columbia, Ministry of the Environment, Victoria, BC. Available online at: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer. Accessed on May 18, 2021.

BC Hydro. 2018. JHTMON-9 Upper and Lower Campbell Lake Reservoir Amphibian Assessment: Monitoring Program Terms of Reference. BC Hydro. May 2018. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/vancouver-island/jhtmon-9-tor-2018-05-04.pdf. Accessed on February 8, 2020.

Biodiversity Centre for Wildlife Studies. 2021. Available online at: http://www.wildlifebc.org/. Accessed on May 25, 2021.

Boyle, K. 2012. Life in a Drawdown Zone: Natural History, Reproductive Phenology, and Habitat Use of Amphibians and Reptiles in a Disturbed Habitat. Masters Thesis, University of Toronto.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, and M.C.E. McNall. 1990a. The Birds of British Columbia. Vol. I. Nonpasserines: Introduction, loons through waterfowl. Royal British Columbia Museum, Victoria, British Columbia.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990b. The Birds of British Columbia. Vol. II. Nonpasserines: Diurnal Birds of Prey through Woodpeckers. Royal British Columbia Museum, Victoria, British Columbia.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall, and G.E.J. Smith. 1997. The Birds of British Columbia. Vol. III. Passerines: Flycatchers through Vireos. Royal British Columbia Museum, Victoria, British Columbia.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall, and G.E.J. Smith. 2001. The Birds of British Columbia. Vol. IV. Passerines: Wood-warblers through old world sparrows. Royal British Columbia Museum, Victoria, British Columbia.

Cedarlund, G. and H. Sand. 1994. Home-range size in relation to age and sex in moose. Journal of Mammalogy 75:1005-1012.

Cichowski, D., and N. MacLean. 2005. Tweedsmuir-Entiako caribou population – technical background information summary (1983-2003). Prepared for Ministry of Environment, Smithers, B.C. 199 p.

Cichowski, D. 2015. Tweedsmuir-Entiako caribou population status and background information summary. Consultant's report prepared for BC Ministry of Forests, Lands and Natural Resource Operations by Caribou Ecological Consulting, December 2015. Available online at: https://a100.gov.bc.ca/pub/acat/documents/r55188/TweedsmuirCaribouPopulationStatusandBackgroundInf_1542742511092_2741941772.pdf. Accessed on May 25, 2021.

Cichowski, D., R.S McNay, and V. Brumovsky. 2020. Tweedsmuir-Entiako Caribou (*Rangifer tarandus*) Tactical Restoration Plan. Prepared for BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development. Smithers, BC. Available online at: https://hctf.ca/wp-content/uploads/2020/10/TEC-Tactical-Restoration-Plan-Final-for-web.pdf. Accessed on May 25, 2021.

Davidson, P.J.A., R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). 2015. The Atlas of the Breeding Birds of British Columbia, 2008-2012. Bird Studies Canada, Delta, B.C. Available online at: http://www.birdatlas.bc.ca. Accessed on May 25, 2021.

EAO (BC Environmental Assessment Office). 2013. Guideline for the selection of valued components and assessment of potential effects. September 9, 2013. Available online at: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/environmental-assessments/guidance-documents/eao-guidance-selection-of-valued-components.pdf. Accessed on May 18, 2021.

eBird 2021. Available online at: https://ebird.org/home. Accessed on May 18, 2021.

E-Fauna BC. 2021. Available online at: https://ibis.geog.ubc.ca/biodiversity/efauna/. Accessed on May 18, 2021.

GeoBC. 2021. Freshwater Atlas Stream Network, Lakes, Watersheds, Wetlands. Available online at: https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/freshwater. Accessed on May 25, 2021.

Greinger, K. 2004. Nechako Reservoir Osprey nest abundance, occupancy, and success. [*document not found*].

Hatler, D. F., D.W. Nagorsen, and A.M. Beal. 2008. Carnivores of British Columbia. Royal British Columbia Museum. Victoria.

Hattler, D.F. 1998. Status of Nechako River beaver and muskrat populations. Alcan British Columbia, Vanderhoof, B.C. Available online at: https://www.neef.ca/resources/wildlife-birds-insects (Record # 3900). Accessed on May 18, 2021.

Hawkes, V.C., K.N. Tuttle, and C.M. Wood. 2015. CLBMON-37. Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment. Year 7 Annual Report – 2014. LGL Report EA3533. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Burnaby, BC. 79 pp + Appendices.

Hill, N.M., P.A. Keddy, and I.C. Wisheu. 1998. A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs. Environmental Management 22:723-736.

Hundertmark, K. J. 1998. Home range, dispersal and migration. Pp. 303-335 In: (A.W. Franzmann and C.C. Schwartz, eds.) Ecology and management of the North American moose. 2nd edition, University press of Colorado, Boulder. 733 pp.

Lee, J. and M. Flowers. 2021. Whitesail Reach woodland caribou habitat recovery project: effectiveness monitoring plan and early monitoring (2019 to 2020). Prepared for Ecosystem Restoration in Northern BC.

Lloyd, R.A. 1998. Report on Osprey nest survey in the Nechako Reservoir, March 26, 1998. Unpubl. rep. prepared for B.C. Min. Environ., Lands & Parks, Smithers, B.C. Cited in Osprey Foraging Report: Grice & MacLeod Forest Management Ltd. [*document not found*].

