Campbell River Project Water Use Plan

Upper and Lower Campbell Lake Reservoir Amphibian Assessment

Implementation Year 2

Reference: JHTMON-9

Final Report

Study Period: 2019-2020

Laich-Kwil-Tach Environmental Assessment Ltd. Partnership
Ecofish Research Ltd.
E. Wind Consulting

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EXECUTIVE SUMMARY

The JHTMON-9 Upper and Lower Campbell Reservoir Amphibian Assessment is a study designed to address key uncertainties identified by the Wildlife Technical Sub-committee (WTC) during the Campbell River System Water Use Planning (WUP) process regarding the impact of operations in the Upper Campbell Reservoir (UCR) and Lower Campbell Reservoir (LCR) on breeding amphibians. These uncertainties are related to our knowledge of the location and characteristics of potential amphibian breeding habitat within the UCR and LCR drawdown zones and the impacts of reservoir water level fluctuations on such habitat. To address these uncertainties, the JHTMON-9 study was designed to identify and characterize amphibian habitats in the drawdown zones, predict effects of reservoir operations on these habitats, and conduct field surveys to inform this work as well as provide information on amphibian breeding biology and use of habitats in the drawdown zones and along the reservoir shoreline. Four study objectives, associated with five management questions, were identified (see Table i).

Two pathways of effect were identified by which reservoir water level changes have the potential to impact breeding amphibians: inundation of a habitat by water from the reservoir when reservoir water levels rise to the elevation of the habitat, and exposure of a habitat when reservoir water levels drop below the elevation of the habitat (and the habitat becomes isolated or disconnected from the reservoir). Two kinds of potential amphibian habitats were identified: "Drawdown Zone Habitats" ("ponds") which are wetlands and ponds hydrologically connected to the reservoirs at least at some water levels; and "Reservoir Shoreline Habitats" which occur along the margins of the main reservoir basin. Pond permanence was classified as "ephemeral" or "permanent" depending on the tendency of ponds to hold water because this affects the likelihood of desiccation when reservoir water levels drop. Six amphibian species are expected to occur in the UCR and LCR study areas: Northwestern Salamander (*Ambystoma gracile*), Long-toed Salamander (*Ambystoma macrodactylum*), Roughskin Newt (*Taricha granulosa*), Western Toad (*Anaxyrus boreas*), Northern Red-legged Frog (*Rana aurora*) and Northern Pacific Treefrog (*Pseudacris regilla*). Because the breeding periods (egg and larval periods; i.e., residency periods) of amphibians differ by species, potential effects of reservoir water level changes are also anticipated to differ by species and life stage.

Drawdown Zone Habitats were identified in the UCR and LCR through desktop mapping, and modeling was used to characterize them in terms of size and distribution (study area, elevation). Amphibian effects metrics, that quantify effects of inundation and exposure of ponds, were calculated from 2006 to 2018 water level data based on elevations of the ponds relative to elevations of reservoir water levels. These effects metrics were calculated by species-specific amphibian egg and larval periods for 0.5 m elevation bands for each study area (UCR and LCR).

Field surveys were conducted at select survey sites in both Drawdown Zone Habitats and Reservoir Shoreline Habitats in both study areas. Amphibian breeding surveys were conducted to documented species (and life stage) presence, timing of breeding, and developmental progress, and amphibian habitat assessments were conducted to assess broad scale (site level) and fine scale (breeding

occurrence level) habitat characteristics. Results from breeding surveys and habitat assessments were used to identify general habitat characteristics associated with amphibian breeding.

The study's results are summarized in relation to the five management questions below and in Table i.

Management Question 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?

Management Question 1a was addressed through the assessment of Drawdown Zone Habitat availability, in terms of pond number and habitat surface area, relative to pond elevation. In total, 370 Drawdown Zone Habitats (ponds) were mapped within the drawdown zones of the two study areas (334 in the UCR, of which 297 were ephemeral and 37 were permanent, and 36 in the LCR, of which 27 were ephemeral and 9 were permanent). The total surface area represented by these ponds was 337,860 m^2 (237,676 m^2 in the UCR and 100,184 m^2 in the LCR). In the UCR, 70% of ponds and 26% of habitat area (surface area) occurred between 215 and 217 mASL elevation bands, the mid-range of drawdown zone elevations. In the LCR, although the greatest number of ponds were also located in the mid-ranges of the drawdown zone elevations, most habitat (by surface area) was found in the upper elevations of the reservoir.

Management Question 1b: Based on modeling, 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)?

Management Question 1b was addressed through modeling which quantified the effect of reservoir water level fluctuations on Drawdown Zone Habitats (ponds) through the calculation of amphibian effects metrics (probability of inundation, probability of non-inundation, probability of transitioning from inundated to exposed, average date exposed, probability of transitioning from exposed to inundated, and average date inundated) by species-specific breeding periods and 0.5 m elevation bands for each study area. Modeling results indicated that the nature and magnitude of potential impacts on amphibian Drawdown Zone Habitats from water level fluctuations due to reservoir operations reflect a complex interaction of reservoir water level, the elevation of potential habitat, and the species-specific timing and duration of egg and larval periods. The characteristics of the ponds in relation to their tendency to hold water (whether ephemeral or permanent) also has implications for the interpretation of model results.

Probability of inundation of Drawdown Zone Habitat was strongly related to elevation, time of year, and annual maximum reservoir water level rise (which varies among years). Inundation is required for dry habitats to become wetted and available for amphibian breeding, although it may also reduce habitat suitability in ponds already wetted. Habitats at low elevations had higher probabilities of inundation than those at high elevations, and those at high elevation were more likely to remain dry (i.e., not become inundated). Reservoir water levels typically decreased early in the amphibian egg period and increased later in the egg period, but the overall probability of inundation within the egg period depended on the timing and duration of the egg period along with the elevation of the potential habitat. Calculated species-specific effects metrics indicated that the probability of inundation remained relatively low across most elevations for most of the egg period (i.e., egg residency period) for species with brief and early egg periods (i.e., Long-toed Salamander, Northwestern Salamander, and Northern Red-legged Frog), whereas it increased in the latter portion of the egg period for species with longer egg periods (e.g., Northern Pacific Treefrog). Probability of inundation varied less over the breeding season in the LCR than the UCR and was less related to the duration of the amphibian breeding period, in accordance with less variable reservoir water levels in the LCR. Low probabilities of inundation during amphibian breeding periods (e.g., egg period) may be associated with a risk of desiccation for Drawdown Zone Habitats that have ephemeral qualities (do not hold water when reservoir water elevations drop below the pond elevation) when breeding is initiated at a time when reservoir levels are typically dropping (early in spring). However, permanent ponds at high elevations may be valuable habitats because they are rarely inundated by the reservoir and therefore may develop and maintain suitable micro-climates (e.g., water temperature, water depth).

The potential impact of habitat transitioning from exposed (isolated from the reservoir) to inundated (flooded by water from the reservoir), or from inundated to exposed, at some point during the egg and larval period of amphibian species depends on pond characteristics (e.g., whether ephemeral or permanent), direction and timing of the transition relative to the timing of the breeding period, the rate of water level change, and the condition of the habitat when it is inundated or exposed (whether previously wet or dry). The probability of habitat transitioning from inundated to exposed was generally low during amphibian egg periods because water levels were rising in late spring/early summer and was highest for early breeding periods (when water levels were dropping following a winter high) and at relatively high elevations. The probability of habitats transitioning from exposed to inundated during the egg period varied among species because water levels are rising in late spring/early summer. As an example, the Northern Red-legged Frog has an early and short egg period, so there is little opportunity for exposed habitats to become inundated, regardless of elevation, because the breeding period does not extend into summer when water levels rise (maximum probability was 21% in both reservoirs). If the egg period is of longer duration, the probability of having exposed habitat becoming inundated was high, especially at higher elevations which were typically exposed at the onset of breeding (e.g., maximum probability was 64% in the UCR and 100% in the LCR for Northern Pacific Treefrog for which the egg period extends into the summer).

Management Question 2a: Which Drawdown Zone Habitats and Reservoir Shoreline Habitats do each amphibian species utilize for laying eggs?

Management Question 2a was addressed by conducting amphibian breeding surveys at select survey sites within Drawdown Zone Habitats (ponds) and Reservoir Shoreline Habitats in the UCR and LCR. Breeding was confirmed for Western Toad, Northern Pacific Treefrog, Northwestern Salamander, and Northern Red-legged Frog, and among these Western Toad and Northern Pacific Treefrog were most common. Rough-Skinned Newt was documented present, but breeding was not observed, and no Long-toed Salamanders were detected. For all species combined, most confirmed breeding sites were within Drawdown Zone Habitat (i.e., ponds: 71% of 38 sites; compared to 15% of 13 sites for Reservoir Shoreline Habitat), although Reservoir Shoreline Habitat was also documented to provide valuable breeding habitat. Similar use was detected for ephemeral (63%) and permanent (68%) ponds for all species combined; however, Western Toad and Northern Pacific Treefrog were found in similar numbers in ephemeral and permanent ponds, whereas Northern Red-legged Frog and Northwestern Salamander were found almost exclusively in permanent ponds. Overall, similar use of the two study areas was documented, but Western Toad were more abundant in the UCR, Northern Red-legged Frog and Northwestern Salamander were found largely in the LCR, and Northern Pacific Treefrog were relatively common in both study areas but were more common in the UCR.

Management Question 2b: What attributes characterize Drawdown Zone Habitats and Reservoir Shoreline Habitats used for egg laying by each amphibian species?

Management Question 2b was addressed by relating the results of breeding surveys to habitat characteristics. Overall, few habitat attributes measured at the broad (site-level) scale appeared to be clearly associated with breeding amphibian presence, and even fewer could be associated with specific species. However, water temperature tended to be warmer at amphibian breeding sites, breeding site substrate tended to be mineral soil and organic matter (rather than rock and mineral soil at non-breeding sites), and American Beaver activity was documented at more sites with amphibian breeding than without. Only slight among-species differences in habitat characteristics were noted; these were related to Drawdown Zone Habitat berm heights, shoreline slopes, and distance to forest cover; however, sample sizes for some species were small making comparison results tentative. The lack of obvious association between measured habitat characteristics and presence of breeding amphibians may be related to several factors, including lack of variability in some habitat characteristics among sites, small sample sizes for some species, flexibility in selected breeding habitat characteristics, and evaluating habitat through amphibian presence/absence rather than measures of breeding success.

Management Question 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 success of amphibians breeding in these locations?"

Management Question 2c was addressed in two ways: 1) through field observations of the response of pond water level to reservoir water level; and 2) through comparison of results of amphibian breeding surveys and habitat assessments between two years that differed substantially in reservoir water levels. The response of pond water level to reservoir water level was investigated for a subset of ponds through field observation. Results indicated that water levels in many ponds were closely linked to water levels in the reservoir for both reservoir systems, suggesting that groundwater flow between the ponds and the reservoir was relatively unimpeded. Thus, reservoir operations were directly influencing amphibian habitat suitability by affecting water depth in ephemeral ponds. The large number of ephemeral ponds identified in the two study areas (88% of ponds in the UCR and 75% of ponds in the LCR) suggests that desiccation of ponds could be a key amphibian management consideration, especially because most amphibian breeding sites were identified within Drawdown

Zone Habitat, rather than Reservoir Shoreline Habitat, and especially in the UCR where ephemeral ponds tended to exist in the 215.5 and 216.5 mASL elevation bands.

Comparison of differences in amphibian breeding location and behaviour indicated that amphibian species responded to differing reservoir water elevations in 2019 (when reservoir water levels were unusually low) and 2020 (when reservoir water levels were typical), which provides evidence for reservoir operations influencing amphibian habitat. Some species modified timing of breeding (delaying breeding in 2019 until habitats became wetted and gained sufficient water depth for egg laying), selected different ponds (the proportion of sites reused between years was lowest for species that use ephemeral ponds and highest for those that use permanent ponds, and for Northern Pacific Treefrog, a higher proportion of ephemeral ponds was used in 2020 than 2019), and laid eggs in shallower water depth in 2019 than 2020. These observations also provide evidence for the potential for some amphibian species to adapt to conditions associated with reservoir operations, although relative breeding success was not determined and could therefore not be linked to such amphibian responses.

Table i. Approach used to address the five JHTMON-9 management questions and key study results.

Management Question	Study Objectives	Approach	Key Results
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?	Objective #3: Determine the degree to which amphibian habitats are influenced by reservoir operations	Mapping and Modeling: Drawdown Zone Habitats (ponds) were identified through mapping, and modelling was used to characterize these ponds in terms of size and distribution (study area, elevation).	• There is about 2.4 times as much potential habitat available in the UCR than the LCR • 23.8 ha and 10.0 ha of habitat, distributed within 334 (297 ephemeral and 37 permanent) and 36 (27 ephemeral and 9 permanent) ponds are in the UCR and LCR, respectively • In the UCR, 70% of ponds and 26% of potential habitat occur between 215 and 217 mASL elevation bands; in the LCR, most ponds are in the mid-ranges of the drawdown zone elevations, but most potential habitat area is in the upper elevations
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)?	Objective #3: Determine the degree to which amphibian habitats are influenced by reservoir operations Objective #4: Consider the potential influence of reservoir operations on amphibian breeding success	Modeling: Amphibian effects metrics were calculated based on probabilities that Drawdown Zone Habitats were below the reservoir water elevation (and would be inundated by water from the reservoir) or above it (and would be isolated from the reservoir) during species-specific amphibian egg and larval periods by elevation band.	• Species life-stage specific effects metrics (probability of inundation, probability of non-inundation, probability of transitioning from inundated to exposed, average date exposed, probability of transitioning from exposed to inundated, and average date inundated) were highly variable given seasonal and yearly changes in reservoir water level, the elevation ranges of potential habitat, and the species-specific timing and duration of egg and larval periods • The permanence of ponds (ephemeral or permanent) has implications for the interpretation of modeling results

Table i. Continued.

