Campbell River Water Use Plan

Monitoring Program Terms of Reference

- **JHTMON-9 Upper and Lower Campbell Lake Reservoir Amphibian Assessment**

May 4, 2018

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Monitoring Program Terms of Reference

1.0 Monitoring Program Rationale

1.1 Background

1.1.1 Campbell River Hydroelectric System

The Campbell River Hydroelectric System includes:

- Upper Campbell Reservoir, impounded by the Strathcona Dam;
- Lower Campbell Reservoir, impounded by Ladore Dam; and
- John Hart Lake Reservoir, impounded by John Hart Dam.

The Upper Campbell Reservoir (including Buttle Lake) is the upper most and largest component of the Campbell River Hydroelectric System. The reservoir's current maximum and minimum operating levels are 212.0-220.5 m respectively (BC Hydro 2012). The reservoir operation is highly variable due to a variety of factors, but the Water Use Plan guidance is to draw down the stored water from January through April, and again in September, and to maintain a minimum level of 217.0 m during the intervening summer months (June 21st and September 10th); at other times of year the reservoir is operated to increase storage (Figure 1; BC Hydro 2012).

The Lower Campbell Reservoir, positioned directly downstream of the Upper Campbell Reservoir and the Strathcona Dam, is operated to have a surface elevation maintained between 174.0 m and 178.3 m without a planned seasonal drawdown; however, between June 21st and September 10th, the 'preferred' zone is maintained, with a minimum of 176.5 m and a maximum of 177.5 m (Figure 2; BC Hydro 2012).

The John Hart Reservoir is located downstream of Ladore Dam and is impounded by John Hart Dam. The John Hart Reservoir is not part of the study area for this project, and operations will not be summarized here.

1.1.2 Water Use Planning

During the Campbell River System Water Use Planning (WUP) process, the Wildlife Technical Sub-committee (WTC) identified eight uncertainties regarding the impact of facility operations on wildlife use in the project[1] area, including two issues that required attention in the form of a monitoring study (Bruce 2002). One of these was the extent of aquatic habitat suitable for six species of obligate aquatic breeding amphibians ("amphibian populations") and the second was the effects of facility operations such as reservoir elevation on that habitat. These uncertainties were not resolved during the WUP process. The WTC recognised that there was moderate likelihood that there could be operational impacts on suitable amphibian habitat, and should that be the case, the impact on local amphibian populations had potential to be high. As a result, the WTC recommended that a monitoring program be carried out to help resolve this uncertainty. In accordance with the Campbell River System WUP, BC Hydro's water licence requires BC Hydro to assesses the response of amphibians to the operation of the system at Upper Campbell Reservoir and Lower Campbell Reservoir.

[1] The term 'project area' here refers to all water bodies or water ways that are potentially impacted by Campbell River project operations upstream of Ladore Dam.

Schedule A

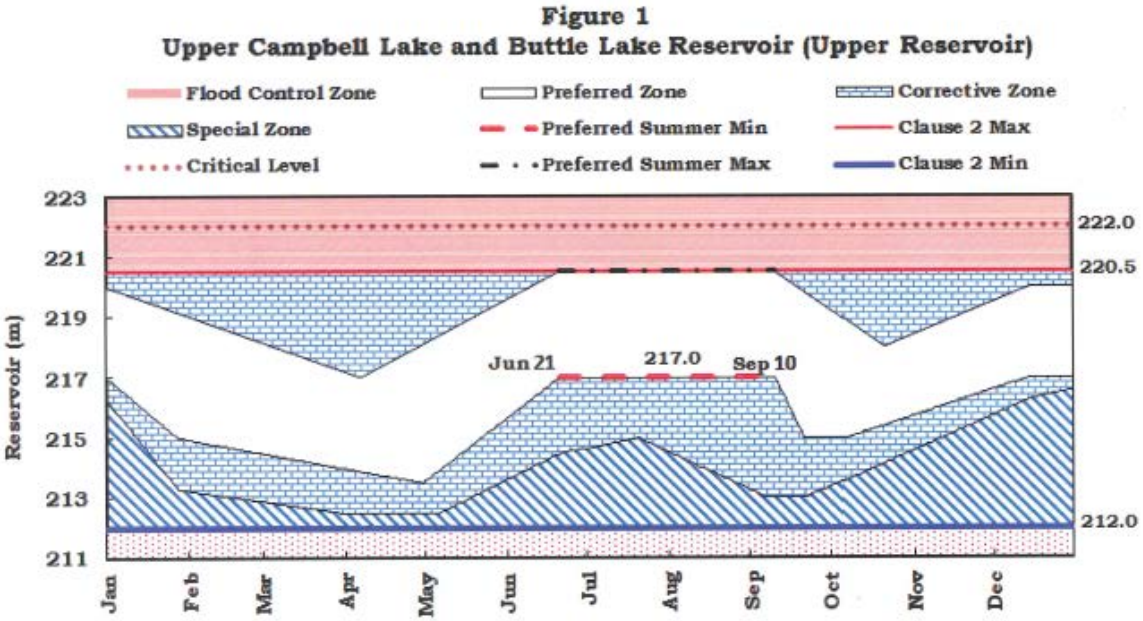

Figure 1: Upper Campbell Reservoir operating zones (from BC Hydro 2012).