Matsuda, B.M., D.M. Green, and P.T Gregory. 2006. Amphibians and reptiles of British Columbia. Royal BC Museum. Victoria.

Miller, M.T. and V.C. Hawkes. 2020. CLBMON-9 Kinbasket Reservoir monitoring of revegetation efforts and vegetation composition analysis: Final Report—2008-2019. Unpublished Report by LGL Limited, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 59 pp. + App. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-9-yr10-2020-04-20.pdf. Accessed on May 18, 2021.

Regehr, H., C. Ashcroft, and J. Kurtz. 2021a. Potential effects of Nechako Reservoir operations on caribou. Consultant's memorandum prepared for the Nechako Water Engagement Initiative by Ecofish Research Ltd., October 29, 2021.

Regehr, H., A. Smith, L. Ballin, E. Wind, J. Abell, and D. Lacroix. 2021b. JHTMON-9 Upper and Lower Campbell Reservoir Amphibian Assessment Final Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessment Ltd. Partnership, Ecofish Research Ltd. and E. Wind Consulting. August 30, 2021.

Rio Tinto 2018. Nechako Reservoir Management. Available online at: https://www.getinvolvednechako.ca/7033/widgets/27307/documents/12582. Accessed on May 18, 2021.

Smith, D.W. and R.O. Peterson. 1991. Behavior of beaver in lakes with varying water levels in Northern Minnesota. Environmental management 15, 395. Available online at: https://doi.org/10.1007/BF02393886. Accessed on May 18, 2021.

Swan, K.D., V.C. Hawkes, and P.T. Gregory. 2015. Breeding phenology and habitat use of amphibians in the drawdown zone of a hydroelectric reservoir. Herpetological Conservation and Biology. 10:864-873.

van Oort, H., J.M. Cooper, A. Peatt, and S. Beauchesne. 2017. CLBMON 36: Kinbasket and Arrow Lakes Reservoirs: nest mortality of migratory birds due to reservoir operations— Year 9, 2016. Unpublished report by Cooper Beauchesne and Associates Ltd., Qualicum Beach, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 32 pp. + Apps. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-36-yr9-2017-02-08.pdf. Accessed on May 18, 2021.

Wright, N., C. Ashcroft, and J. Kurtz. 2021. Wetlands within the Nechako Reservoir basin potentially affected by operations. Consultant's memorandum prepared for the Nechako Water Engagement Initiative by Ecofish Research Ltd., June 18, 2021.

Personal Communications

Schindler, H. 2021. Wildlife Biologist at the Ministry of Forests, Lands, Natural Resource Operations and Development (FLNRORD). Telephone communication with H. Regehr, J. Kurtz, and Jennifer Carter, Ecofish Research Ltd., on May 18, 2021.

Warburton, D. 2021. Triton Environmental Consultants. Email communication with J. Carter, Ecofish Research Ltd. on February 17, 2021.

APPENDICES

Appendix A. Resources Consulted During Wildlife Issues Scoping.

Resource Type	Reference
Document	Ballin, L., T. Gower, M. Bayly, M. Hocking, M. Sloan, H. Regehr, and D. Lacroix. 2018. JHTWORKS-3: Upper Campbell Reservoir Drawdown Zone Revegetation Treatment Report – Year 1. Draft V2. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessments Ltd. Partnership and Ecofish Research Ltd., January 12, 2018.
	BC Hydro. 2018. JHTMON-9 Upper and Lower Campbell Lake Reservoir Amphibian Assessment: Monitoring Program Terms of Reference. BC Hydro. May 2018. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/vancouver-island/jhtmon-9-tor-2018-05-04.pdf.
	BC Ministry of Agriculture and Lands and Integrated Land Management Bureau. 2007. Morice land and resource management plan. Available online at: https://www2.gov.bc.ca/assets/gov/farming-natural-resources-and-industry/natural-resource-use/land-water-use/crown-land/land-use-plans-and-objectives/skeena-region/morice-lrmp/morice_lrmp_july2007.pdf.
	BC Parks. 2006. Management direction statement and ecosystem management plan for Entiako Provincial Park and Entiako Protected Area. BC Parks Ministry of Enivronment, Environmental Stewardship Division, November 2006. Available online at: https://bcparks.ca/planning/mgmtplns/entiako/entiako_mds.pdf?v=1617836692626.
	Boyle, K. 2012. Life in a Drawdown Zone: Natural History, Reproductive Phenology, and Habitat Use of Amphibians and Reptiles in a Disturbed Habitat. Masters Thesis, University of Toronto.
	Brown, T.G., L. Rzen, and E. White. 1995. Survey of piscivorous birds of the Nechako and Stuart Rivers. Canadian Manuscript Report of Fisheries and Aquatic Sciences No. 2285. Available online at: https://www.neef.ca/uploads/library/1870_Brownetal1995_PiscivorousBirds.pdf.
	Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990a. The Birds of British Columbia. Vol. I. Nonpasserines: Introduction, loons through waterfowl. Royal British Columbia Museum, Victoria, British Columbia.
	Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser and M.C.E. McNall. 1990b. The Birds of British Columbia. Vol. II. Nonpasserines: Diurnal Birds of Prey through Woodpeckers. Royal British Columbia Museum, Victoria, British Columbia.
	Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall, and G.E.J. Smith. 1997. The Birds of British Columbia. Vol. III. Passerines: Flycatchers through Vireos. Royal British Columbia Museum, Victoria, British Columbia.
	Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, M.C.E. McNall, and G.E.J. Smith. 2001. The Birds of British Columbia. Vol. IV. Passerines: Wood-warblers through old world sparrows. Royal British Columbia Museum, Victoria, British Columbia.
	Cedarlund, G. and H. Sand. 1994. Home-range size in relation to age and sex in moose. Journal of Mammalogy 75:1005-1012.
	Cichowski, D., and N. MacLean. 2005. Tweedsmuir-Entiako caribou population – technical background information summary (1983-2003). Prepared for Ministry of Environment, Smithers, B.C. 199 p.
	Cichowski, D. 2015. Tweedsmuir-Entiako caribou population status and background information summary. Consultant's report prepared for BC Ministry of Forests, Lands and Natural Resource Operations by Caribou Ecological Consulting, December 2015. Available online at: https://a100.gov.bc.ca/pub/acat/documents/r55188/TweedsmuirCaribouPopulationStatusandBackgroundInf_1542742511092_2741941772.pdf.
	Cichowski, D., R.S McNay, and V. Brumovsky. 2020. Tweedsmuir-Entiako Caribou (Rangifer tarandus) Tactical Restoration Plan. Prepared for BC Ministry of Forests, Lands, Natural Resources Operations and Rural Development. Smithers, BC. Available at: Available at: https://hctf.ca/wp-content/uploads/2020/10/TEC-Tactical-Restoration-Plan-Final-for-web.pdf.