Management Question	Study Objectives	Approach	Key Results
2a) Which Drawdown Zone Habitats and Reservoir Shoreline Habitats do each amphibian species utilize for laying eggs?	Objective #1: Expand our knowledge of amphibian breeding in Drawdown Zone and Reservoir Shoreline habitats Objective #2: Determine which habitats are used for egg laying and whether there are differences in habitat selection by species	Field surveys: Amphibian breeding surveys were conducted at Drawdown Zone Habitats and Reservoir Shoreline Habitats (along the shorelines of the reservoirs) to document species (and life stage) presence, timing of breeding, and developmental progress.	• Breeding was confirmed for Western Toad, Northern Pacific Treefrog, Northwestern Salamander, and Northern Red-legged Frog • Most confirmed breeding sites were within Drawdown Zone Habitat but Reservoir Shoreline Habitat also provided some valuable breeding habitat • Western Toad and Northern Pacific Treefrog were found in both ephemeral and permanent ponds; Northern Red-legged Frog and Northwestern Salamander were found almost exclusively in permanent ponds • Western Toad and Northern Pacific Treefrog were more common in the UCR and Northern Red-legged Frog and Northwestern Salamander were more common in the LCR
2b) What attributes characterize Drawdown Zone Habitats and Reservoir Shoreline Habitats used for egg laying by each amphibian species?	Objective #2: Determine which habitats are used for egg laying and whether there are differences in habitat selection by species	Field surveys: Results from amphibian breeding surveys were related to results from broad scale (site level) and fine scale (microsite level) amphibian habitat assessments to identify habitat characteristics associated with breeding.	• Few obvious habitat associations were documented; however, water temperature tended to be warmer, breeding site substrate tended to be mineral soil and organic matter, and there was more American Beaver activity at more sites with amphibian breeding than without • Slight among-species differences in habitat characteristics were noted related to Drawdown Zone Habitat berm heights, shoreline slopes, and distance to forest cover • Several factors were identified as potentially responsible for lack of obvious association between measured habitat characteristics and presence of breeding amphibians

Table i. Continued.

Management Question	Study Objectives	Approach	Key Results
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 success of amphibians breeding in these locations?	Objective #3: Determine the degree to which amphibian habitats are influenced by reservoir operations Objective #4: Consider the potential influence of reservoir operations on amphibian breeding success	Field surveys: The relationship between pond water levels and reservoir water levels was investigated and amphibian breeding survey results were compared between years with low (2019) and typical (2020) reservoir water levels.	• Field observations indicated that water levels in many ponds are closely linked to water levels in the reservoirs; thus reservoir operations are directly influencing amphibian habitat suitability by affecting water depth in ephemeral ponds • Comparison of differences in amphibian breeding behaviour (timing of egg laying, depth of water during egg laying) and location (type of pond) indicated that some amphibian species responded to differing reservoir water elevations in 2019 (when reservoir water levels were unusually low) and 2020 (when reservoir water levels were typical), which provides evidence for reservoir operations influencing amphibian habitat

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF MAPS

LIST OF APPENDICES

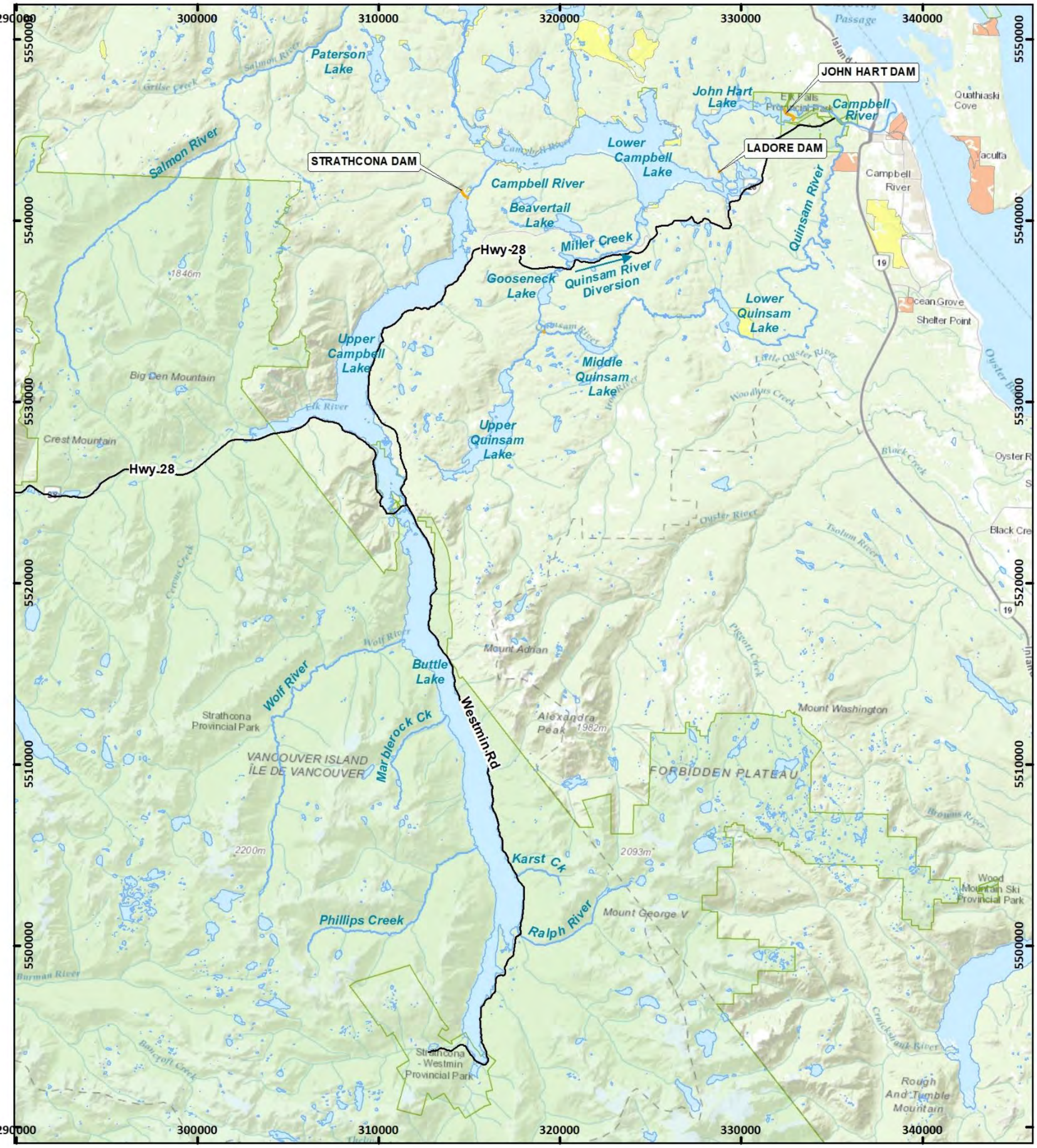
1. INTRODUCTION

During the Campbell River System Water Use Planning (WUP) process, the Wildlife Technical Sub-committee (WTC) identified several uncertainties regarding the impact of facility operations on wildlife. Among these were two key uncertainties related to amphibians: 1) the extent of amphibian aquatic breeding habitat within the Upper Campbell Reservoir (which includes Upper Campbell Lake and Buttle Lake) (UCR) and Lower Campbell Reservoir (LCR) (Map 1); and 2) the effects of reservoir water level management on aquatic amphibian breeding habitat. The JHTMON-9 Upper and Lower Campbell Reservoir Amphibian Assessment is a study designed to address these key uncertainties in two phases. In Phase 1 (completed in 2019), desktop mapping and modeling was conducted during which potential amphibian breeding ponds in the drawdown zone were selected and mapped, and the effects of water level fluctuations due to reservoir operations on this set of ponds was modeled in relation to potential amphibian habitat. In Phase 2, a field study was conducted during which a subset of ponds and potential shoreline breeding habitats were investigated to determine amphibian presence and use, and this was linked with pond characteristics related to reservoir operations. Following this, modeling was updated from that conducted in Phase 1 by incorporating information gained during Phase 2 field studies.

Ecofish, Laich-Kwil-Tach, and E. Wind Consulting were retained by BC Hydro to complete the JHTMON-9 Upper and Lower Campbell Reservoir Amphibian Assessment (the "study"). Phase 1 of the study was completed in 2019 and Phase 2 was completed in 2021. This report provides results from both phases of the study.

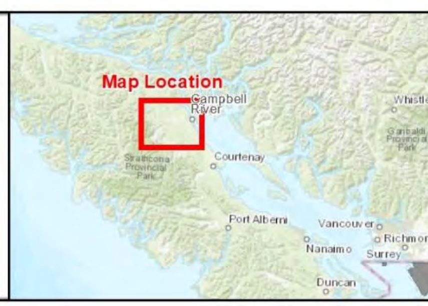
The sections below describe background information on water use planning, details on BC Hydro operations in the UCR and LCR, potential effects to amphibians in relation to reservoir operations, management questions and study objectives of JHTMON-9, and scope of the JHTMON-9 study.

Project Area Overview



Legend

- Dam
- Paved Road
- First Nation Reserve
- Recreational Sites
- Parks and Protected Areas



MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

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ECOFISH RESEARCH

Map 1

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1.1. Background to Water Use Planning

The goal of water use planning is to provide a balance between the competing uses of water, which include fish and wildlife, recreation, and power generation. WUPs were developed for all of BC Hydro's hydroelectric facilities through a consultative process involving local stakeholders, government agencies, and First Nations. The framework for water use planning requires that a WUP be reviewed on a periodic basis, and monitoring is typically identified through the WUP process and implemented in the years following the adoption of the WUP to address outstanding uncertainties and management questions.

As the Campbell River Water Use Plan process reached completion, several uncertainties remained with respect to the effects of BC Hydro operations on wildlife use and habitat availability in the reservoirs or in habitats hydrologically connected to reservoirs, particularly for wildlife species with key life history requirements dependent on aquatic habitat. The Campbell River WUP monitoring programs were developed to address uncertainties that affected decision making during the consultative committee process and to provide improved information for future WUP decisions. JHTMON-9 is a monitoring program that was developed to address key uncertainties related to the effects of water level management of the UCR and LCR on the availability and suitability of breeding amphibian habitat.

1.2. BC Hydro Infrastructure and Operations

The Campbell River WUP project area is complex and includes facilities and operations in the Campbell and Quinsam watersheds on the east coast of Vancouver Island, British Columbia, due west of the city of Campbell River (Map 1). The UCR, which includes both the Upper Campbell Lake and Buttle Lake, is 31,000 ha in size and is the largest reservoir in the Campbell River hydroelectric system. The UCR is impounded by the Strathcona Dam, which was constructed between 1955 and 1958 and had a second generating unit installed in 1968. The dam also provides primary flow regulation for the Ladore and John Hart Dams, which are located downstream. The UCR's historic (pre-WUP) operational water elevation has been between 210.0 m and 221.0 mASL (meters above sea level). The current WUP licenced storage for operations in the UCR is 212.00 mASL to 220.5 mASL, with a preferred range of 217.0 to 220.5 mASL between June 21 and September 10 (BC Hydro 2012) (Figure 1). The LCR, which consists of Lower Campbell Lake (approximately 2,700 ha in size), is impounded by the Ladore Dam. The Ladore Dam was originally completed in 1949, and two generating units were added in 1957. The LCR's historic operational water elevation has been between 163.65 mASL and 178.3 mASL (Figure 2), and the current WUP storage licence limits for operation is 174 mASL to 178.3 mASL, with a preferred range between 176.5 and 177.5 mASL between June 21 and September 10 (BC Hydro 2012). The reservoirs are operated according to the Campbell River WUP (BC Hydro 2012). Details of BC Hydro's Campbell River infrastructure and operations are provided in the Campbell River System WUP (BC Hydro 2012).

Figure 1. Upper Campbell Reservoir WUP Operating zones (reproduced from BC Hydro 2012).