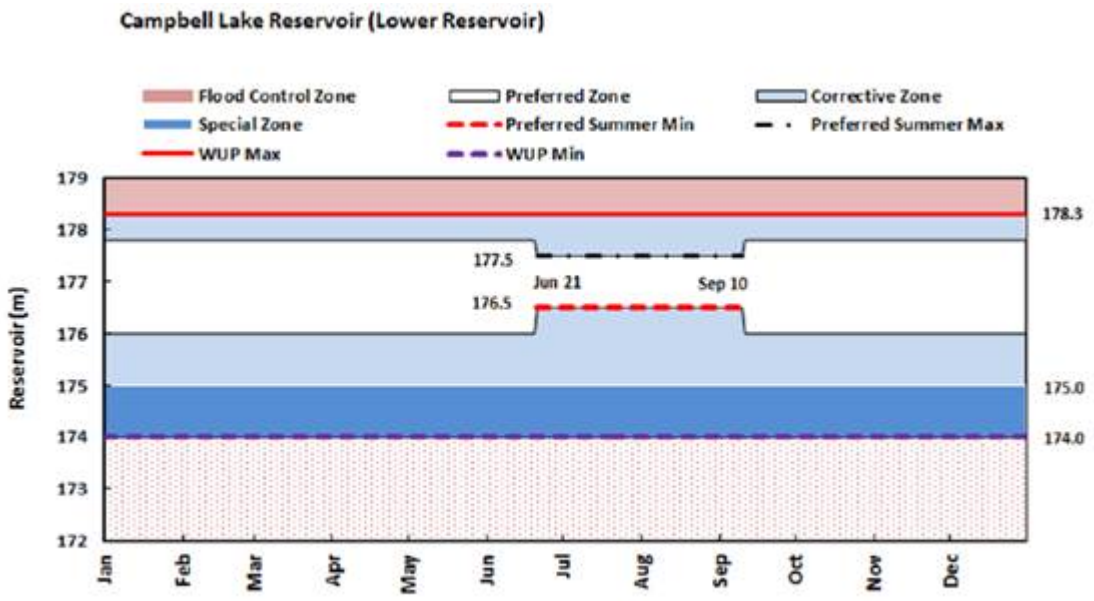

Figure 4-2: Lower Campbell Reservoir Operation Zones

Figure 2: Lower Campbell Reservoir operating zones (from BC Hydro 2012).

1.1.3 Amphibian Species of Interest

All species of obligate aquatic-breeding amphibians that breed in the focal reservoirs (e.g., along the shoreline), and/or in ponds that are connected to reservoir hydrology (i.e., ponded areas that are flooded when reservoir water elevations are high) will be the focus of this monitoring program. Based on amphibian species distributions in B.C., there are potentially six amphibian species to consider: 3 salamanders (Northwestern Salamander, Long-toed Salamander and Roughskin Newt), and 3 frogs/toads (Western Toad, Red-legged Frog and Northern Pacific Treefrog). A literature review of the biology of each species has been completed and is summarized in Table 1. Two of the target species are listed under SARA as schedule 1, special concern. The study will primarily focus on the SARA listed species and the common amphibian species found within the study area. The study may also consider invasive bullfrogs as part of the assessment (not included in Table 1).

A field reconnaissance to Upper and Lower Campbell Reservoirs was completed on June 20, 2017. Many large aggregations of Western Toad tadpoles were observed in flooded grassy areas along the margin of Buttle Lake at Ralph River where the water was shallow and very warm. Western Toad tadpole aggregations were also observed in one location in Upper Campbell Reservoir. Reservoir levels were very high at the time of the field reconnaissance, so it is not known if toad eggs were laid along the margin of the reservoir, or if they were laid in adjacent ponds that were inundated by the high reservoir levels, allowing the tadpoles to move into the reservoir. One salamander larvae of undetermined species (either Northwestern Salamander or Long-toed Salamander) was observed in a flooded area along the margin of Upper Campbell Reservoir. Tadpoles of undetermined species (not toad tadpoles) were observed in a pond connected to Upper Campbell Reservoir via a culvert.