Resource Type	Reference
Document	DWB (DWB Consulting Service Ltd.). 2019. Whitesail reach caribou calving islands rehabilitation: project plan and site prescriptions. Prepared for Society of Ecological Restoration in Northern BC (SERNbc) by DWB Consulting Service Ltd, March 2019. Available online at: https://sernbc.ca/uploads/library/additional_related/Caribou_Recovery/Whitesail_Reach_Habitat_Recovery_Project_Plan_and_Site_Prescriptions_March_22_2019.pdf
	EAO (BC Environmental Assessment Office). 2013. Guideline for the selection of valued components and assessment of potential effects. September 9, 2013. Available online at: https://www2.gov.bc.ca/assets/gov/environment/natural-resource-stewardship/environmental-assessments/guidance-documents/eao-guidance-selection-of-valued-components.pdf.
	Fraser Basin Council. 2015. Nechako watershed health report. Available online at: https://www.fraserbasin.bc.ca/_Library/Water_BCWF/Nechako-Mar31-2015_FINAL.pdf.
	Greinger, K. 2004. Nechako Reservoir Osprey nest abundance, occupancy and success.
	Hatler, D. F., D.W. Nagorsen, and A.M. Beal. 2008. Carnivores of British Columbia. Royal British Columbia Museum. Victoria.
	Hattler, D.F. 1998. Status of Nechako River beaver and muskrat populations. Alcan British Columbia, Vanderhoof, B.C. Cited at https://www.neef.ca/resources/wildlife-birds-insects (Record # 3900).
	Hawkes, V.C., K.N. Tuttle, and C.M. Wood. 2015. CLBMON-37. Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment. Year 7 Annual Report – 2014. LGL Report EA3533. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generations, Water License Requirements, Burnaby, BC. 79 pp + Appendices.
	Helm, R. D. MacDonald, B. Sinclair, D. Chan, T. Herrington, A. Chalmers, and B.G. Shepherd. 1980. A review of the Nechako River watershed. Fisheries and Environment Canada. Department of Fisheries and Oceans.
	Hill, N.M., P.A. Keddy, and I.C. Wisheu. 1998. A hydrological model for predicting the effects of dams on the shoreline vegetation of lakes and reservoirs. Environmental Management 22:723-736.
	Hundertmark, K. J. 1998. Home range, dispersal and migration. Pp. 303-335 In: (A.W. Franzmann and C.C. Schwartz, eds.) Ecology and management of the North American moose. 2nd edition, University press of Colorado, Boulder. 733 pp.
	Lee, J. and M. Flowers. 2021. Whitesail Reach woodland caribou habitat recovery project: effectiveness monitoring plan and early monitoring (2019 to 2020). Prepared for Ecosystem Restoration in Northern BC.
	Lloyd, R.A. 1998. Report on Osprey nest survey in the Nechako Reservoir, March 26, 1998. Unpubl. rep. prepared for B.C. Min. Environ., Lands & Parks, Smithers, B.C. Cited in Osprey Foraging Report: Grice & MacLeod Forest Management Ltd.
	Matsuda, B.M., D.M. Green, and P.T Gregory. 2006. Amphibians and reptiles of British Columbia. Royal BC Museum. Victoria.
	Miller, M.T. and V.C. Hawkes. 2020. CLBMON-9 Kinbasket Reservoir monitoring of revegetation efforts and vegetation composition analysis: Final Report—2008-2019. Unpublished Report by LGL Limited, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 59 pp. + App. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-9-yr10-2020-04-20.pdf.