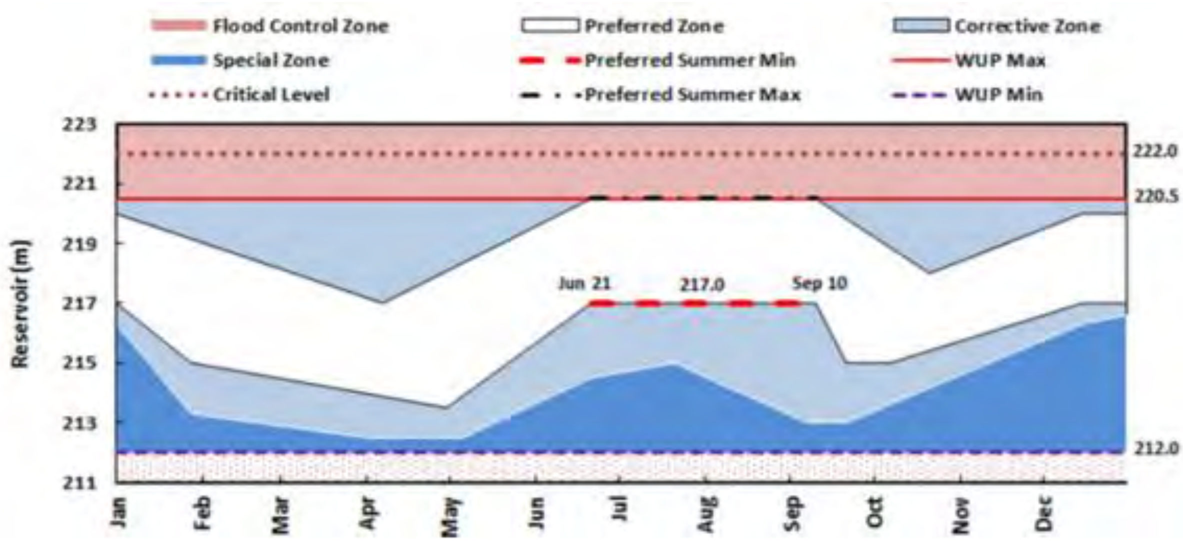
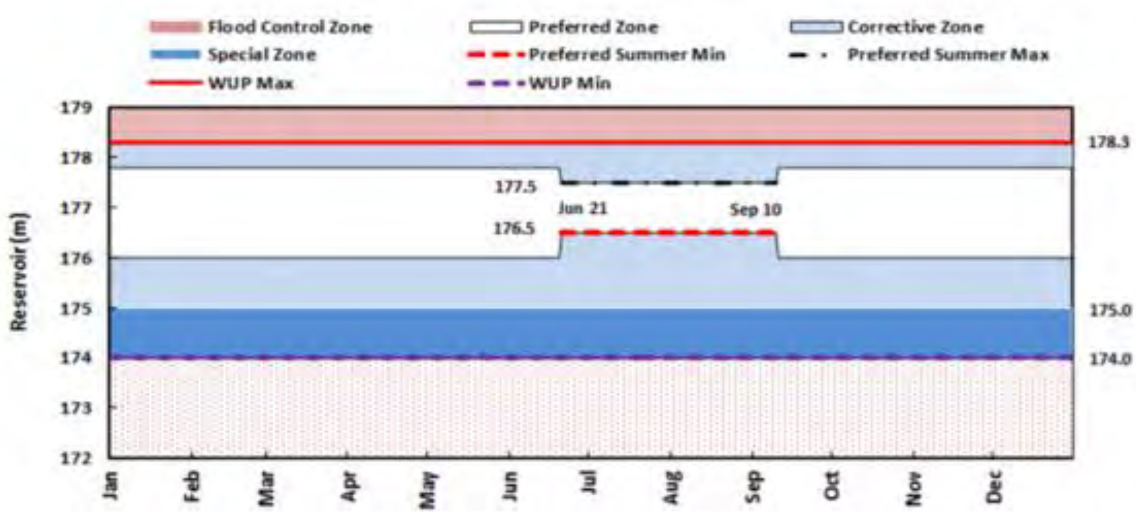


Figure 2. Lower Campbell Reservoir WUP Operating zones (reproduced from BC Hydro 2012).



1.3. Potential Effects of Reservoir Operations on Amphibian Habitat

Six amphibian species are expected to breed in habitats in or adjacent to the UCR and LCR (Table 1 in BC Hydro 2018, Appendix A) and may be affected by reservoir water level fluctuations. The six species of amphibian are: three salamander species (Northwestern Salamander (*Ambystoma gracile*), Long-toed Salamander (*Ambystoma macrodactylum*), and Roughskin Newt (*Taricha granulosa*)); and three frog species (Western Toad (*Anaxyrus boreas*), Northern Red-legged Frog (*Rana aurora*) and Northern

Pacific Treefrog (*Pseudacris regilla*)). Several life stages may potentially be present for these species: eggs, larvae, metamorphs, juveniles, and breeding adults. Among these life stages, breeding adults and fully aquatic life stages (eggs and larvae) are most likely to be affected by reservoir operations. The two broad types of potential amphibian breeding habitat that occur within or adjacent to the UCR and LCR (Map 1) that can be affected by changes in water levels within the reservoirs are: 1) "Drawdown Zone Habitats" (also referred to as "ponds") which are wetlands and ponds in the reservoir drawdown zone; and 2) "Reservoir Shoreline Habitats" which occur within the main reservoir basins, along the margins of the reservoirs (e.g., a small bay with low gradient with emergent vegetation may be suitable habitat).

Seasonal and annual changes in water levels in the reservoirs (see Figure 1 and Figure 2 above) can affect the quantity, location, timing, and quality of habitat available to amphibians breeding. Rising water levels may be associated with a change to habitat availability; for example, a decrease in the availability of Drawdown Zone Habitats (as they become submerged), or an increase in the availability of Reservoir Shoreline Habitats (as the reservoir perimeter expands). Fluctuating water levels can also directly alter key habitat characteristics, such as the water depth and temperature, which affects the suitability of breeding habitat. These habitat alterations may be caused by relatively small changes in water levels or can be more extreme, such as when habitats previously isolated from the reservoir become overtopped with water from the reservoir, or when reservoir water level reductions cause hydrologically connected habitats to disconnect and dry out.

Effects of reservoir water level fluctuations on potential amphibian breeding Drawdown Zone Habitat can be broadly classified within two pathways of effect: 1) inundation of a habitat by water from the reservoir when reservoir water levels rise to the elevation of the habitat, and 2) exposure of a habitat when reservoir water levels drop below the elevation of the habitat and the habitat becomes isolated or disconnected from the reservoir. However, the manner in which inundation or exposure can affect potential habitats may vary depending on the timing of the water level change, the condition of the habitat when it is inundated or exposed (whether previously wet or dry), and the characteristics of the potential habitat, including the tendency of the habitat to hold water when reservoir water levels drop. Reservoir water level fluctuations can also affect Reservoir Shoreline Habitats by increasing or decreasing habitat available along the reservoir margins.

Inundation of potential habitats by water from the reservoir can negatively affect habitat if the habitat is already wetted and its isolation from the reservoir had resulted in the development of suitable habitat characteristics for amphibian breeding. For example, inundation may reduce water temperature of a breeding habitat which can slow the rate of egg and larval development (Swan *et al.* 2015), or can change water depth so that it is sub-optimal for egg deposition. Water temperature has a strong positive correlation with embryo and larva development (Marian and Pandian 1985; Álvarez and Nicieza 2002; COSEWIC 2012, 2015); therefore, inundation is expected to slow embryo and larval development. Inundation may also introduce amphibian predators, such as fish, and may therefore increase predation risk for amphibians (Swan *et al.* 2015) or cause behavioural changes (Jara and Perotti

2010; Kurali *et al.* 2018; Kloskowski 2020). However, inundation may also cause potential amphibian habitats that are dry to become wetted and may therefore increase the availability of breeding habitat.

Similarly, although exposure of potential habitats may be beneficial if it causes suitable micro-climates to develop, it can be detrimental if wetted habitats drain once reservoir water levels recede. The loss of water from habitats can reduce the depth of egg masses attached to submerged and emergent vegetation, potentially increasing UV-B exposure, can force larvae to move to suboptimal habitats, and can cause the desiccation and mortality of eggs or larvae (Environment Canada 2016). Given these potentially differing effects of reservoir water level changes on amphibian breeding habitats, the extent to which water levels in an amphibian habitat are linked to water levels in the reservoir is an important consideration when interpreting the effects of water level changes.

The timing of inundation or exposure of habitats relative to amphibian life stages is also a key consideration for the interpretation of effects. For example, inundation at the start of the breeding season may be required to create habitat needed for egg laying and wetted habitat that becomes inundated after eggs have already been laid may become reduced in suitability, affecting development and survival of eggs and larvae. Because the timing of breeding differs among amphibian species and different life stages differ in their vulnerabilities, the timing of water level changes in relation to the timing of species-specific amphibian breeding periods can be critical when evaluating potential effects of reservoir water level management. Eggs are immobile and thus highly vulnerable to changes in habitat suitability, whereas larvae and adults are mobile and thus may be able to move as conditions change which may increase their tolerance to changes in habitat conditions. Further, eggs and larvae develop at different rates. For this study, the species-specific egg and larval periods were defined as the periods of time that eggs or larvae of a particular species are present in the habitat (equivalent to egg and larval residency periods), and the egg and larvae development times were defined as the time required for eggs to hatch and larvae to metamorphose, respectively.

1.4. Study Objectives and Management Questions

The study has four main objectives, as stated in the program's Terms of Reference (TOR) (BC Hydro 2018):

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 laying, 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.

These objectives are associated with five management questions:

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 modeling, 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 success of amphibians breeding in these locations?

1.5. Scope of the JHTMON-9 Study

The JHTMON-9 study, which has two phases, was initiated in 2018 (BC Hydro 2018). During Phase 1, which was completed in 2019, Drawdown Zone Habitats (amphibian breeding ponds; see Section 1.3) were identified within two study areas (the UCR and the LCR) using desktop mapping, and modeling of reservoir water levels (e.g., magnitude and timing of water level changes) in relation to the anticipated breeding chronology of amphibian species potentially present. Phase 2, which was initiated in 2019, involved conducting field visits to selected potential amphibian breeding habitats (Reservoir Shoreline Habitats and Drawdown Zone Habitats; see Section 1.3) over two amphibian breeding seasons (2019 and 2020), then using information obtained from field studies on amphibian species presence, occupancy of habitats, breeding chronology, and habitat characteristics in relation to reservoir water levels, to revise modeling analyses, and thereby evaluate potential effects of reservoir operations on amphibian breeding habitat. Together, these two phases addressed the study objectives and management questions of the JHTMON-9 study (Section 1.4). This report presents the methods and results from both phases of this study.

2. METHODS

The JHTMON-9 study was designed to address four objectives and five management questions (Section 1.4) through a combination of desktop habitat mapping, modeling, and field surveys (summarized in Table 1). Details on the definition and selection of potential amphibian habitats for the study, modeling of the interaction between potential amphibian habitats and water level changes, and the methods employed during field surveys, are provided in the sections below.

Table 1. Approach used to address the five JHTMON-9 management questions.

Management Question	Approach
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?	Mapping and Modeling: Drawdown Zone Habitats (ponds) were identified through desktop mapping, and modelling was used to characterize these ponds in terms of size and distribution (study area, elevation). Methods are presented in sections 2.2 and 2.3.1 and results are presented in sections 3.1 and 3.2.1 and in Appendix B.
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)?	Modeling: Amphibian effects metrics were calculated based on probabilities that Drawdown Zone Habitats were below the reservoir water elevation (and would be inundated by water from the reservoir) or above it (and would be isolated from the reservoir) during species-specific amphibian egg and larval periods by elevation band. Methods are presented in Section 2.3 and results are presented in Section 3.2 and Appendices C and D.
2a) Which Drawdown Zone Habitats and Reservoir Shoreline Habitats do each amphibian species utilize for laying eggs?	Field surveys: Amphibian breeding surveys were conducted at Drawdown Zone Habitats and Reservoir Shoreline Habitats (along the shorelines of the reservoirs) to document species (and life stage) presence, timing of breeding, and developmental progress. Methods are presented in Section 2.4 and results are presented in Section 3.3 and Appendix E.
2b) What attributes characterize Drawdown Zone Habitats and Reservoir Shoreline Habitats used for egg laying by each amphibian species?	Field surveys: Results from amphibian breeding surveys were related to results from broad scale (site level) and fine scale (microsite level) amphibian habitat assessments to identify habitat characteristics associated with breeding. Methods are presented in Section 2.4 and results are presented in section 3.3 and Appendix E.
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 success of amphibians breeding in these locations?	Field surveys: Evidence of potential operational effects on amphibian habitat was obtained from investigation of the relationship between pond water levels and reservoir water levels and by comparing amphibian breeding survey results between years with low (2019) and typical (2020) reservoir water levels. Methods are presented in Section 2.4 and results are presented in Section 3.3 and Appendix E.

2.1. Amphibian Habitat Classification

2.1.1. Drawdown Zone Habitats and Reservoir Shoreline Habitats

Two types of amphibian habitat were identified for this study in accordance with the management questions (Table 1): 1) "Drawdown Zone Habitats"; and 2) "Reservoir Shoreline Habitats". Selection of Drawdown Zone Habitats (ponds) for the study and the defined elevational boundaries is described in Section 2.2. Reservoir Shoreline Habitats are potential amphibian habitats that occur along the edge of the reservoirs. Such habitats cannot be as clearly delineated as Drawdown Zone Habitats and they were identified in the field. Because Reservoir Shoreline Habitats occur within the main reservoir basin, desktop mapping and modeling of potential amphibian habitat (sections 2.2 and 2.3) apply only to Drawdown Zone Habitats.

2.1.2. Ephemeral and Permanent Drawdown Zone Habitats

Drawdown Zone Habitats (ponds) were divided into two classes depending on their permanence (ability to hold water). This classification was developed during Phase 2 to differentiate types of ponds in relation to their response to changing reservoir water levels. Field studies conducted in Phase 2 indicated that water levels in many ponds are closely linked to those of the reservoir (discussed in Section 4.6.1), so that and when reservoir water levels drop, water levels also drop in the ponds, even though the water surface of the ponds are not connected to the water in the reservoir. However, the degree of connection between pond water levels and reservoir water levels differed among ponds, and some ponds were observed to hold water even when reservoir water levels dropped below their elevation.

Given these observations, Drawdown Zone Habitats (ponds) were classified as "ephemeral" or "permanent" in relation to their tendency to hold water when reservoir water levels drop. This allowed distinguishing ponds within which breeding amphibians may be at risk of desiccation when reservoir water levels drop (the pond becomes exposed) from those where there would be little or no desiccation risk. Ephemeral ponds were defined as those that will not hold water when reservoir levels drop below the pond elevation (bottom of pond) and permanent ponds were defined as those that will continue to hold water when reservoir water levels drop below the bottom of the pond. This pond classification was made based on available imagery and, for some sites, field observations. Specifically, field observations indicated that most ponds that retained water (were permanent) and where amphibian breeding was observed were either: 1) deep enough that the pond bottom was below the level of the reservoir; 2) maintained by impoundment and organic soils; or 3) had a surface inflow or subsurface seepage from an upstream water source. Thus, pond depth, substrate, and alternative water sources were considered in the classification. Although pond type (ephemeral or permanent) was not directly incorporated into modeling, the relative frequency, amount of potential amphibian habitat represented, and distribution (including by elevation) of each type of pond has implications for the interpretation of modeling results.