All six amphibian species breed between late winter and spring, but the phenology varies considerably within this time span depending on species (Table 1). Due to regulation of the lake elevations in this system (especially at Upper Campbell Reservoir), the habitats available for breeding, will change throughout the season and a variety of issues could arise. Within the WUP guidance for Upper Campbell Reservoir (Figure 1), there is considerable latitude of operational variability in water levels (raising and lowering) during the late winter and spring breeding period (Figure 3). Amphibian eggs may be subject to desiccation, increased predation and changing temperatures due to water level variability and changes in connectivity to the reservoir. Western Toad eggs hatch quickly (< 2 weeks), potentially allowing this species to be more tolerant of changing water levels. For other species, eggs take as long as 6 weeks to hatch, and could be more vulnerable to changing water levels before egg hatching. After hatching, the growing tadpoles/larvae may be more tolerant of changing water levels, although connection of breeding ponds to the larger reservoir could result in increased predation of rearing amphibians.

Northwestern Salamanders, Roughskin Newts and Western Toads are the most tolerant of fish presence due to behavioural adaptations (e.g., using shallow habitats in the presence of fish; becoming nocturnally active; Northwestern Salamander) or because they are unpalatable to fish (Roughskin Newt and Western Toad; Table 1). It is possible that these three species may be more likely to breed along the margins of the reservoirs when compared to Long-toed Salamanders, Red-legged Frogs and Pacific Treefrogs. The latter group of species may be more likely to breed in smaller ponds in the drawdown zone or ponds connected to the reservoirs via culverts, should the habitats be suitable at the time of egg-laying (i.e., sufficient water). Data collected through this project will be used to determine if there are differences between species in terms of breeding habitats in the study area.

Table 1: Biology of the six amphibian species of concern for this project.

Species	Status	Timing of Egg Deposition	Egg-laying Habitat Features	Time Until Hatching	Diet in Larval Stage	Habitat in Larval Stage	Timing Until Metamorphosis	Tolerance of Fish	Potential Breeding Habitat in Project Area
Northwestern Salamander (*Ambystoma gracile*)	Yellow-listed	late February to April (most in late March to April)[1]	permanent ponds, beaver ponds or stream backwaters[1]; attach eggs to a small-diameter stick or rigid stem, 0.5-2m below water surface[1]; eggs attached to vegetation in shallows[4]	2-4 weeks[2]; late April and May[1]	zooplankton and aquatic inverts[2]	hatchlings in surface sediments or under small debris[1]; larvae under submerged logs or surface sediments in water usually deeper than 0.5m[1]	1-2 years[2]; late July - October[1]; usually their second summer[1]	larvae restricted to shallows in lakes with fishes[3,13]; preyed on by trout[2,12]; nocturnal when fish present[5,13]	likely breeds in permanent ponds attached to reservoir, and possibly along margins of reservoirs themselves
Long-toed Salamander (*Ambystoma macrodactylum*)	Yellow-listed	December to March[1]	temporary or permanent ponds, or in quiet water at the edge of lakes and streams[6]; eggs attached to vegetation or loose on the bottom[6]	2-6 weeks[7]; March - April[1]	zooplankton, immature insects, snails, tadpoles and occasionally other salamander larvae[6]		late April - July[1]	preyed upon by fish[8,10]; sensitive to presence of fish[9,10,14], and may use more refuge habitat (submerged vegetation, surface cover) in water with fish[11]	most likely to breed in ponds adjacent to reservoir; use of reservoirs may be low to due fish presence
Roughskin Newt (*Taricha granulosa*)	Yellow-listed	late March - April (most in late April-June)[1]	lakes, reservoirs, ponds, and stream pools or backwaters[15]; eggs attached to aquatic plants or submerged twigs[15]	late April - July[1]	zooplankton and small aquatic invertebrates[15]		late September - October[1]	eggs and larvae contain toxin and are not predated upon by fish[16]	likely breeds in reservoirs and backwaters