Resource Type	Reference
Document	Nagorsen, D.W. 1996. Opossums, shrews and moles of British Columbia. Royal British Columbia Museum. Victoria.
	Nagorsen, D.W. 2005. Rodents & lagomorphs of British Columbia. Royal British Columbia Museum. Victoria.
	Regehr, H., A. Smith, L. Ballin, E. Wind, J. Abell, and D. Lacroix. 2021. JHTMON-9 Upper and Lower Campbell Reservoir Amphibian Assessment Final Report. Consultant's report prepared for BC Hydro by Laich-Kwil-Tach Environmental Assessment Ltd. Partnership, Ecofish Research Ltd. and E. Wind Consulting. August 30, 2021.
	Regehr, H., C. Ashcroft, and J. Kurtz. 2021. Potential effects of Nechako Reservoir operations on caribou. Consultant's memorandum prepared for the Nechako Water Engagement Initiative by Ecofish Research Ltd., October 29, 2021.
	Rio Tinto 2018. Nechako Reservoir Management. Available online at: https://www.getinvolvednechako.ca/7033/widgets/27307/documents/12582.
	Shackleton, D. 1999. Hoofed mammals of British Columbia. Royal British Columbia Museum. Victoria.
	Smith, D.W. and R.O. Peterson. 1991. Behavior of beaver in lakes with varying water levels in Northern Minnesota. Environmental management 15, 395. Available online at: https://doi.org/10.1007/BF02393886.
	Swan, K.D., V.C. Hawkes, and P.T. Gregory. 2015. Breeding phenology and habitat use of amphibians in the drawdown zone of a hydroelectric reservoir. Herpetological Conservation and Biology. 10:864-873.
	van Oort, H., J.M. Cooper, A. Peatt, and S. Beauchesne. 2017. CLBMON 36: Kinbasket and Arrow Lakes Reservoirs: nest mortality of migratory birds due to reservoir operations— Year 9, 2016. Unpublished report by Cooper Beauchesne and Associates Ltd., Qualicum Beach, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 32 pp. + Apps. Available online at: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-36-yr9-2017-02-08.pdf.
	Wright, N., C. Ashcroft, and J. Kurtz. 2021. Wetlands within the Nechako Reservoir basin potentially affected by operations. Consultant's memo prepared for Nechako Water Engagement Initiative by Ecofish Research Ltd, June 18, 2021.
Website	All About Birds - The Cornell Lab of Ornithology. Available online at: https://www.allaboutbirds.org/news/.
	BC CDC (BC Conservation Data Centre). 2021. BC Species and Ecosystems Explorer. Government of British Columbia, Ministry of the Environment, Victoria, BC. Available online at: https://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/conservation-data-centre/explore-cdc-data/species-and-ecosystems-explorer.
	Biodiversity Centre for Wildlife Studies. 2021. Available online at: http://www.wildlifebc.org/.
	Davidson, P.J.A., R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). 2015. The Atlas of the Breeding Birds of British Columbia, 2008-2012. Bird Studies Canada, Delta, B.C. Available online at http://www.birdatlas.bc.ca.
	eBird 2021. Available online at: https://ebird.org/home.
	E-Fauna BC. 2021. Available online at: https://ibis.geog.ubc.ca/biodiversity/efauna/.
	GeoBC. 2021. Freshwater Atlas Stream Network, Lakes, Watersheds, Wetlands. Available online at: https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/freshwater.
	https://nechako.riotintoflowfacts.com/#reservoir.
	https://sernbc.ca/projects/Whitesail-Reach-Woodland-Caribou-Habitat-Restoration-Project

Resource Type	Reference
Personal Communication	Cichowski, D. 2021. Consultant at Caribou Ecological Consulting. Email communication with H. Regehr, Ecofish Research Ltd., on April 20, 2021.
	Fillier, D. 2021. Conservation Specialist at BC Parks. Telephone communication with H. Regehr and Jennifer Carter, Ecofish Research Ltd., on April 9, 2021.
	McColl, D. 2021. Ecosystems Biologist at the Ministry of Forests, Lands, Natural Resource Operations & Development (FLNRORD). Telephone communication with H. Regehr, J. Kurtz, and Jennifer Carter, Ecofish Research Ltd., on March 23, 2021.
	McMillan, S. 2021. Senior Park Ranger at BC ParksTelephone communication with H. Regehr and Jennifer Carter, Ecofish Research Ltd., on April 9, 2021.
	Roberts, A-M. 2021. Wildlife Ecologist at the Ministry of Forests, Lands, Natural Resource Operations & Development (FLNRORD). Telephone communication with H. Regehr, J. Kurtz, and Jennifer Carter, Ecofish Research Ltd., on March 23, 2021.
	Schindler, H. 2021. Wildlife Biologist at the Ministry of Forests, Lands, Natural Resource Operations & Development (FLNRORD). Telephone communication with H. Regehr, J. Kurtz, and Jennifer Carter, Ecofish Research Ltd., on May 18, 2021.
	Warburton, D. 2021. Triton Environmental Consultants. Email communication with J. Carter, Ecofish Research Ltd. on February 17, 2021.

Appendix B. Wildlife Issues Related to Operations of the Nechako Reservoir by Species Group Identified During a High-Level Issues Scoping Review. See Appendix A for Information Sources.