2.2. Amphibian Habitat Mapping

Amphibian habitat mapping was conducted to identify the Drawdown Zone Habitats (ponds) that can be affected by water level fluctuations. Identification of this set of ponds was the first step in addressing management question 1a (Table 1): to identify Drawdown Zone Habitats along with their surface areas and surface elevations that are potentially influenced by water level fluctuations in the UCR and LCR. Ponds were selected based on several criteria and were within defined polygons for each reservoir. Ponds were first mapped/selected by BC Hydro and this mapped selection was then reviewed by Ecofish Research Ltd. (Ecofish). The methods of pond mapping/selection within the UCR and LCR study areas are described below.

2.2.1. Pond Selection

The selection of ponds for analysis was conducted based on elevation, size, and isolation from the reservoir. For each reservoir impoundment, the polygon within which all selected ponds were located was defined by an upper and a lower elevation boundary. These boundaries were 212.0 mASL to 221.0 mASL for UCR, and 174.0 mASL to 179.0 mASL for LCR. These ranges are based on the minimum and maximum operating levels prescribed in the WUP, rounded up to the nearest 1 m. Ponds were selected if pond features were entirely contained within the study area polygons. All ponds identified within these elevation boundaries that appeared separated/isolated from the reservoir were selected and digitized provided that they were ≥1 m^2 in surface area.

2.2.2. Pond Digitization and Creation of Attribute Tables

BC Hydro's photogrammetry department delineated ponds within the drawdown zone of the UCR that appeared separated/isolated from the reservoir and were not inundated at the time of aerial imagery capture, and added attribute information, including surface elevation. The data sources used included aerial orthophotography, Lidar-imagery, and various surface data for Upper Campbell Lake and Buttle Lake. The attribute table included the following variables: 1) "pond_id" (a unique pond identification number); 2) "area_m" (surface area of pond feature in m^2); 3) "pond_elevation" (pond surface elevation); and 4) "pond_delineation".

Three key data sources were used for pond delineation/selection:

1. Aerial images and stereo collected bare earth surface data from April 19, 2002. Reservoir elevations at the time of the photograph were 211.9 mASL for UCR and 214.58 mASL for Buttle Lake.
2. Aerial orthophoto from September 7, 2014 (terrain data collected from previous data sources were reviewed and photogrammetrically updated on this date). Reservoir elevations for both UCR and Buttle Lake in this orthophoto were 216.76 mASL.
3. Lidar Ortho images and bare earth lidar points used in surface creation from October 13 and October 26, 2017. Reservoir elevations for both UCR and Buttle Lake for these images were 216.15 mASL.

The steps used to digitize ponds along with attribute information (elevation, surface area) within the study area were to:

1. Combine surface data from a data sources (listed above) into a seamless terrain model.
2. Generate a Digital terrain model (DTM) using the Bentley Map and InRoads software. Aerial and Lidar Orthophoto was displayed in a background;
3. Create lower and upper study area boundaries along contours of upper and lower boundary elevations (as defined above);
4. Identify visible ponds using orthophotographs and digitize either by "pass through contour" (surface elevation set to the value of the contour) or "cursor on surface" (surface elevation assigned as the average elevation of the pond outline) methods. Large ponds were typically selected by the "pass through contour" method;
5. Assign surface elevation for each pond identified. The pond surface elevation was set equal to the average elevation of the pond polygon outline. If there was a berm between the pond and the reservoir that is outside of the pond polygon, this was not accounted for in the assignment of pond surface elevation (see also Section 2.3.3); and
6. Calculate surface area for each pond identified.

BC Hydro Wildlife Biologist Harry van Oort reviewed the ponds delineated in the UCR and mapped ponds in the LCR. Following this, the UCR and LCR drawdown zone pond spatial layer was reviewed by Ecofish. Ecofish's review was supported by: 1) 0.5 m resolution digital elevation model (DEM) created by Ecofish from LiDAR data for UCR and LCR collected on October 13, 2017, provided by BC Hydro (the LiDAR had a resolution of 8 points per square meter (Hofer, pers. comm. 2018a) on average); and 2) orthophotos for UCR and LCR taken on October 13, 2017. Ecofish's review was also supported with input from BC Parks Conservation Specialist, Erica McClaren, who has extensive knowledge of amphibian distribution in both reservoirs, and Elke Wind a local amphibian expert. Results of the JHTMON-10 Upper and Lower Campbell Lake Reservoirs Shoreline Vegetation Model Validation Project and breeding habitat requirements for the six amphibian species potentially breeding within the drawdown zone informed the habitat mapping.

Ecofish edits to the habitat mapping layer (i.e., addition and/or removal of ponds) were approved by BC Hydro Wildlife Biologist Harry van Oort. BC Hydro's photogrammetry department added attribute data, including pond surface elevation, to the LCR and UCR spatial layers for any ponds that were added during this process, to ensure consistency.

2.2.3. Mapping Assumptions and Limitations

One mapping assumption/limitation was identified that may affect interpretation of results. This was:

- <u>Ponds selected for analysis were assumed to be isolated from the reservoir for at least some period of time</u>. However, confidence in isolation for at least some period of time was limited by data resolution and water levels in the images.

Despite quality control measures described above, it should be understood that the presence, size, and surface elevation of ponds are dynamic, and there was insufficient information to quantify and account for pond variability over time. As such, the pond delineation data should be considered as representing one potential example of the state of the drawdown zone. Because pond delineation was based on imagery taken at low reservoir levels, there is a potential bias in the estimation of size of ponds depending on their elevation: pond surface area may be assessed to be larger when a pond is inundated than when it is not; thus low elevation ponds may be biased high relative to high elevations ponds. In comparison, permanent ponds are relatively stable and would therefore have been mapped with greater precision and less bias. The effect of imagery capture bias is not expected to have large ramifications for the current study because the study is generally concerned with processes (not calculating absolute impacts), and because key amphibian breeding sites are likely to be well-represented in the data (the study confirmed selection for well-established permanent ponds).

2.3. Amphibian Habitat Modeling

A modeling approach was used to address two of the study's management questions (Table 1): 1a) to identify Drawdown Zone Habitats along with their surface areas and surface elevations that are potentially influenced by water level fluctuations in the UCR and LCR; and 1b) to evaluate how Drawdown Zone Habitats are potentially affected by water level fluctuations. Modeling was conducted to characterize Drawdown Zone Habitats in terms of size and distribution (study area and elevation) and to quantify the effect of reservoir water level fluctuations on these habitats by calculating probabilities related to inundation or exposure of ponds (referred to as amphibian effects metrics), which were identified as key effects pathways (Section 1.3). Because breeding chronology of aquatic life stages (egg and larval periods) differ among amphibian species, amphibian effects metrics were calculated separately for the egg periods (the periods of time during which egg laying and egg development occurs for a species; i.e., egg residency period) and larval periods (larval residency period) for each of the six amphibian species potentially present.

Analysis was conducted for Drawdown Zone Habitats within the elevational boundaries selected for mapping habitat (see Section 2.2.1 above) and for 0.5 m elevation bands using daily mean reservoir water elevation data from 2006-2018, which is the period when water level management was assumed to be consistent with the WUP (BC Hydro, pers. comm. 2018). Thus, modeling results were assumed to apply to the current water management regimes.

All modeling analyses were carried out using the R software language. Model inputs (taken from attribute tables developed during habitat mapping (Section 2.2) and BC Hydro water elevation data) provided the information needed to conduct the analyses. Model input variables are listed in Table 2.

Table 2. Input variables used for amphibian habitat modeling.

Name	Unit	Description
Pond ID	--	A unique ID number for each pond
Pond Area	m^2	The surface area of each pond
Pond Elevation	m	The elevation above sea level for each pond
Reservoir Daily Water level	m	The elevation of the reservoir level above sea level

2.3.1. Locations, Sizes, and Permanence of Drawdown Zone Habitats

For each 0.5 m elevation band within the overall elevational boundaries (Section 2.2.1), the number and area of all ponds were calculated for the UCR and LCR by 0.5 m water level band (elevation bands). Specifically, for each 0.5 m water level band, the following metrics were calculated for UCR and LCR:

- Number of ephemeral and permanent ponds; and
- Area of ephemeral and permanent ponds.

2.3.2. Impacts of Water Level Fluctuations on Drawdown Zone Habitats

Key statistics related to amphibian habitat availability and suitability that can be affected by reservoir water level fluctuations (amphibian effects metrics) were calculated based on probabilities that Drawdown Zone Habitats at specific elevations were below the reservoir water elevation (and would be inundated by water from the reservoir) or were above the reservoir water elevation (and would be exposed and isolated from the reservoir). As discussed in Section 1.3, inundation and exposure of ponds have implications for amphibian breeding habitat availability and suitability, although the nature of the effect depends on pond type (ephemeral or permanent), the timing of the water level effect relative to the timing of amphibian breeding periods, and the condition of the habitat when it is inundated or exposed (whether previously inundated or exposed). Given differences in among-species breeding chronology, amphibian effects metrics were calculated separately for the egg and larval periods for each of the six amphibian species potentially present. Amphibian effects metrics that were calculated for the egg and larval period for each amphibian species and for each 0.5 m elevation band within the UCR and LCR are:

- Probability of inundation: Percentage of years that the elevation band is below the reservoir water level (i.e., all Drawdown Zone Habitats at that elevation are inundated) during the species-specific egg and larval period in question;
- Probability of non-inundation: Percentage of years that the elevation band is above the reservoir water level (i.e., all Drawdown Zone Habitats at that elevation are exposed and isolated) during the species-specific egg and larval period in question;
- Probability of transitioning from inundated to exposed: Percentage of years that the elevation band was inundated but became exposed (i.e., all Drawdown Zone Habitats at that

elevation that were inundated and then became isolated) during the species-specific egg and larval period in question;

  - Average date exposed: Average date when the transition occurred from being inundated to exposed, for years when this transition occurred (N/A if it has never occurred) during the species-specific egg and larval period in question (minimum and maximum dates were also calculated);

- Probability of transitioning from exposed to inundated: Percentage of years that the elevation band was exposed but became inundated (i.e., all Drawdown Zone Habitats at that elevation became inundated) during the species-specific egg and larval period in question); and

  - Average date inundated: Average date when the transition occurred from being exposed to inundated, for years when this transition occurred (N/A if it has never occurred) during the species-specific egg and larval period in question (minimum and maximum dates were also calculated).

Amphibian effects metrics were estimated based on the frequency distributions of observed daily water levels in each reservoir during the post-WUP period (2006-2018) in relation to the timing of amphibian egg and larval periods. For example, if the elevation band of 218.0 to 218.5 mASL in the UCR was inundated at some point during the Northwestern Salamander egg period for half of the years in the record, then the probability of inundation for this band for this breeding period was estimated to be 50%. Similarly, if there was a transition from inundated to exposed for this elevation band during this breeding period for one of 13 years on record, then the probability for this transition was 7%. Thus, probabilities that the described events occurred (e.g., ponds inundated or transitioning from one condition to another) are equivalent to the percent of years (of the years on record) that this event occurred.

Estimated amphibian egg and larval periods used during modeling (Table 3) were derived from field observations (Section 3.3.2.2) and literature review; however, because development rates vary spatially and seasonally in relation to water availability and temperature, and to ensure that each breeding period would be fully encompassed by modeling, we defined these periods conservatively. For example, we considered the start of the egg period for each species to be the earliest date that egg laying could be initiated under suitable conditions. The beginning of the larval period for Long-toed Salamander was defined as January 1 because larvae can overwinter and metamorphose the following spring (Howard and Wallace 1985). The Northwestern Salamander larvae period was defined as continuous because larvae or neotenic adults may be present in aquatic habitat year-round (Eagleson 1976). It should be noted that these periods refer to the period during which eggs or larvae may be present in the habitat, not the time that it takes for eggs to hatch or larvae to metamorphose (the latter are referred to as development times).

Table 3. Start dates, end dates, and duration of egg and larval periods for the six amphibian species suspected to breed in the Upper Campbell Reservoir and Lower Campbell Reservoir as defined for modeling. Dates were informed from field work (for species documented breeding; Section 3.3.2.2) and literature review and, for modeling purposes, periods were defined conservatively to encompass the entire possible range of each period.