Species	Status	Timing of Egg Deposition	Egg-laying Habitat Features	Time Until Hatching	Diet in Larval Stage	Habitat in Larval Stage	Timing Until Metamorphosis	Tolerance of Fish	Potential Breeding Habitat in Project Area
Western Toad (*Anaxyrus boreas*)	Yellow-listed, but SARA Sched. 1 (Special Concern); COSEWIC Special Concern	late March - April[1]	shallow, littoral zones of lakes, temporary and permanent pools and wetlands, bogs and fens, and roadside ditches[17]; lay eggs in water <0.5m deep[1]; can lay eggs in water up to 2m deep, but they prefer <1m deep[20]; breeding sites may be open and unprotected by riparian or aquatic veg or woody debris[21]; key feature of breeding sites is warm water temperature[22]; toads show high fidelity to breeding sites[23]	2-12 days[1,17]	larvae filter suspended plant material or feed on bottom detritus[19]	benthic habitats[17]; hatchlings and tapoles live in warmest, shallowest water available[1, 21] to accelerate their rate of development and provide cover from predators[21]; may disperse to deeper water at night[21]	1-3 months[17,21]; late July to early September[1]	egg predators unknown[21]; tadpoles unpalatable to fish and newts[18,24]	documented tadpoles in shallows of reservoirs in project area; may breed in the reservoirs and in adjacent ponds
Red-legged Frog (*Rana aurora*)	Blue-listed, SARA Sched. 1 (Special Concern), COSEWIC Special Concern	February to April[30]	variety of permanent and temporary water bodies, including potholes, ponds, ditches, springs, marshes, margins of large lakes, and slow-moving portions of rivers[25]; water temp >21C is unsuitable[26]; usually abundant emergent vegetation[27]; deposit eggs in areas that receive sun for at least part of the day[27]; high fidelity to breeding sites[29]; use shallow shoreline habitat with emergent veg which may be affected by fluctuating water levels[27]; eggs attached to stem at the surface of the water[30]	late March - April[1]; mid-March to mid-May[28]	filamentous green algae[27] and potentially suspended plant material or benthic detritus[30]	benthic habitats[30]	11-14 weeks[28]; emerge in July to early September[1] (may overwinter as tadpoles)	tadpoles are predated upon by trout[28]	may breed in reservoir and in adjacent ponds, although survivorship could be low in areas with fish and newt predators of tadpoles

Species	Status	Timing of Egg Deposition	Egg-laying Habitat Features	Time Until Hatching	Diet in Larval Stage	Habitat in Larval Stage	Timing Until Metamorphosis	Tolerance of Fish	Potential Breeding Habitat in Project Area
Northern Pacific Treefrog (*Pseudacris regilla*)	Yellow-listed	late February to June[1]	eggs attached to objects in shallow water[31]; breed in marshes, lakes, ponds, ditches, reservoirs and slow-moving streams[32]	ongoing from April through early July[1]; hatch in 3-5 weeks[31]	larvae scape periphyton off rocks, eat filamentous algae and epiphytic diatoms in floating mats, bottom feed on benthic detritus, and surface feed on films of diatoms and pollen[33]		2-3 months[31]; late July to October[1]	tadpoles predated upon by fish[9,34], and tadpoles may increase refuge use in presence of native predators[34]	may breed in reservoir and in adjacent ponds, although survivorship could be low in areas with fish and newt predators of tadpoles

References: [1]Corkran and Thoms 1996; [2]B.C. Conservation Data Centre 2017a; [3]Leonard et al. 1993; [4]Blaustein et al. 1995a; [5]Taylor 1984; [6]B.C. Conservation Data Centre 2017b; [7]Green and Campbell 1992; [8]Gregory et al. 2006; [9]Bull and Marx 2002; [10]Pearson and Goater 2009; [11]Kenison et al. 2016; [12]Larson and Hoffman 2002; [13]Hoffman et al. 2004; [14]Funk and Dunlap 1999; [15]B.C. Conservation Data Centre 2017c; [16]Gall et al. 2011; [17]B.C. Conservation Data Centre 2017d; [18]Kiesecker et al. 1996; [19]Nussbaum et al. 1983; [20]Corn 1998; [21]COSEWIC 2012; [22]Ultsch et al. 1999; [23] Bull, and Carey 2008; [24]Formanowicz and Brodie Jr. 1982; [25]Blaustein et al. 1995b; [26]Hayes et al. 2008; [27]COSEWIC 2015; [28]Calef 1973a; [29]Calef 1973b; [30]B.C. Conservation Data Centre 2017e; [31]B.C. Conservation Data Centre 2017f; [32]Stebbins 1985; [33]Kupferberg et al. 1994; [34]Pearl et al. 2003.

The habitat suitability for egg-laying within the reservoir and backwater areas at the time of year when each species breeds is uncertain. Species that breed at times when the Buttle Lake/Upper Campbell Reservoir is typically nearing the lowest water elevations (April/May) may be limited in the availability of suitable substrates (e.g., vegetation, small diameter twigs) within the drawdown zone for egg attachment. The water levels in wetted areas connected to the reservoir by culverts is unknown at times of the year when the reservoir is nearing the lowest elevations.