Species Group	Species Potentially Present	Habitat	Habitat Category[1]	Pathways of Effects	Data Availability / Certainty (Low, High)	Magnitude of Potential Effects (Low, Moderate, High)	Recommendations
Aquatic-breeding amphibians	Toads, frogs, and salamanders (e.g., Western Toad, Long-toed Salamander, Columbia Spotted Frog, Wood Frog)	Breed in ponds and pools, and potentially in slow-moving streams or shallow/small lakes; may also breed along shorelines of reservoirs where suitable habitat exists, such as in shallow, low gradient bays	Wetland	• Water level fluctuations in wetlands caused by reservoir operations can impact the suitability of habitat for breeding amphibians; water levels in the reservoir are typically decreasing in early spring when amphibian egg laying occurs and they are rising later in the spring when eggs or larvae may be present • Habitat may be adversely affected through mechanisms such as changes in water depth and water temperature that can affect habitat suitability for eggs and larvae and can cause mortality (e.g., desiccation, inundation with water from the reservoir) • The extent to which amphibians can be affected depends on the elevation of wetland habitats relative to the water level in the reservoir, wetland habitat characteristics (e.g., depth, substrate, other water sources), and amphibian species-specific timing of breeding and egg and larval development times	Low: • Few data were found on the occurrence of amphibians in the watershed; no records were found for aquatic habitat likely to be affected by reservoir operations • A desktop wetlands assessment (Wright *et al.* 2021) provided information on wetlands within the reservoir footprint; however, this assessment was purely a GIS desktop exercise and was limited to wetlands as defined by the Freshwater Atlas (FWA); other habitats that are not classified as wetlands by the FWA (e.g., seasonal shallow waters) likely occur within the drawdown zone that are suitable for amphibian breeding	Moderate: • Although data on habitat and amphibian presence are lacking, amphibians are likely to be breeding within aquatic habitats affected by reservoir operations: the range of several species encompasses the watershed (and two species have been recorded in the watershed between Eutsuk Lake and Ootsa Lake (E-Fauna BC 2021)), and suitable aquatic habitats are likely present within the reservoir drawdown zone that were not identified in the desktop wetlands assessment (Wright *et al.* 2021) • Productivity can be adversely affected by reservoir operations through impacts to the suitability of habitat for amphibian survival, growth, and development • Some amphibian species are of conservation concern (e.g., Western Toad is federally of Special Concern)	• To address data gaps, identify potential habitat that can be affected by reservoir operations and determine occupancy (habitat use and species presence); this could involve review of existing information, identification of aquatic habitat using aerial imagery, ground truthing of the wetlands assessment (Wright *et al.* 2021) and imagery, and/or field surveys • To evaluate potential impacts of reservoir water level fluctuations on occupied amphibian breeding habitat and breeding success, predict and evaluate the types of interactions that are likely to occur based on key habitat characteristics (e.g., water sources, bed depth, substrate) and amphibian life history characteristics (e.g., species-specific timing of breeding and egg and larval development times) in relation to the timing and magnitude of water level changes; models developed to assess effects to amphibian habitat in other reservoir systems (e.g., BC Hydro 2018) could be consulted for guidance