Species	Egg Period			Larval Period		
	Start	End	Duration (days)	Start	End	Duration (days)
Long-toed Salamander	10-Mar	15-Apr	37	01-Jan	07-Sep	250
Northern Pacific Treefrog	20-Mar	29-Jul	132	24-Apr	07-Sep	137
Northern Red-legged Frog	10-Mar	15-May	67	09-Apr	07-Sep	152
Northwestern Salamander	10-Mar	13-Jun	96	01-Jan	31-Dec	365
Roughskin Newt	01-Mar	30-Jul	152	28-Mar	07-Sep	164
Western Toad	15-Mar	25-Jun	103	07-Apr	07-Sep	154

2.3.3. Model Assumptions and Limitations

Several model assumptions and limitations were identified that affect interpretation of results. These are:

- Modeling results apply only to Drawdown Zone Habitats (ponds). Predictions from models are specific to the ponds selected for analysis, which are ponds located within the defined elevational boundaries (with ranges are based on the minimum and maximum operating levels prescribed in the WUP).
- Modeling results were based on all Drawdown Zone Habitats (ponds) identified during mapping and for all amphibian species and life stages. Modeling included all ponds and all species; however, not all species may breed in all locations (e.g., elevations, study areas), not all ponds may have suitable habitat characteristics for all species (e.g., pond permanence, substrate characteristics, vegetation, riparian habitat), and factors other than interaction with reservoir water levels will affect habitat suitability. Thus, when modeling results for Drawdown Zone Habitats are presented by species and life stage, this refers to all identified ponds regardless of the potential occurrences of amphibian species within them although not all species could potentially breed in all ponds.
- Modeling predictions are based on data for the period 2006-2018. Thus, modeling results assumed that current and future reservoir water levels will reflect those observed during this time period.
- Inundation of ponds was evaluated by reservoir water elevation only, which may represent a simplification of topography. A pond was considered inundated (overtopped) when the reservoir elevation matched the pond surface elevation. However, this assumes a smooth topographical landscape. If a raised landmass or elevated berm is located between the pond and the reservoir, this may result in a discrepancy when predicting timing of inundation ponds.

- Modeling assumed that pond hydrology is dominated by the reservoir and not other water sources, such as streams. If ponds are hydrologically affected by other water sources, modeling of inundation statistics may be incorrect. Pond inundation also did not consider the presence of culverts which, if present, can impact the flooding of ponds in accordance with the culvert elevation relative to pond surface and bottom elevations.
- The amphibian egg and larval periods defined for this analysis are best generalized estimates. Timing of amphibian egg and larval periods was estimated from two years of field observations and literature review; however, timing of breeding is influenced by environmental conditions and there is substantial among-year variation.
- The inundation statistics calculated through modeling are related to hydrological effects on potential habitat and do not consider potential behavioural adaptive responses of amphibians (such as movement by mobile life stages). The modeling results should be interpreted from the perspective of what is happening to the habitats that are potentially available for amphibian species, not from a perspective of how a particular species may be able to best exploit these habitats as they change.

2.4. Field Surveys

Field surveys ("surveys") were designed to identify, characterize, and monitor breeding sites of aquatic amphibians in a subset of Drawdown Zone Habitats identified during desktop mapping and modeling and at additional Reservoir Shoreline Habitats identified in the field. This work addressed three of the study's management questions (Table 1): 2a) to identify Drawdown Zone Habitats and Reservoir Shoreline Habitats used by breeding amphibians; 2b) to identify habitat characteristics of these habitats; and 2c) to evaluate evidence for reservoir operations affecting habitat suitability of these habitats. To fully address these management questions, surveys had two main components, amphibian breeding surveys and amphibian habitat assessments. Two types of surveys were used for breeding surveys and habitat assessments that reflected the level of effort applied and the amount of detail recorded: systematic and rapid. Systematic surveys were designed to provide detailed data on amphibian use, breeding success, and habitat characteristics which may change throughout the season, whereas rapid surveys were designed to optimize detection of amphibians and to characterize habitat in a short period of time.

Surveys were conducted during the amphibian breeding season in 2019 and 2020. Data from field surveys were recorded in digital iForms loaded onto hand-held tablets. Total effort expended on amphibian breeding surveys and habitat assessments was 97 person-days.

Selection of survey sites and the methods used to survey breeding amphibians and habitat are described in the sections below. Data on environmental conditions considered relevant to the interpretation of field survey results were also compiled as described below.

2.4.1. Environmental Conditions

Data considered relevant to the interpretation of amphibian breeding surveys and habitat assessments included precipitation, temperature (obtained from Environment Canada (2021)), and reservoir water levels (obtained from BC Hydro (Den Biesen, pers. comm. 2020)) for the years during which field surveys were conducted (2019 and 2020). Temperatures and precipitation during the two survey years were compared to averages for the last ~40 years. Reservoir water elevations during the two field survey years (2019 and 2020) were related to amphibian breeding periods to assist with the interpretation of results from amphibian breeding and habitat assessment surveys.

2.4.2. Survey Sites

A total of 51 survey sites ("sites") were established in the field, 37 in the UCR and 14 in the LCR (Map 2, Map 3, Map 4). Survey sites were established in both Drawdown Zone Habitats (28 and 10 in the UCR and LCR, respectively) and Reservoir Shoreline Habitats (9 and 4 in the UCR and LCR, respectively). Survey sites in Drawdown Zone Habitats were selected from those identified during desktop mapping and used for modeling (sections 2.2 and 2.3). About half of the identified Drawdown Zone Habitats in both reservoirs were selected as survey sites. Survey sites in Reservoir Shoreline Habitats were selected in the field. Survey sites in both habitat types were chosen based on accessibility and known or apparent suitability for amphibian breeding (e.g., survey sites in Reservoir Shoreline Habitat were established in shoreline areas of reservoirs with low gradient and anchoring substrate such as emergent vegetation). In both habitat types, survey sites were chosen to target habitats representing a variety of environmental characteristics and were considered likely to provide valuable amphibian breeding habitat. Locations (UTMs) were recorded for each survey site.

2.4.3. Amphibian Breeding Surveys

Amphibian breeding surveys ("breeding surveys") were conducted at survey sites selected within Drawdown Zone and Reservoir Shoreline habitats in the UCR and LCR. For each survey site, data were collected to document species/life stage presence, timing of breeding, and developmental progress (by collecting species-specific presence/not detected data for breeding adults, eggs, larvae, and other life stages throughout the breeding season). Results of breeding surveys were also related to habitat characteristics (see Section 2.4.4). Both positive (amphibians present) and negative (amphibians not detected) data were recorded. For some comparisons, amphibian observations were categorized into those definitively associated with breeding (breeding records) and those not necessarily associated with breeding (non-breeding records). For classification into breeding and non-breeding records, for all species except Western Toad, the presence of eggs or larvae were considered breeding records (signifying definitive evidence of breeding in the location detected), and adults and metamorphs were not considered breeding records because these life stages are mobile and can be found in locations where breeding did not occur. For Western Toad, metamorphs and juveniles were also considered breeding records in addition to eggs and larvae and only adults were not considered breeding records because Western Toad metamorphs and juveniles are unlikely to move far from their natal ponds (COSEWIC 2002a) (note that in no cases were juvenile Western Toads observed at a pond where egg masses and/or larvae were not also observed).

Breeding surveys were timed to coincide with the expected breeding periods of the aquatic-breeding amphibian species that occur in the area. Visits were scheduled to primarily target the egg stage (deposition and development) but also continued at reduced frequency with the aim of extending to the metamorphosis of larvae to terrestrial juveniles. Surveys were conducted between March 13 and August 9 in 2019 and between March 17 and August 13 in 2020. In addition to survey data collected during breeding surveys at survey sites, incidental observations of amphibians of all life stages were recorded, georeferenced, and photographed (including activity, age class and sex if known), as time permitted.

Two types of breeding surveys (systematic and rapid) were used to achieve a balance between the number of surveys and level of effort and detail. These are described below.

2.4.3.1. Systematic Breeding Surveys

Systematic breeding surveys were conducted over multiple site visits per season and involved selecting an area within a survey site and surveying this area ("survey area") following provincial protocols for pond breeding amphibians (RIC 1998a). Survey areas were chosen as optimal areas for breeding (e.g., shallow, south-facing areas with anchoring substrate, which maximized the likelihood of detection and survey efficacy) and to reflect the habitat characteristics for which the site had been selected. Effort during systematic breeding surveys were limited to a maximum of one hour per survey site to ensure that the field visitation schedule for all survey sites could be maintained. Less time was spent at survey sites that were relatively small or lacked complexity.

Systematic breeding surveys were initiated prior to the first field visit by selecting the survey area and survey start point using maps, aerial photographs, and results of previous work if available. If necessary, pre-selected survey areas and survey start locations were modified during the first field visit or throughout the season to ensure that surveys occurred in optimal habitat. The areas initially surveyed were resurveyed as closely as possible when surveys were repeated at a site within the season.

A minimum of two surveyors experienced in amphibian identification and handling conducted each survey. A provincial general wildlife live capture and release permit was obtained so that amphibians could be handled for identification and/or training purposes (Permit #NA19-461655; FLNRORD 2019). However, amphibians were handled only when necessary, for identification (captured with dip nets), and at such times provincial standards (RIC 1998b) were followed, including the Interim Standard Operating Procedure for Hygiene Protocol for Amphibian Field Staff and Researchers (MOE 2008) and Federal Animal Care Standards (CCAC 2004). Captured individuals were released immediately back into the same location. Care was taken to not handle or dislodge eggs from attachment sites.

Surveys were conducted using methods best suited for the conditions (e.g., wading in shallow water, use of mask and snorkel in deep water or where vegetation limits visibility) in the aquatic portion of the shoreline (from the water's edge to approximately 2 m deep) (RIC 1998a). Within this area, surveyors visually searched the water column and substrate for amphibians as they moved systematically forward, parallel to the shoreline. Moist shoreline habitats were also scanned for potential congregating adults, and any areas dewatered since the previous visit were scanned for evidence of egg stranding (although these would be difficult to detect due to high likelihood of desiccation and/or predation). Numbers of each developmental stage (eggs, tadpoles/larvae, toadlets, and adults) were counted or estimated for each species detected. When large numbers of individuals of a developmental stage were observed in one location (>10 individuals for eggs, tadpoles, metamorphs and juveniles), numbers were estimated. Estimates were made by counting individuals within a defined area (e.g., number of eggs on a given length of strand; number of eggs within one egg mass; tadpoles within a given area of the pond), then extrapolating to the area of occupancy (e.g., to the entire egg strand; to the total number of egg masses counted; to the total area of the pond occupied by tadpoles at approximately the same density). To estimate numbers of Western Toad eggs (which are laid in strands that can get intertwined with those of other females), "female layings" were estimated (analogous to egg masses) from the numbers of female toads present. Given these methods, large numbers of eggs, tadpoles, and juveniles should be taken as rough order of magnitude estimates only (similar to categorical estimates of abundance). Adults were classified as amplexed, not amplexed, or unknown, and were individually counted unless there were large numbers within the water column, in which case numbers were estimated. However, estimates of numbers of adults were considered relatively accurate. Start and end times were recorded for each survey. Photographs of habitat and developmental stages were taken. Habitat data, including detailed data on the location and condition of breeding occurrences, was recorded so that amphibian breeding data could be associated with habitat characteristics (see Section 2.4.4).

2.4.3.1. Rapid Breeding Surveys

The objective of rapid breeding surveys was to determine status and timing of breeding and therefore involved documenting breeding occurrences in a systematic manner while collecting less detailed information than for systematic breeding surveys. Optimal areas for breeding were also targeted (as described for systematic breeding surveys above), and the same data were recorded for individual amphibian detections; however, the time spent during the assessment was not predefined and effort varied by site based on site-specific objectives (e.g., determination of breeding status, evaluation of occupancy, verification of habitat type). Effort, areas searched, and search start and end times were recorded.

2.4.4. Amphibian Habitat Assessments

Attributes of amphibian breeding habitat were characterized at two scales: 1) broad scale (site level), which refers to the survey site as a whole; and 2) fine scale (microsite level), which refers to the individual breeding occurrences or groups of occurrences. Broad scale habitat assessments were conducted at all survey sites visited; however, fine scale habitat assessments were only conduced when amphibian breeding was documented. Similar to amphibian breeding surveys (Section 2.4.3), two types amphibian habitat assessments were conducted when habitat was characterized at the broad scale, systematic and rapid. These differed in their objectives (amount of detail desired) and therefore in the amount of detail recorded (see Section 2.4.4.1 below). Rapid assessments were conducted at least once at all survey sites, and at least one systematic survey was also conducted at approximately 25% of these sites. Amphibian habitat assessments were conducted in 2019 and 2020, concurrent with amphibian breeding surveys (see Section 2.4.3 for survey dates).

2.4.4.1. Broad Scale Habitat Assessment

Broad scale habitat characteristics were recorded for each survey site during systematic and rapid habitat assessments, with data collection differing by type of assessment (Table 4). Habitat characteristics that did not change over the breeding season were assessed only once per year (e.g., vegetation characteristics, presence of American Beaver (*Castor canadensis*) activity, amount of coarse woody debris (CWD) cover) and habitat characteristics that changed over the season (e.g., water temperature and water depth of the survey area) were recorded during each visit. Reservoir elevations were obtained for each visit from publicly available hydrometric data (Government of Canada 2021).

Broad scale habitat characteristics were qualitatively compared among survey sites where breeding was detected (breeding sites) and not detected (non-breeding sites) for all species combined and for individual species. Average water temperature and water depth, which change across the season, were compared between breeding and non-breeding sites for the period between April 21 and April 25 because many sites were surveyed in both years during this period.

Table 4. Broad scale (site level) habitat characteristics recorded during systematic and rapid assessments.