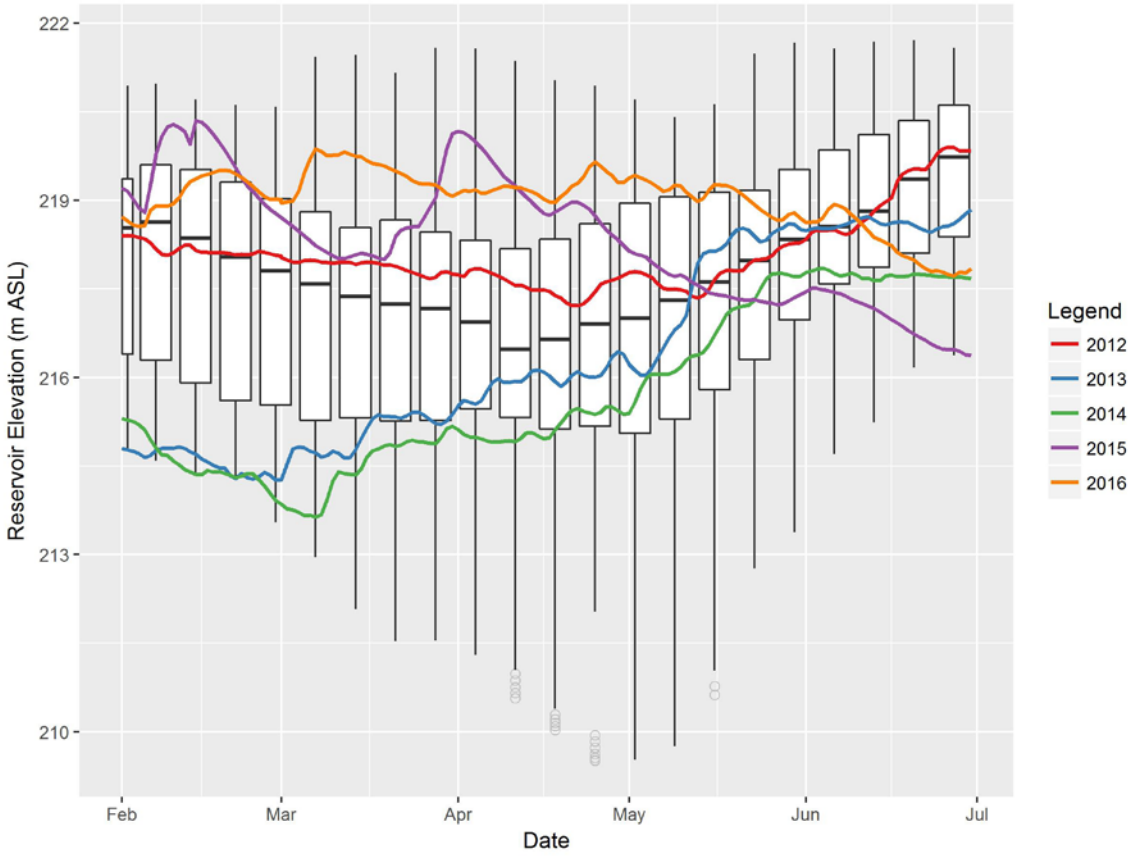

Figure 3: Historic water surface elevations of the Upper Campbell Reservoir graphed as weekly box plots, and drawn as lines for five recent years.

1.1.4 Project Area

The project area is restricted to habitats that are potentially impounded by the Upper and Lower Campbell Reservoirs. The project may consider any wetland habitat or pool within the drawdown zone of these reservoirs, including adjacent wetlands with water surface elevations that are potentially influenced by the reservoir via sub-surface water passage (i.e., through culverts) or which straddle the full pool elevations. Hereafter, all such wetlands and ponds are called “Drawdown Zone Habitats”. Vegetated and non-vegetated shorelines of the reservoirs will also be considered and will hereafter be referred to as “Reservoir Shoreline Habitats”. Independent wetlands that are not influenced by reservoirs are not considered by this project.

1.2 Management Questions

The purpose of this project is to assess the response of amphibians to the operation of the system at Upper Campbell and Lower Campbell Reservoirs. The assessment of the impact of reservoir operations on amphibians will determine which habitats are important for breeding amphibians, how those habitats are affected by operations (e.g., timing of inundation etc.), and how that may affect amphibian breeding success (e.g., egg survival).

This project has four main objectives:

1. To expand knowledge of amphibian species diversity utilizing Drawdown Zone Habitats and Reservoir Shoreline Habitats of the Upper and Lower Campbell Reservoirs;
2. To determine which Drawdown Zone Habitats and Reservoir Shoreline Habitats are used by amphibians for egg mass deposition, and whether there are differences in habitat selection by amphibian species;
3. To determine the degree to which Drawdown Zone Habitats and Reservoir Shoreline Habitats are influenced by reservoir operations during the amphibian egg-laying period; and
4. To consider the potential influence of reservoir operations on amphibian breeding success (e.g., egg survival).