Species Group	Species Potentially Present	Habitat	Habitat Category[1]	Pathways of Effects	Data Availability / Certainty (Low, High)	Magnitude of Potential Effects (Low, Moderate, High)	Recommendations
Waterbirds	Loons (Common Loon)	Breed in large and small freshwater lakes; nests on ground along shores, on islands, amongst submerged marsh vegetation, and on partially submerged logs and trees	Wetland, Reservoir	• Water levels may change in the reservoir, or in wetlands affected by the reservoir, during the bird nesting season, potentially adversely affecting breeding success • Water levels in the reservoir are generally rising during the bird nesting season (when birds have eggs or nestlings in their nests); Bird nests on or near the ground or over water (directly on ground near shore, in emergent vegetation over water, on stumps or snags protruding above ground or water, on islands, in riparian vegetation) in the reservoir or in wetlands affected by the reservoir may therefore become flooded when water levels rise, which could cause mortality of eggs or nestlings, adversely affecting breeding success	Low: • Breeding records exist for the watershed for a number of species (Campbell *et al.* 1990a and 1990b, E-Fauna BC); however, association of such breeding records with aquatic habitat likely to be affected by the reservoir would require access to specific databases • A desktop wetlands assessment (Wright *et al.* 2021) has provided some indication of potential habitat for species closely associated with wetlands and it may be possible to coarsely evaluate potential habitat presence through habitat mapping; however, some avian species may also breed in or adjacent to the reservoir	Moderate: • Although data on habitat and species presence associated with aquatic habitat likely to be affected by the reservoir are lacking, some birds are likely to be breeding in wetlands affected by the reservoir and within the reservoir over or close to water (the breeding range of many species encompasses the watershed) • Productivity can be adversely affected by reservoir operations through nest flooding because reservoir water levels are rising during the bird nesting season • The desktop wetlands assessment (Wright *et al.* 2021) documented that only one wetland defined by the FWA interacts with the reservoir; however, some species may also breed within the reservoir • The risk of impacting breeding success of waterbirds and passerines that nest on the ground and near water, if present, will vary by species, depending on nest site preference (e.g., nest height over ground or water, nest proximity to shoreline), timing of nesting, and life history characteristics (e.g., developmental strategy and length of vulnerable developmental periods (egg incubation period, nestling and post-nestling periods for some species)) • A number of species potentially breeding in the area are provincially or federally at risk (e.g., Eared Grebe, Horned Grebe, American Bittern)	• To address data gaps, identify bird species that nest in the reservoir or in wetlands affected by the reservoir and identify locations where interactions between active bird nests and reservoir operations could occur; this could involve review of existing information (including accessing existing databases such as those associated with the Biodiversity Centre for Wildlife Studies, eBird, Atlas of Breeding Birds of BC), identification of potential nesting habitat using aerial imagery and provincial vegetation databases, ground truthing of the wetlands assessment (Wright *et al.* 2021) and imagery, and/or field surveys • To evaluate potential impacts of reservoir water level fluctuations on bird breeding success: ◦ use data on species-specific use of habitats (within the drawdown zone or in wetlands affected by the reservoir), nest site characteristics, and nesting chronology to evaluate potential impacts on breeding success by species and/or species group ◦ key life history characteristics (e.g., nest site characteristics, timing of nesting, length of vulnerable developmental periods) could be associated with broad scale habitat characteristics (e.g., vegetation and elevation) to predict effects of water management on indicator species ◦ similar work conducted for other reservoirs (e.g., van Oort *et al.* 2017) could be consulted for guidance
	Grebes (e.g., Eared Grebe, Horned Grebe, Red-necked Grebe)	Breed in freshwater wetlands where emergent vegetation is present; nests over water in emergent vegetation	Wetland				
	Waders (e.g., Sora, American Coot, Wilson's Phalarope, American Bittern)	Breed in a variety of wetlands where emergent vegetation is plentiful; nest on ground or over water	Wetland				
	Swans (Trumpeter Swan)	Primarily breed in freshwater, on edges of large inland waters; typically in emergent marsh vegetation, or on a muskrat house, beaver lodge, or island	Wetland, Reservoir				
	Geese (Canada Goose)	Breed on islands in lakes, ponds, marshes, slow-moving rivers, ponds and bogs, and in man-made environments such as reservoirs; may breed in freshwater marsh with tall shrub vegetative cover and on ground or on platforms (e.g., on Osprey nests and muskrat and beaver lodges)	Wetland, Reservoir, River				
	Ground-nesting ducks (e.g., Green-winged Teal, Mallard, Northern Pintail, Blue-winged Teal, American Wigeon, Ring-necked Duck, Lesser Scaup)	Breed in a variety of wetlands, with species exhibiting different preferences for wetland type, proximity to water, water depth, and nest site characteristics; most species nest on the ground, with the nest typically well concealed in vegetation; some species nest on islands or over submerged vegetation	Wetland, Reservoir				
	Mergansers (Common Merganser)	Breed in freshwater with forested shores; nest on ground or near ground along shores of lakes or on islands	Wetland, Reservoir				
	Gulls (Bonaparte's Gull, Mew Gull, Ring-billed Gull, Herring Gull)	Typically nest on islands in lakes or ponds; nests are on the ground, among driftwood, or on hummocks, stumps, or pilings	Wetland, Reservoir				
	Shorebirds (e.g., Killdeer, Spotted Sandpiper)	Nest on ground along perimeters of lakes and rivers (Spotted Sandpiper) or on gravelly substrate a variety of distances from water (Killdeer)	Wetland, Reservoir, River				
Near-ground water-associated nesting passerines	Passerines that nest on or near the ground and near water (e.g., Common Yellowthroat, Northern Waterthrush, Wilson's Warbler, Song Sparrow)	Nest in riparian vegetation with nest site characteristics and height of nest off ground varying by species (nests can be on the ground to several meters off the ground)	Wetland, Reservoir, River				

Species Group	Species Potentially Present	Habitat	Habitat Category[1]	Pathways of Effects	Data Availability / Certainty (Low, High)	Magnitude of Potential Effects (Low, Moderate, High)	Recommendations
Near-water cavity-nesting birds	Cavity nesting waterfowl (Wood Duck, Common Goldeneye, Barrow's Goldeneye, Bufflehead, Hooded Merganser)	Nest in cavities of trees along the borders of forested wetlands, nests ranging in height from ground to a few metres off the ground	Wetlands, Reservoir	• Water levels may change in the reservoir, or in wetlands affected by the reservoir, during the bird nesting season, potentially adversely affecting breeding success • Water levels in the reservoir are generally rising during the bird nesting season; thus rising water levels in the reservoir or in wetlands affected by the reservoir have the potential to flood nests in cavities that are close to the water and close to the ground while eggs are in the nest, which could cause mortality of eggs, adversely affecting breeding success	Low: • Few data were found on potential habitat or species presence/occurrence in the watershed; breeding records exist for Barrow's Goldeneye and Bufflehead in the vicinity of Ootsa Lake (Campbell *et al.* 1990a), although these breeding records could not be specifically associated with aquatic habitat likely to be affected by the reservoir (would require access to specific databases)	Low: • For several species, nests are typically located far enough off the ground (Campbell *et al.* 1990a) to remain above maximum reservoir water levels; however, nests of Barrow's Goldeneye and Bufflehead are closer to the ground and could be at risk of flooding as water levels rise in summer if suitable nesting habitat is present around the reservoir or around wetlands affected by the reservoir • Specialized nesting habitat is required (relatively large trees with suitable cavities) • The desktop wetlands assessment (Wright *et al.* 2021) documented that only one wetland defined by the FWA interacts with the reservoir • The young of cavity nesting waterfowl are precocial and can swim shortly after hatch; thus the nests are vulnerable to flooding only during the ~ one month incubation period	• To address data gaps, confirm absence of nesting habitat adjacent to the reservoir and wetlands affected by the reservoir, especially for Barrow's Goldeneye and Bufflehead; this could be done coincident with the evaluation of nesting habitat for waterbirds, as described above
Water-associated Raptors	Osprey	Nest in and along a variety of waterbodies, typically in trees or on man-made platforms and structures, near or over water	Wetland, Reservoir, River	• Nest sites close to the water surface may be flooded when water levels rise during the bird breeding season (some Osprey nests may be low enough to become flooded; see photos in https://www.getinvolvednechako.ca/wei/maps/wewanttohearfromyou) • Nest sites may be lost if live or dead trees used for nesting within or adjacent to areas flooded by the reservoir are lost due to logging/timber salvage or erosion • Food supply and water quality may be affected if water level management impacts abundance of prey (fish)	Moderate: • Previous studies were conducted on Osprey presence and nesting habitat; however, this work was not recent (1980s and 1990s); reports (Lloyd 1998, Greinger 2004) are not readily available	Low: • Nests are typically located far enough off the ground (or above water) (Campbell *et al.* 1990b) to remain above maximum reservoir water levels • No tree salvage is currently occurring • Osprey nests have been identified as a management concern in the reservoir in the past, inventory has been conducted. and a nest platform program was previously implemented to offset loss of nest trees • Management of prey (fish) is addressed through ongoing management for fish	• No recommendations