Parameter	Data Collection Approach			Measurement Unit or Categories	Method
	Systematic Assessment		Rapid Assessment		
	Once per Year	Each Visit			
Metadata (site name, UTM coordinates, date, time, surveyors, weather, location, comments)		x	x	n/a	
Habitat	x		x	Shallow Pool, Small Lake, Small Bay, Large Bay, Other[1]	Classification
Reservoir elevation at time of survey		x	x	Meters (m)	Derived from publicly available hydrograph for time of survey[2]
Water depth of survey area		x	x	Measured maximum depth and estimated average depth (m) of the area within the pond that was surveyed	Measured
Water temperature		x	x	°C	Measured
Shoreline vegetative cover (by vegetation category)	x		x	Percent vegetation (0 (0%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (>75%)); species and structure described	Classification; description
Submerged and Emergent/aquatic vegetation cover and type	x		x	Percent vegetation (0 (0%), 1 (1-5%), 2 (5-25%), 3 (25-50%), 4 (50-75%), 5 (>75%)); vegetation type (e.g., graminoids, low shrubs); dominant species and structure described	Classification; description
Coarse woody debris (CWD) cover	x		x	Category of cover (high (>50%), medium (10-50%), low (10%), none (0%)); size described	Classification; description
Surface substrate			x	Category of surface substrate (organic matter, mineral soil, decaying wood, fines, gravel, cobble, boulder, bedrock; dominant, subdominant, trace)	Classification of type; classification of dominance
Organic substrate material presence and depth	x			Category of organic substrate (high (>50 cm organics), medium (>5-50 cm organics), low (>0-5 cm organics), none (no organics))	Classification

Table 4. Continued.

Parameter	Data Collection Approach			Measurement Unit or Categories	Method
	Systematic Assessment		Rapid Assessment		
	Once per Year	Each Visit			
Vegetation community (TEM)	x		x	Vegetation community classification (e.g., hairgrass-water sedge, spearwort lakeflat, Sitka willow- water sedge, unvegetated shoreline, hardhack-Sitka sedge)	Derive from JHTMON-10[3] vegetation community classification
Exposure (insolation)	x		x	Category of exposure (full sun, partial sun, full shade)	Classification
Predatory fish exposure		x		Yes or no	Classification
Beaver activity		x	x	Yes or no	Classification
Shoreline slope	x			Category of percent slope (high (>15%), medium (6-15%), low (0-5%))	Classification
Wave action (fetch)	x			Category of wave action (high, medium, low, none; categorized relative to minimum and maximum potential wave action observed across the survey sites)	Classification
Distance to forest cover	x			Category of distance (high (>200 m), medium (>50 m), low (>10 m), none (0-10 m))	Classification
Water source	x			Category (precipitation, seep, stream, sub-irrigation, flood, etc.)	Classification
Berm height[4]	x			Meters (m)	Estimation

[1] Small lake - >200 m diameter, with mineral soil substrate and aquatic vegetation; Large bay - ~>100 m across; Small bay - ~<100 m across; Shallow pool – pond ~< 200 m in diameter.

[2] https://wateroffice.ec.gc.ca/report/real_time_e.html?mode=Graph&type=&stn=08HD033&startDate=2018-09-05&endDate=2018-10-02&prm1=46&y1Max=&y1Min=&prm2=-1&y2Max=&y2Min=).

[3] Ballin *et al.* 2015.

[4] Height of land between the pond and the reservoir, as measured from the pond surface.

2.4.4.2. Fine Scale Habitat Assessment

When amphibians of any life stage were documented during breeding surveys, habitat characteristics were recorded at the scale of the microsite or breeding occurrence. Table 5 presents the fine scale habitat characteristics that were recorded. Among these, water depth of breeding occurrences (or group of occurrences) and in the location of breeding occurrences were most relevant to interactions with reservoir water level fluctuations and these metrics were analyzed in relation to amphibian species and year.

Table 5. Fine scale habitat characteristics assessed at the breeding occurrence scale.

Parameter	Measurement Unit or Categories
Water depth of breeding occurrence (i.e., depth of egg mass/larvae in water column)	Meter (m)
Water depth at location of occurrence (i.e., water depth of water body in location of breeding occurrence)	Meter (m)
Location relative to shoreline	Location category (e.g., in shallow water, along the shoreline)
Substrate/attachment/position	Attachment, substrate, and/or position category for breeding occurrences (e.g., on woody debris, attached to vegetation, under rock, within water column)
Water temperature	°C
Aspect	Degrees (°)

3. RESULTS

Amphibian habitat mapping, modeling, and field survey results are presented in the sections below. Desktop mapping was used to identify Drawdown Zone Habitat (ponds) for each study area (Section 3.1), and modeling was conducted using WUP water level data to assess potential habitat availability (number of ponds and habitat area) by elevation band and to characterize Drawdown Zone Habitats through amphibian effects metrics calculated by elevation band for amphibian species-specific egg and larval periods (Section 3.2). These analyses addressed management questions related to the locations of Drawdown Zone Habitats and the potential impacts of reservoir water level fluctuations. Results from field surveys (Section 3.3) were used to inform modeling and addressed management questions related to breeding habitat use by amphibian species for both Drawdown Zone and Reservoir Shoreline habitats.

3.1. Amphibian Habitat Mapping

All Drawdown Zone Habitats (ponds) selected during mapping along with their identification numbers, elevations, and surface areas, are listed in Appendix B. In total, 363 ponds were mapped by BC Hydro and Ecofish within the defined elevational boundaries, of which 334 were associated with the UCR and 36 with the LCR.

3.2. Amphibian Habitat Modeling

3.2.1. Locations, Sizes, and Permanence of Drawdown Zone Habitats

Of the 334 Drawdown Zone Habitats (ponds) mapped in the UCR study area (Section 3.1), most occurred within the 215.5 and 216.5 mASL elevation bands (over 90 ponds were identified in each of these two elevation bands; Figure 3) and most (89%) were classified as ephemeral (Table 6). About 62% of the surface area of all identified ponds in the UCR was within ponds classified as permanent (Figure 3); however, one large 102,000 m^2 pond situated at the 216.0 mASL elevation band accounted for 70% of the surface area of permanent ponds. Without this one large permanent pond, permanent pond surface area (44,129 m^2) was approximately half of ephemeral pond surface area (91,247 m^2). Permanent ponds were more evenly distributed across the elevational range of the drawdown zone in the UCR than ephemeral ponds, but none were located at or below 215 mASL. More ponds in the UCR study area were adjacent to Buttle Lake (253) than adjacent to Upper Campbell Lake (107) (Map 2, Map 3, Map 4).

Fewer ponds were identified in the LCR study area than the UCR study area, and these accounted for less surface area (Table 6). Similar to results for the UCR, ponds classified as ephemeral were more common (75% of ponds) than permanent ponds. Most occurred in the 176 mASL elevation band (Figure 4). Ephemeral ponds averaged 1,400 m^2 in size, with the largest (total surface area of 18,000 m^2) located within the 175.5 mASL elevation band. Few permanent ponds (9 in total) were identified; these had an average area of 7,000 m^2. The majority of the habitat (by surface area) accounted for by permanent ponds in the LCR is located above 177.5 mASL elevation band (Table 6, Figure 4). For all ponds combined, most ponds were located in the mid-ranges of the drawdown zone elevations, but most habitat (by surface area) was found in the upper elevations of the reservoir (55% of the total habitat area is in the 177.5 to 178 mASL elevation bands).

Overall, substantially more potential amphibian Drawdown Zone Habitat was identified in the UCR than the LCR study area by numbers of ponds (90% of 370 ponds) and by area (70% of 337,860 m^2 total area). In both study areas combined, most identified ponds were classified as ephemeral (88% of 370 ponds), but more habitat (by surface area) was accounted for by permanent ponds (62% of 337,860 m^2 total area) than ephemeral ponds. Thus, assuming that all identified Drawdown Zone Habitats are suitable amphibian habitat, there was about 2.4 times as much potential habitat available, across all elevations, in the UCR than the LCR and, for both reservoirs combined, there was about

1.6 times as much permanent habitat as ephemeral habitat. In general, the UCR study area contained many ponds that were small (<1 ha) and the LCR contained fewer but larger ponds. The average size of all ponds in the UCR was 711.6 m^2 and the average size of all ponds in the LCR was 2,782 m^2.

Figure 3. Numbers and area (ha) of ephemeral and permanent Drawdown Zone Habitats (ponds) by elevation band in the Upper Campbell Reservoir study area.

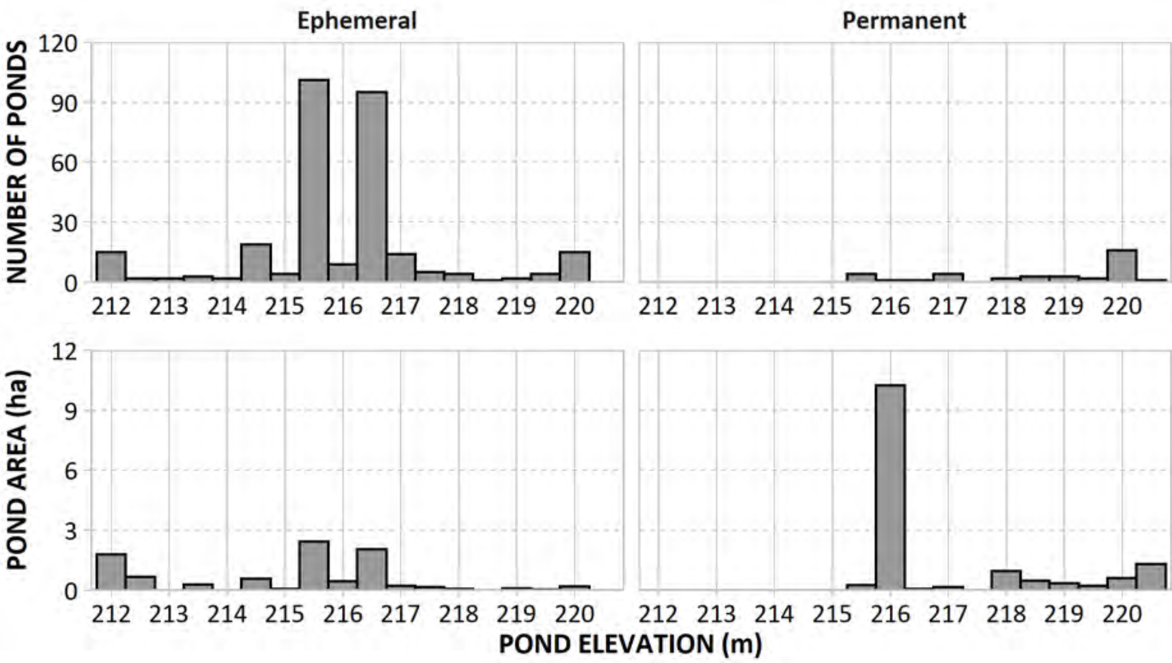


Figure 4. Numbers and area (ha) of ephemeral and permanent Drawdown Zone Habitats (ponds) by elevation band in the Lower Campbell Reservoir study area.

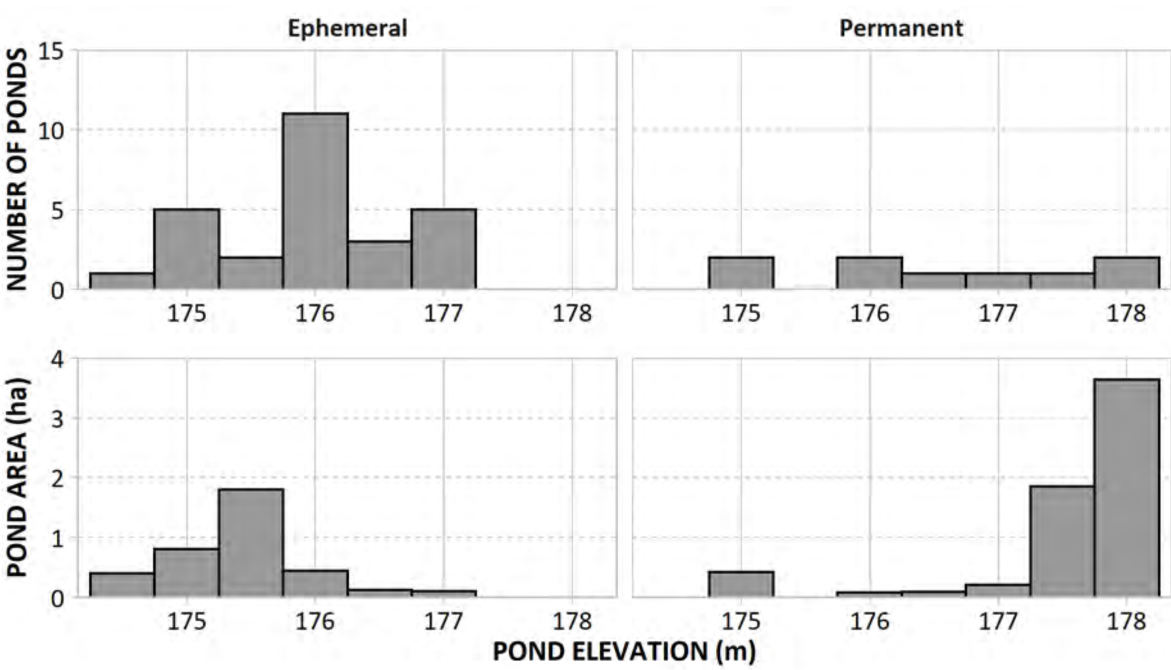


Table 6. Numbers and area (m^2) of ephemeral and permanent Drawdown Zone Habitats (ponds) by elevation band in the Upper Campbell Reservoir and Lower Campbell Reservoir.