Five Management Questions (MQ) will be addressed by this monitoring program. The first two questions will be addressed through a desktop study at the regional scale and the final three questions will be addressed through field investigations.

1a. Where are the Drawdown Zone Habitats that are potentially influenced by water level fluctuations of Upper and Lower Campbell Reservoir, and what are the surface areas and surface elevations of these pools when the reservoirs have receded?
1b. Based on modelling, how are Drawdown Zone Habitats (identified in 1a) potentially affected by water level fluctuations due to reservoir operations during the amphibian breeding season (January through September)?
2a. Which Drawdown Zone Habitats and Reservoir Shoreline Habitats do each amphibian species utilize for laying eggs?
2b. What attributes characterize Drawdown Zone Habitats and Reservoir Shoreline Habitats used for egg laying by each amphibian species?
2c. Based on field observations, is there evidence of reservoir operations influencing habitat suitability at amphibian breeding locations? If so, how might reservoir operations affect the breeding success of amphibians (e.g., egg survival, growth, larval survival, etc.) breeding in these locations?

It is recognized that addressing MQ-2c is likely to include a mixture of empirical observation and literature review depending on challenges associated with field observation; informed by new and existing available data, some speculation might be required.

1.3 Key Water Use Decision

Information from this study will inform the extent to which WUP operations may affect amphibian breeding success, and possibly amphibian populations, and will identify data gaps.

2.0 Monitoring Program Proposal

2.1 Approach

2.1.1 Mapping and Modelling Component

Management questions 1a and 1b will be addressed through a mapping and modelling exercise completed in the first year of the contract. Recent orthoimagery taken at low pool will be examined to determine the locations of pools and wetlands ("Drawdown Zone Habitats") within the drawdown zone of both reservoirs. Photogrammetry and LIDAR data will be used to establish attributes of each Drawdown Zone Habitat, including the wetted area (ha) and minimum/maximum water surface elevation (m asl).

Prior to modeling, the Drawdown Zone Habitat mapping will be reviewed by a biologist to assess its relevance, and to determine whether additional attributes should be considered for analysis.

Drawdown Zone Habitat mapping and information on historic reservoir operations will be used to model how the Drawdown Zone Habitats are affected by water level fluctuations due to reservoir operations during the amphibian breeding period (January through September). Metrics of influence (e.g., timing of inundation, depth) will be carefully chosen based on the nature and variability of reservoir operations and to capture the most salient issues affecting amphibians. The model will be interpreted for species-specific life history stages (e.g., Western Toad egg development period) to ascertain the influence of water level fluctuations on breeding amphibians. The magnitude of the potential influence (e.g., proportion of potential habitat affected) for each species life history stage will be estimated.

The results of the mapping and modelling component will be compiled in an interim report at the end of the first year of the contract.

2.1.2 Amphibian Field Survey Component

Management questions 2a through 2c will be addressed through field surveys of a subset of Drawdown Zone Habitats (identified in the mapping and modelling component) and Reservoir Shoreline Habitats. Amphibian breeding surveys, conducted throughout the combined egg-laying period (see Table 1), will be completed over a single field season to expand knowledge of (1) the community of amphibians utilizing Drawdown Zone Habitats and Reservoir Shoreline Habitats for breeding and (2) the habitats used for depositing egg masses.

Timing of inundation by the reservoir will be noted for Drawdown Zone Habitats. It may be useful to install water level loggers in select Drawdown Zone Habitats for which the relationship with reservoir water levels is less clear (e.g., wetted areas connected to the reservoir via a culvert). Habitat attributes of breeding locations and other representative locations will be recorded before and after inundation by the reservoir to determine how

changing reservoir water levels may affect breeding habitat suitability. Data on timing of inundation of Drawdown Zone Habitats by the reservoir will be compared to the model developed in the first part of the project. Egg mass locations will be revisited at subsequent field visits to determine fate of the egg mass with changing reservoir levels.

The results of the amphibian field surveys, breeding habitat characterization, and effects of reservoir water level fluctuations on habitat attributes will be compiled in a final report at the end of the second year of the contract.

2.2 Methods

2.2.1 Mapping and Modelling Component

The consultant will meet with BC Hydro at the start of the project to establish the methods used for the mapping and modelling component of the project. The criteria for defining how Drawdown Zone Habitats are mapped, described, and modelled will be determined at that time. BC Hydro may undertake the mapping portion of the project and provide the data to the consultant. Assumptions and limitations of the mapping and modelling component of the project will be fully explored in conjunction with BC Hydro.

2.2.2 Amphibian Field Survey Component

2.2.2.1 Field Preparation

The biology and breeding habitat preferences for each of the species listed in Table 1 will be reviewed in conjunction with maps of the study area to select locations for breeding surveys.