Species Group	Species Potentially Present	Habitat	Habitat Category[1]	Pathways of Effects	Data Availability / Certainty (Low, High)	Magnitude of Potential Effects (Low, Moderate, High)	Recommendations
Aquatic Predatory Birds	Birds that forage on fish or aquatic invertebrates (e.g., Great Blue Heron, Belted Kingfisher, Bald Eagle, gulls, mergansers, Barrow's Goldeneye, Bufflehead, Double-crested Cormorant, shorebirds)	A variety of aquatic environments, including within the reservoir, in wetlands, or river habitats	Wetland, Reservoir, River	• Flow management decisions can alter foraging habitat which can affect prey abundance (fish, aquatic invertebrates) and foraging success	Low: • A study was conducted on piscivorous birds in the Nechako and Stuart rivers in relation to fish predation (Brown *et al.* 1995); however, this work was not recent and was limited in scope	Low: • Management of water quality and prey (fish, aquatic invertebrates) is addressed through ongoing management for fish	• No recommendations
Ungulate - Caribou	Caribou: Northern Mountain Population, Southern Mountain Population	Habitat use changes seasonally, in accordance with predators, snow conditions, and arboreal lichen availability; Tweedsmuir-Entiako caribou typically winter in the eastern portion of their range and summer in the western portion of their range; calving occurs in alpine and subalpine areas and in low elevation areas throughout the summer range, including on islands in Whitesail Lake and Eutsuk Lake	Reservoir	• Reservoir operation (flooding during reservoir impoundment) has caused woody debris to accumulate along reservoir and island shorelines which has been linked to movement disruption of caribou (i.e., difficulty in accessing reservoir shorelines and calving islands during migration and calving). • Reservoir drawdown creates land links to calving islands used for predator protection • Reservoir operation can cause drawdown zone shorelines to become difficult to access due to steepness of banks and lack of riparian vegetation; this could affect the ease of which caribou are able to descend to the water and to climb back onto the shore when crossing the reservoir during migration or swimming to calving islands, if low water levels coincide with timing of caribou movement	High: • Substantial data exist on habitat use, movements, and population status of the Tweedsmuir-Entiako caribou population (e.g., Cichowski 2015, Cichowski *et al.* 2020)	High: • The rate of accumulation of log debris has accelerated in recent years and the risk that the caribou migration route through Whitesail Lake could be abandoned due to movement obstruction is considered high; the loss of access to calving islands has the potential to impact calf survival; both of these potential effects have population-level implications • Restoration of caribou habitat impacted by reservoir operations has been identified as a priority by the province and Indigenous groups • All populations are at risk	• Collaborate in restoration of caribou habitat and monitoring as per recommendations developed by BC FLNRORD (Cichowski *et al.* 2020); relevant recommendations are focused on removal of obstructions, which includes reducing large woody debris along movement and migration pathways (shorelines of the mainland and calving islands); priorities for reservoir shoreline cleanup, treatment options, and a monitoring approach have been developed (Cichowski *et al*. 2020), and a pilot project is being implemented in Whitesail Reach (DWB 2019, Lee and Flowers 2021) • Incorporate the effect of drawdown on the isolation of calving islands into the evaluation of trade-offs during the structured decision-making water use planning process; maintaining slightly higher water levels in late May would maximize the availability of calving islands for caribou (see Regehr *et al.* 2021) • Investigate the extent to which reservoir drawdown affects access to the reservoir for caribou due to shoreline and bank characteristics within caribou movement pathways during caribou movement time periods and evaluate potential options and benefits of shoreline and riparian enhancements