	Number				Area (m^2)			
Elevation	Ephemeral	Permanent	Total	Cumulative Total	Ephemeral	Permanent	Total	Cumulative Total
Lower Campbell Reservoir								
178		2	2	36		36,347	36,347	100,184
177.5		1	1	34		18,589	18,589	63,837
177	5	1	6	33	1,109	2,107	3,216	45,248
176.5	3	1	4	27	1,285	1,004	2,289	42,032
176	11	2	13	23	4,456	912	5,368	39,743
175.5	2		2	10	18,030		18,030	34,375
175	5	2	7	8	8,089	4,238	12,327	16,345
174.5	1		1	1	4,018		4,018	4,018
Lower Campbell Reservoir Total	*27*	*9*	*36*		*36,987*	*63,197*	*100,184*	
Upper Campbell Reservoir								
220.5		1	1	334		13,025	13,025	237,676
220	15	16	31	333	1,903	5,981	7,884	224,651
219.5	4	2	6	302	437	2,261	2,698	216,767
219	2	3	5	296	940	3,528	4,468	214,069
218.5	1	3	4	291	184	4,749	4,933	209,601
218	4	2	6	287	594	9,714	10,308	204,668
217.5	5		5	281	1,651		1,651	194,360
217	14	4	18	276	2,248	1,660	3,908	192,709
216.5	95	1	96	258	20,341	633	20,974	188,801
216	9	1	10	162	4,501	102,300	106,801	167,827
215.5	101	4	105	152	24,423	2,578	27,001	61,026
215	4		4	47	685		685	34,025
214.5	19		19	43	5,638		5,638	33,340
214	2		2	24	163		163	27,702
213.5	3		3	22	2,760		2,760	27,539
213	2		2	19	123		123	24,779
212.5	2		2	17	6,598		6,598	24,656
212	15		15	15	18,058		18,058	18,058
Upper Campbell Reservoir Total	*297*	*37*	*334*		*91,247*	*146,429*	*237,676*	

3.2.2. Impacts of Water Level Fluctuations on Drawdown Zone Habitats

Modeling results for amphibian effects metrics (defined in Section 2.3.2) used to evaluate effects pathways of inundation and desiccation (see Section 1.3) of Drawdown Zone Habitats are presented below. These metrics are presented graphically and in table format in relation to species-specific egg and larval periods and elevation band. All amphibian effect metrics are shown graphically in Appendix C, and graphical depiction of the probability of inundation is also presented in Section 3.2.2.1. Bar graphs in Appendix C show the probability of an event happening (note that probabilities are shown by the height of grey bars and that this is overlaid over a pond frequency histogram, i.e., the number of permanent and ephemeral ponds by pond surface elevation), and line graphs in Appendix C show the time scale across which these events may occur. Results are also presented in table format by amphibian species and life stage, for each elevation band, in Appendix D (note that Appendix D shows the probability of non-inundation which is the inverse of the probability of inundation). It should be kept in mind that although all metrics were generated for all species using the entire set of Drawdown Zone Habitats (ponds) identified during mapping, modeling does not account for variability in the intrinsic suitability of pond habitats; factors other than interaction with reservoir water levels will also affect habitat suitability (see Section 2.3.3).

3.2.2.1. Probability of Inundation

Probability of inundation was strongly related to elevation of the Drawdown Zone Habitat in both reservoirs, with ponds at low elevations having higher probabilities of inundation than those at high elevations during all time periods (Appendix C, Appendix D). For example, Drawdown Zone Habitats above about 218 mASL in the UCR generally had a relatively low probability of becoming inundated throughout the year (Figure 5). In the UCR, the probability of inundation also varied across the season for all elevation bands (Figure 5), with a decrease in spring (early April to mid-May), an increase in the summer, and a decrease again in the late fall (November). Probability of inundation varied less over the breeding season in the LCR than the UCR (Figure 6), in accordance with less variable reservoir water levels (Figure 2).

The probability of inundation during egg and larval periods must be considered separately for each amphibian species given differing breeding phenologies. For most Drawdown Zone Habitats in the UCR, there was a low probability of inundation early in the egg period but the overall probability of inundation within the egg period depended on the duration of the egg period along with the elevation of the potential habitat (Figure 5). The probability of inundation of Drawdown Zone Habitat remained relatively low across most elevations for most species' egg periods, especially for species with brief and early egg periods, such as Long-toed Salamander, Northwestern Salamander, and Northern Red-legged Frog. For species with longer egg periods, such as Northern Pacific Treefrog, Roughskin Newt, and Western Toad, there was an increasing probability of inundation towards the end of their extended egg periods. In general, there was a high probability of inundation during the larval stages for all species, although this probability was lowest for the upper parts of the UCR drawdown zone (Figure 5).

Table 7 and Table 8 identify elevation bands where Drawdown Zone Habitat was wetted by the reservoir at some point in time, in at least half of years, during each species-life stage time period. As shown in Table 7, habitats were inundated at some point at least 50% of the time during all amphibian egg and larval periods at or below 217.0 mASL in the UCR. In comparison, potential habitat was inundated at least 50% of the time for the egg and larval period for most species up to the 177 mASL level in the LCR (Table 8).

Figure 5. Probability of inundation by elevation band across the year for Drawdown Zone Habitats, in the Upper Campbell Reservoir, during the egg and larval periods of amphibian species.

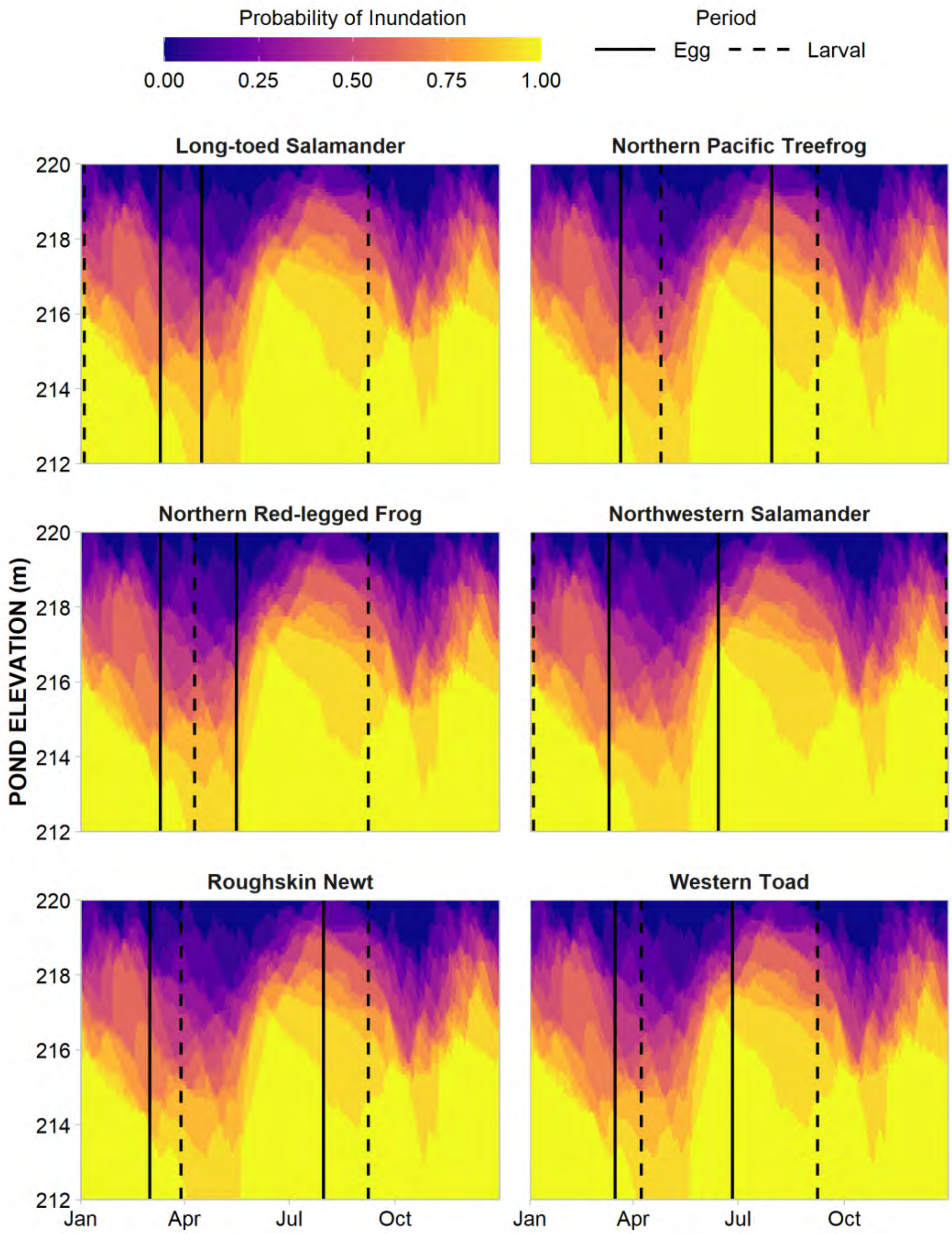


Figure 6. **Probability of inundation by elevation band across the year for Drawdown Zone Habitat, in the Lower Campbell Reservoir, during the egg and larval periods of amphibian species.**

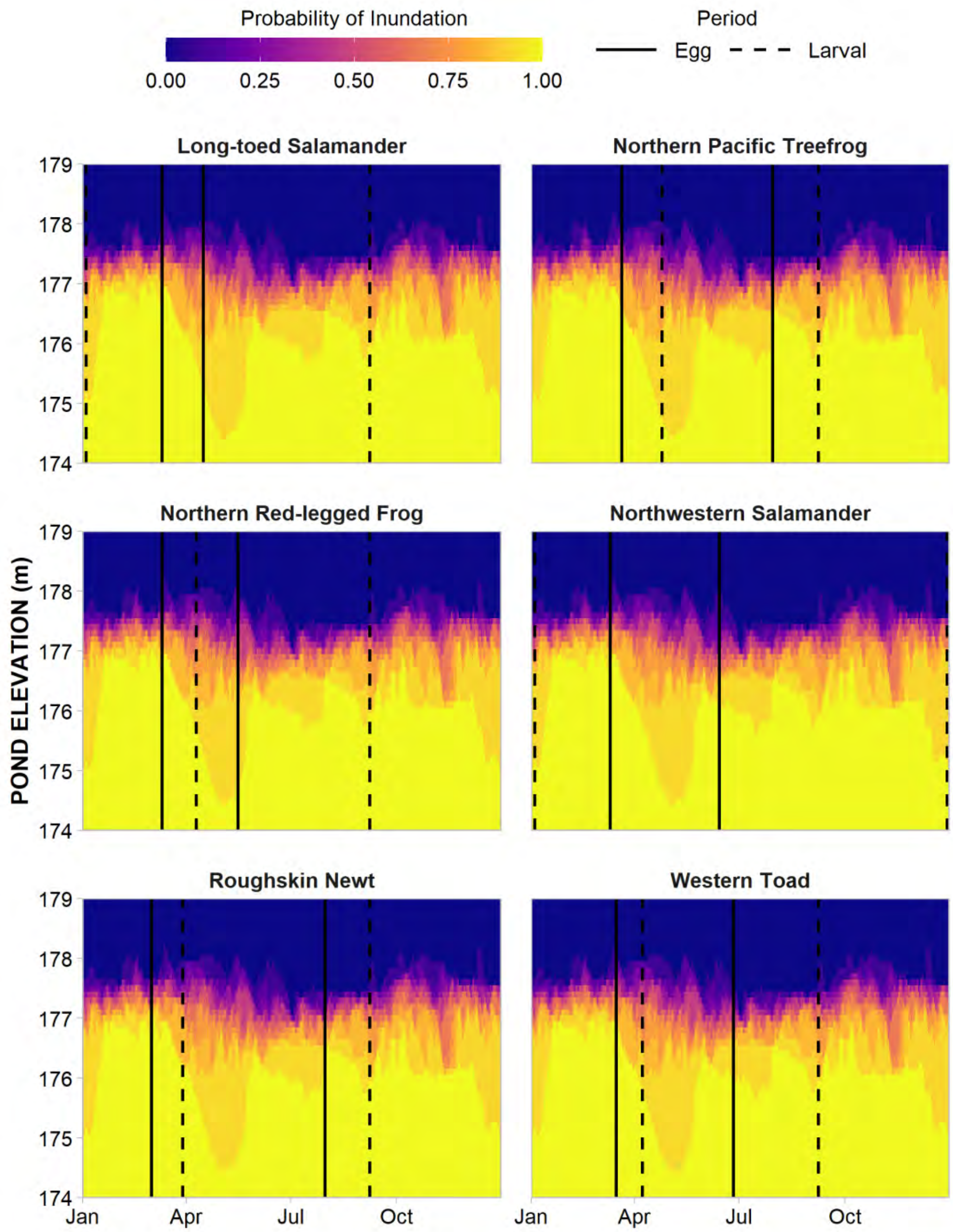


Table 7. Elevation bands for which the probability of inundation was ≥50% at some point during the egg or larval periods of amphibian species in the Upper Campbell Reservoir.

Species[1]	Age Class	Elevation Band (m)																
		212.0	212.5	213.0	213.5	214.0	214.5	215.0	215.5	216.0	216.5	217.0	217.5	218.0	218.5	219.0	219.5	220.0
LTSA	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-
NPTF	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-
NRLF	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-
NWSA	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50
RSNE	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-
WETO	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-

[1]LTSA = Long-toed Salamander; NPTF = Northern Pacific Treefrog; NRLF = Northern Red-legged Frog; NWSA = Northwestern Salamander; RSNE = Roughskin Newt; WETO = Western Toad

Table 8. Elevation bands for which the probability of inundation was ≥50% at some point during the egg or larval periods of amphibian species in the Lower Campbell Reservoir.