Several sampling designs can be deployed for this study; these will be planned during year 1. BC Hydro will provide guidance on sampling designs for the consultant to consider during the initial kick-off meeting. Site selection should aim primarily to maximize a diversity of cases, rather than focussing on high levels of spatial replication, but spatial replication needs to be considered in monitoring common habitat classes. At a minimum, site selection will include Drawdown Zone Habitats (selecting a subset of those identified in the mapping component of the project) over a range of elevations, with differing hydrological circumstances (e.g., including semi-attached or culvert-connected wetlands), and sites representing vegetated and unvegetated Reservoir Shoreline Habitats. Additionally, shoreline slope should be considered.

The timing of amphibian breeding surveys should be determined. Survey timing should correspond with the timing of egg deposition for the species of interest, where possible. Due to the wide range in the timing of breeding of the various species, multiple field visits will be required.

Details on the selection of survey designs, proposed monitoring locations and the scheduling of surveys will be included in the interim report at the end of the first year of the project.

2.2.2.2 Amphibian Breeding Surveys

Amphibian breeding surveys (see Systematic Surveys in Resources Information Standards Committee (RISC) 1998a) for all potentially-occurring species will be carried out at selected survey locations at the appropriate time of year. Egg masses will be

searched for, identified to species, the number of eggs estimated or counted, and georeferenced and/or marked in the field. Marked egg mass locations should be revisited at subsequent field visits to determine fate of the egg mass. Tadpoles and larvae will be identified to species, if possible, their developmental stage recorded, and their locations recorded. Surveys for larval amphibians through trapping may be considered in Drawdown Zone Habitats to confirm the species that are breeding in these habitats if few egg masses are found. Auditory surveys for Pacific Treefrogs should be considered.

Sampling will be carried out in a standardised manner. All data will be archived according to RISC (1998b) and BC Hydro protocols. All SARA data will be provided to the Conservation Data Center using appropriate forms, and data on other wildlife species will be provided to the Wildlife Species Inventory (WSI) database using appropriate forms. Contractors will provide the data directly to CDC and WSI.

2.2.2.3 Amphibian Breeding Habitat Assessment

General habitat characteristics relevant to breeding amphibians should be recorded for all sampling locations, including (but not limited to) elevation, average depth, surface area, and vegetation and cover features that characterize the site. Habitat characteristics at egg mass locations should be recorded, including (but not limited to) the depth of the water where the egg mass was located, the depth of the egg mass in the water column, the water temperature, and the substrate that the egg mass was attached to. Changes in habitat characteristics at sampling locations should be recorded throughout the breeding season as reservoir water levels change, and after inundation by the reservoir for Drawdown Zone Habitats; this will include changes in depth and water temperature at egg mass locations.

2.2.2.4 Water Level Monitoring

Timing of inundation by the reservoir will be noted for Drawdown Zone Habitats during amphibian breeding surveys. This information will be compared to the predicted timing of inundation based on the model developed in the first part of the project.

The consultant may choose to install water level loggers in select Drawdown Zone Habitats for which the relationship with reservoir water levels is less clear (e.g., wetted areas connected to the reservoir via a culvert). Data from the water level loggers should be analyzed in conjunction with data on reservoir elevations to determine hydrological connections between these areas.

2.2.2.5 Additional Methodological considerations

The study design may also consider the use of minnow traps to assess amphibian biodiversity via larval detections. Ancillary data on predatory fish communities would be beneficial to the project, but would not be considered in survey design.

2.2.3 Safety Concerns

A safety plan will be developed for all aspects of the study in accordance with WorkSafe BC and BC Hydro procedures and guidelines. It is important to note that, because of the remoteness of some of the study areas and the large geographical area that must be

covered, all field work must be carried out by a minimum two-person crew and that appropriate check-in and checkout procedures must be followed.

2.3 Data Analysis

The sampling methodology will be reported clearly, including descriptions of sampling designs, clear description of which monitoring locations are included in each design, which sites were repeatedly monitored, and for what purposes, and clearly reporting sample size for each hierarchy of data.

All field data will be entered into a common relational database in a format consistent with RISC (1998b) standards, which includes the use of standard attribute terminology, definitions, and coding schemes. Where possible, the data will be entered into standard forms as described in RISC (1998b) which will be submitted to the Conservation Data Centre (CDC) of the BC Ministry of Environment for Species Inventory (SPI) database entry. Use of this standardised format will ensure that data collected over the years and across geographical areas are compatible and can be extracted and compared without concern regarding differences in file format or attribute definitions. BC Hydro will provide direction on data entry and file formats.