Species Group	Species Potentially Present	Habitat	Habitat Category[1]	Pathways of Effects	Data Availability / Certainty (Low, High)	Magnitude of Potential Effects (Low, Moderate, High)	Recommendations
Ungulate - Moose	Moose	Prefers mosaic of second-growth forest, openings, swamps, lakes, wetlands; requires water bodies for foraging and hardwood-conifer forests for winter cover	Wetland, Reservoir	• Reservoir operation may cause movement disruption when accessing or crossing over the reservoir, as described for caribou above, due to accessibility of drawdown zone shorelines or woody debris accumulations	Moderate: • Telemetry studies are ongoing in the watershed focused on habitat selection and linking landscape features to mortality; however, only adult females are being monitored and observed movements across the reservoir have not been analyzed to investigate associations with factors potentially relevant to reservoir operations (e.g., time of year, location of crossing)	Low: • Based on telemetry data for adult female moose, regular seasonal movements that involve reservoir crossings have not been observed	• To address data gaps, investigate documented moose movements that cross portions of the reservoir to evaluate whether the timing and locations of such movements can be linked to potential reservoir operational effects, and use remote camera monitoring results from the Whitesail Reach Woodland Caribou Habitat Restoration Project (Lee and Flowers 2021) to evaluate whether shoreline access issues identified for caribou may also apply to moose
Aquatic mammals	American Beaver	Occupy artificial ponds, reservoirs, floodplains, and backwaters of large rivers, and canals if food is available; generally avoid lakes with strong wave action and fast-moving streams; waters with greatly fluctuating flow or water levels generally are poor habitat	Wetland, Reservoir, River	• Rising water levels due to reservoir operations have the potential to flood dens during the breeding period, either within the reservoir or in wetlands affected by the reservoir • Dropping water levels may cause exposure of underwater den entrances and may cause the water column to freeze in winter which can limit underwater movement and prevent access to important resources (e.g., American Beavers store food for winter in water under the ice); winter drawdown in reservoirs has been linked to altered behaviour and reduced body condition in American Beavers (Smith and Peterson 1991)	Low: • Few data were found on potential habitat or species presence/occurrence in the watershed or on management concerns for species other than American Beaver; however occurrence data may exist from museum and harvest records for some species (e.g., American Mink, American River Otter; E-Fauna BC 2021) • One report is known to exist on beaver and muskrat populations in the watershed (Hattler 1998) but this work was not recent and scope could not be evaluated (report is not readily available) • The desktop wetlands assessment (Wright *et al.* 2021) provides some indication of potential wetland habitat but was limited to wetlands as defined by the Freshwater Atlas (FWA)	Moderate: • Although data on habitat and species presence are lacking, reservoir operations could cause den flooding in the breeding season and freeze up of the water column in winter, potentially affecting behaviour, survival, and productivity of aquatic mammals • Aquatic mammals have been identified as a focal species group for water management, and water management is occurring to mimic normal spring conditions	• To address data gaps, compile information on presence and distribution of aquatic mammals; this could involve desktop review (including accessing existing databases such as those of museum and harvest records) and/or field investigation • Identify potential interactions with reservoir operations (evaluate where, how, and to what extent water level fluctuations caused by reservoir operations have the potential to affect survival and reproduction of aquatic mammals)
	Common Muskrat	Occupy fresh or brackish marshes, lakes, ponds, swamps, and other bodies of slow-moving water; most abundant in areas with cattail; rare or absent in large artificial impoundments where fluctuating water levels eliminate littoral zone plants (food supply)	Wetlands				
	North American River Otter	Occupy a variety of aquatic habitats, where there are fish; more common in forested habitat; use burrows made by other animals	Wetland, Reservoir, River				
	American Mink	Occurs in permanent or semipermanent wetlands with abundant cover, marshes, and riparian zones. Dens vary, including burrows/dens made by other species (e.g., muskrat and beaver), hollow log, under tree roots, and burrow dug in bank	Wetland, Reservoir, River				

Species Group	Species Potentially Present	Habitat	Habitat Category[1]	Pathways of Effects	Data Availability / Certainty (Low, High)	Magnitude of Potential Effects (Low, Moderate, High)	Recommendations
Riparian-associated species	Wildlife species that are associated with riparian areas - i.e., for which riparian areas have important habitat features (e.g., Fisher, bats (e.g., Silver-haired Bat, Hoary Bat, Yuma Myotis, Little Brown Myotis), aquatic mammals (e.g., American Mink and American Beaver), birds (e.g., waterbirds and passerines such as Northern Waterthrush, Common Yellowthroat, Song Sparrow), amphibians)	Riparian areas	Wetland, Reservoir, River	• Reservoir operation causes drawdown zone banks (riparian habitats) to become scoured and vegetation communities to become impoverished, which affects habitat values for wildlife species associated with riparian areas (e.g., foraging, roosting, and movement habitat for mammals, foraging, roosting, and nesting habitat for birds, migration/movement habitat for terrestrial life stages of amphibians)	Low: • Few data were found on occurrences of riparian associated species in the watershed although additional information may be available in specific data bases	Moderate: • Water level fluctuations are likely to have some impacts on productivity, survival, or behaviour for species associated with riparian areas • Some species associated with riparian habitat are provincially or federally at risk (Fisher, Little Brown Myotis)	• To address data gaps, identify presence and distribution of riparian-associated species and locations where interactions with reservoir operations are likely (evaluate where, how, and to what extent currently impoverished riparian areas could provide suitable habitat for these species); this could involve desktop review (including accessing existing databases) and/or field investigation • To improve our understanding of the potential for improving the value of riparian habitat (bank and vegetation characteristics) for a variety of wildlife species, investigate the potential for enhancing habitat along drawdown zone shorelines through physical works and/or water level management (e.g., revegetation, using seasonal flooding to enhance vegetation communities); similar work conducted for other reservoirs (e.g., Ballin *et al.* 2018, Miller and Hawkes 2020) could be consulted; the potential for benefits is likely to vary by location based on shoreline characteristics and habitat attributes in the vicinity of the riparian areas

[1] Wetland: habitat in and adjacent to wetlands affected by the reservoir; Reservoir: habitat in or along the shores of the reservoir; River: habitat in or adjacent to rivers.