Data analyses will include:

- Distribution of mapped Drawdown Zone Habitats as a function of elevation. This could include a histogram of pond elevations and a density graph of pond surface area across elevations.
- Modeling of inundation statistics of Drawdown Zone Habitats based on historic reservoir elevation data. This task should first assess if and how pre-WUP and post-WUP operations differed and consider whether these differences were consistent with WUP guidelines. A WUP effect should be accounted for (e.g., by segregating analysis according to operational regime). Inundation modeling during breeding season (January through September) should control for pond feature elevation, should consider pond feature area as well as pond feature counts, and should consider examination of a range of biologically relevant dependent variables such as (1) within and across year inundation, (2) seasonal differences in probability/risk of inundation, (3) inundation durations, and (4) inundation depth. These are suggestions, and contractor input and expertise are welcomed.
- Correlation of the inundation model to the observed timing of inundation of Drawdown Zone Habitats during field work.
- Descriptions of the habitat characteristics at confirmed breeding locations for each species, and any consistencies within and/or between species;
- Descriptions of any changes in habitat characteristics at sampling locations after inundation by the reservoir.
- Summary statistics on the frequency of egg mass observations (binomial detection, counts, and/or densities).
- Summary statistics and description of larval observations.
- If appropriate, summary statistics and description of amphibian eggs/larvae monitoring in relation to reservoir operations.

This list provides example guidance, and the contractor is encouraged to pursue any analytical approaches (statistical, graphical, etc.) that help address the Management Questions.

2.4 Reporting

Two reports will be prepared as part of this monitoring program:

1. An interim report will be prepared at the end of year 1 that reports the results of the mapping and modelling component, and describes the site selection for the field component in year 2. This report should include the following:
    a. methods used for the mapping component of the project, including information sources and selection of minimum size of Drawdown Zone Habitats to map;
    b. methods used for the modelling component of the project, including information sources and the reservoir operation scenarios modelled;
    c. limitations and assumptions of the mapping and modelling;
    d. answers to management questions 1a and 1b, including a map showing the locations of wetted areas in the drawdown zones of Upper and Lower Campbell Reservoirs and figures illustrating the modelling results;
    e. details on site selection for amphibian field studies in year 2, and the proposed timing of the field sampling.
2. A final report will be prepared at the end of the monitoring program that summarizes the amphibian breeding surveys and habitat assessment. This report will include the following:
    a. a summary of the results of the interim report on the modelling component, and an examination of the correlation between field data on the timing of inundation of Drawdown Zone Habitats and the timing of inundation suggested by the model;
    b. the methods and results of amphibian breeding surveys, including the timing of observations of the various amphibian species, the fate of detected egg masses through the breeding season, and the developmental stages of larvae/tadpoles observed and the likely timing of breeding for those individuals;
    c. the methods and results for habitat characterization at sampling locations and egg mass locations, including any consistencies within and/or between species in habitat characteristics at breeding locations and where eggs are laid, and how habitat characteristics at breeding locations and egg mass locations changed throughout the breeding season and with inundation by the reservoir;
    d. methods used to select locations for water level loggers, and results from the water level logger data, including correlations with reservoir elevations;
    e. answers to management questions 2a through 2c; and
    f. a complete set of clearly labelled geo-referenced maps showing the sampling locations and egg/animal observations.

In addition to the two reports, all data will be entered into one or more relational databases with tables describing sites, surveys, and observations, and submitted as a deliverable. It is expected that there will be at least two databases related to the two

scales of study, but additional databases may be appropriate if several sampling designs are used (e.g., where spatially vs. temporally replicated designs are used).

2.5 Interpretation of Results

Results of the mapping and modelling component of the project will provide a regional overview of the availability of potential amphibian breeding locations in the drawdown zones of both reservoirs, and how these sites are potentially affected by changing reservoir water levels during the amphibian breeding period.

Results of the amphibian breeding survey component of the project will provide greater certainty regarding the species of amphibians that breed in the reservoirs and in the Drawdown Zone Habitats of these reservoirs. This information, in conjunction with the timing of breeding of each species, can be used to determine the time of year when breeding amphibians will be most sensitive to changes in reservoir elevations.

Measurement of the habitat attributes at breeding locations, and changes in these attributes as reservoir levels change, will provide a basis for assessing the potential impact of changing reservoir levels on amphibian breeding success.

2.6 Schedule

The mapping and modelling component of the project will be completed in the first year of the project. The amphibian breeding surveys, habitat characterization, and water level logger installation (if used) will take place in the second year of the project. Additional field work beyond year 2 is possible. The need for this will be assessed at the end of year 2, based on the results of the first year of field work.

2.7 Budget

Total Program Cost: $245,774.

3.0 References

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