Species[1]	Age Class	Elevation Band (m)										
		174.0	174.5	175.0	175.5	176.0	176.5	177.0	177.5	178.0	178.5	179.0
LTSA	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
NPTF	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-	-
NRLF	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
NWSA	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-
RSNE	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
WETO	Eggs	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-
	Larvae	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	≥ 50	-	-	-

[1]LTSA = Long-toed Salamander; NPTF = Northern Pacific Treefrog; NRLF = Northern Red-legged Frog; NWSA = Northwestern Salamander; RSNE = Roughskin Newt; WETO = Western Toad

3.2.2.2. Probability of Non-inundation

The probability of non-inundation is the probability that a given elevation band will be exposed (isolated from the reservoir) during a specific amphibian species egg or larval period. This metric is the inverse of the probability that Drawdown Zone Habitats in the elevation band will be inundated (probability of inundation) and therefore also directly reflects seasonal reservoir water level fluctuations. Thus, patterns observed for probability of inundation by species and life stage (described in Section 3.2.2.1) also apply to probability of non-inundation, although in reverse.

3.2.2.3. Probability of Transitioning from Inundated to Exposed

In the UCR, the probability that inundated Drawdown Zone Habitats become exposed (isolated from the reservoir) at some point during the egg period ranged from about 10% to 40% depending on species and site elevation (Figure 3 of Appendix C, Appendix D). In general, this probability was greatest at mid-elevations in the drawdown zone (e.g., 216.5 to 218 mASL). The probability of transitioning from inundated to exposed was also higher for larval periods than egg periods for species with long larval periods (Long-toed Salamander and Northwestern Salamander). For other species, with larval periods that coincide with rising water levels, this probability was generally slightly lower.

A similar pattern in the probability of transitioning from inundated to exposed during the egg periods of the six amphibian species was documented for the LCR (Figure 4 of Appendix C). Potential habitats at and below 176 mASL tended to remain inundated throughout the egg period, those at and above 178 mASL generally remained exposed, and those at mid-elevations (176.5 to 177.5 mASL) had the greatest probability of transitioning from inundated to exposed (21% to 93%; Appendix D).

The timing of transitioning from inundated to exposed varied widely for species, period, reservoir, and position within drawdown zone (Figures 7 and 8 in Appendix C, Appendix D). The line graphs in Figures 7 and 8 of Appendix C show that habitat may transition from inundated to exposed (i.e., be de-watered by the reservoir) at any point between the minimum (earliest; purple point) and maximum (latest; green point) dates. When low elevation Drawdown Zone Habitats in the UCR became exposed, this occurred later in the season (Figure 7 in Appendix C, Appendix D). For the larval periods, there was a longer period (broader range of dates) across which habitat could transition to being exposed at most elevations than for egg periods because larval periods extend later into the season when reservoir water levels are dropping. Higher elevations tended to be associated with earlier maximum dates for exposure (i.e., high elevation habitat became exposed earlier than low elevation habitat).

The timing of the transition from inundated to exposed showed a similar pattern in the LCR (Figure 8 in Appendix C, Appendix D). Drawdown Zone Habitats in elevation bands between 176 and 177.5 mASL tended to have a relatively broad period over which habitat transitioned from inundated to exposed during the egg and larval periods (i.e., the dates of transition varied widely). Habitats at elevations above and below this range tended to rarely transition from inundated to exposed because at low elevations, exposure was less likely to occur regardless of previous inundation and at high elevations inundation was less likely to occur.

3.2.2.4. Probability of Transitioning from Exposed to Inundated

The probabilities of exposed Drawdown Zone Habitats becoming inundated during breeding periods are shown graphically in Figures 5 and 6 of Appendix C, and in table format in Appendix D (expressed as the % of years). This probability differed from the inundation metric explored in Section 3.2.2.1 because the habitat had to be exposed prior to being inundated. There was a greater probability of habitat transitioning from exposed to inundated for species with longer egg and larval periods. This probability was greatest through the mid-elevations where water levels tended to increase at some point during egg and larval periods. This probability was low for low elevation bands because these were more continuously inundated. This probability was also low for higher elevation bands because water levels were less likely to reach these elevations. Patterns were broadly similar between the UCR and the LCR, but the probability of transitioning from exposed to inundated was limited to a narrower mid-elevation band within the LCR drawdown zone. In the UCR, the probability that inundated Drawdown Zone Habitats became inundated at some point during the egg period ranged from about 5% to 70% depending on species and site elevation (Figure 5 of Appendix C, Appendix D), and in the LCR, probabilities ranged from about 15% to 40% (Figure 6 of Appendix C, Appendix D.

The timing of the transition from exposed to inundated is shown in Figures 9 and 10 in Appendix C, and in Appendix D. The transition tended to occur earlier in the season in the UCR than the LCR. Generally, inundation of exposed habitat was later at higher elevations. Variation in timing occurred at mid-elevations where water levels commonly fluctuated throughout the egg and larval periods. For species such as Northern Red-legged Frog that have short egg periods, there was reduced opportunities for inundation of exposed habitat to occur. For most species and life stages, the timing of transitions in the UCR was highly variable between the elevations of 214 and 218 mASL. There was less variability among species and life stages in the transition from exposed to inundated in the LCR compared with the UCR, due to the lower range of variation in water levels in the LCR.

3.3. Field Surveys

3.3.1. Environmental Conditions

Weather and climatic conditions differed in 2019 and 2020 which influenced amphibian breeding survey and habitat assessment results. As evident in Figure 7, temperature and precipitation were typical in 2020 (similar to average) but 2019 was unusually cold and dry during winter and spring. This resulted in lower than usual reservoir recharge (filling of the reservoir following late winter low water levels; see Figure 1 and Figure 2). Water levels were at the lower targeted reservoir operating zones in 2019 (BC Hydro 2012) and they remained lower than average throughout the summer. Water levels were about 2 m to 3 m lower in 2019 than 2020 in the UCR throughout the amphibian breeding season for most species (Figure 8) and 1 m to 1.5 m lower in 2019 than 2020 in the LCR (Figure 9). In addition, water levels began to drop from their winter highs about a month earlier in 2019 than in

2020 in the UCR and decreased steadily by over 7 m until early April when the reservoir began to recharge.

In 2019, water levels in the LCR had a smaller maximum range than the UCR (compare Figure 8 and Figure 9). In both study areas, peak water levels occurred in the winter (mid-February to early March) and the fall (early October); however, water levels fluctuated to a greater extent in the LCR than the UCR. For example, the peak in October 2019 (about 1.4 m in magnitude) was much greater than the peak at that time in the UCR (about 0.4 m).

The superimposed species-specific amphibian egg and larval periods on reservoir water levels indicates that water levels were unusually low early in the egg period for most species in 2019 in both reservoirs (Figure 8 and Figure 9). Water levels recovered during the egg periods for those species with longer egg period, such as Roughskin Newt and Northern Pacific Treefrog, but remained low for all or most of the egg period for species that have early and short egg periods (e.g., Long-toed Salamander and Northern Red-legged Frog). Reservoir water levels increased or remained stable through most of the larval periods for most species.

Figure 7. **Temperature and precipitation for Campbell River, showing 2019, 2020 and 1981 – 2012 averages. Data from Environment Canada (2021).**

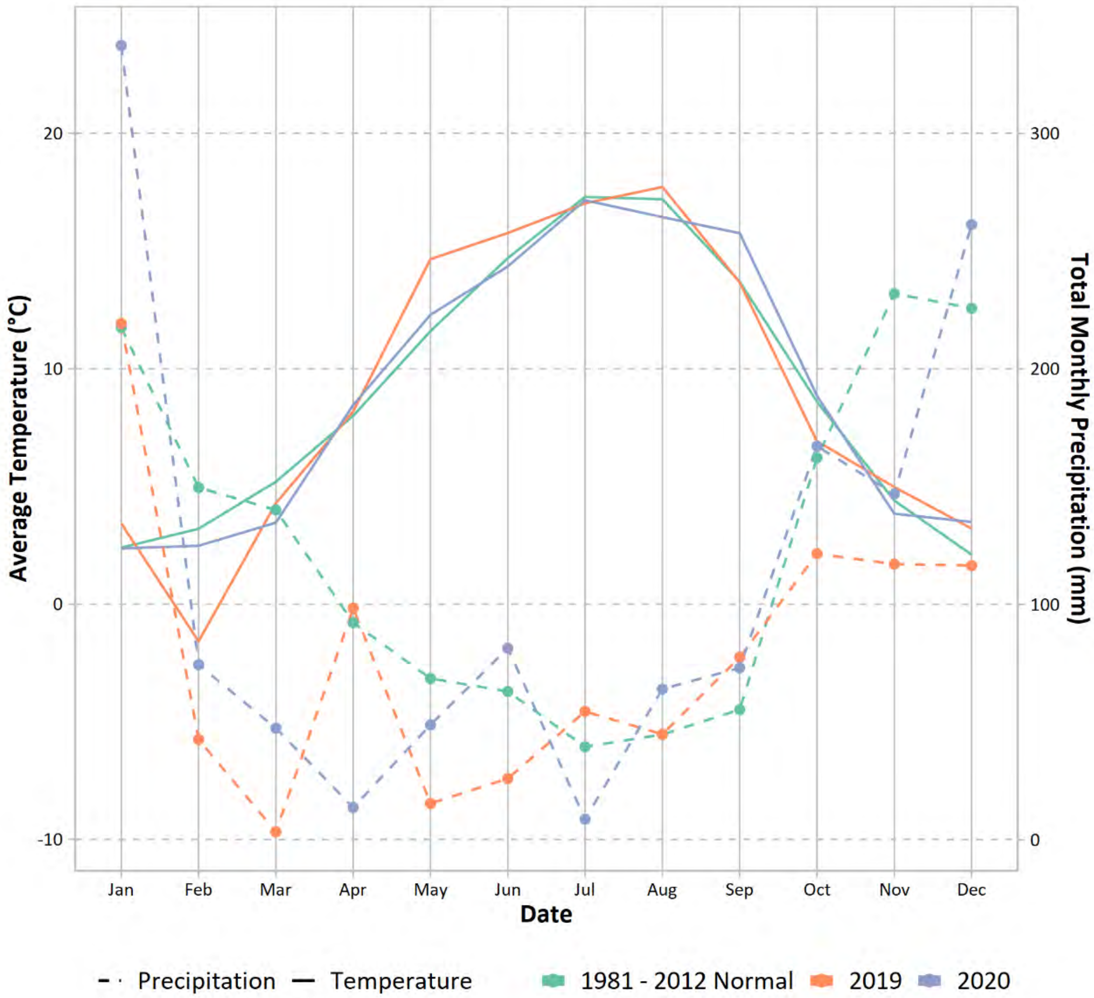


Figure 8. **Reservoir water levels in the Upper Campbell Reservoir in 2019 and 2020 in relation to the egg and larval periods of amphibian species.**

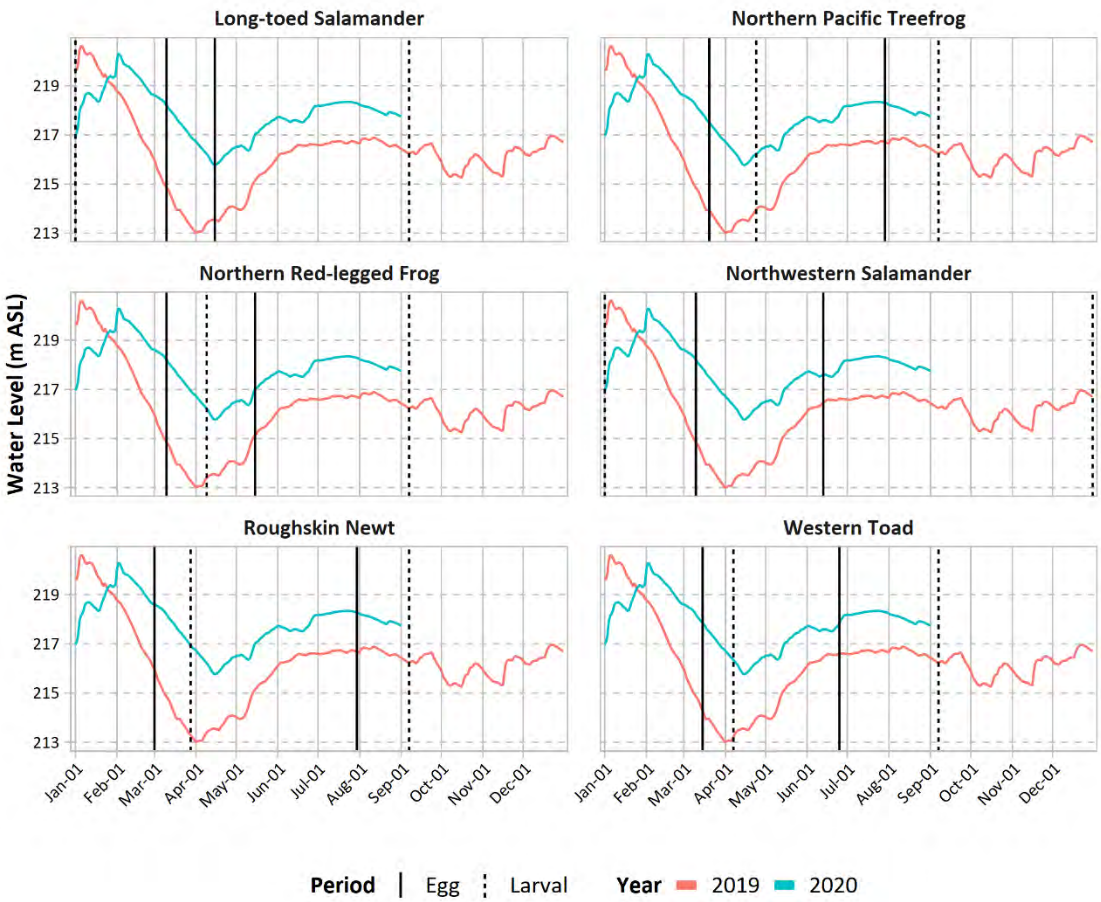
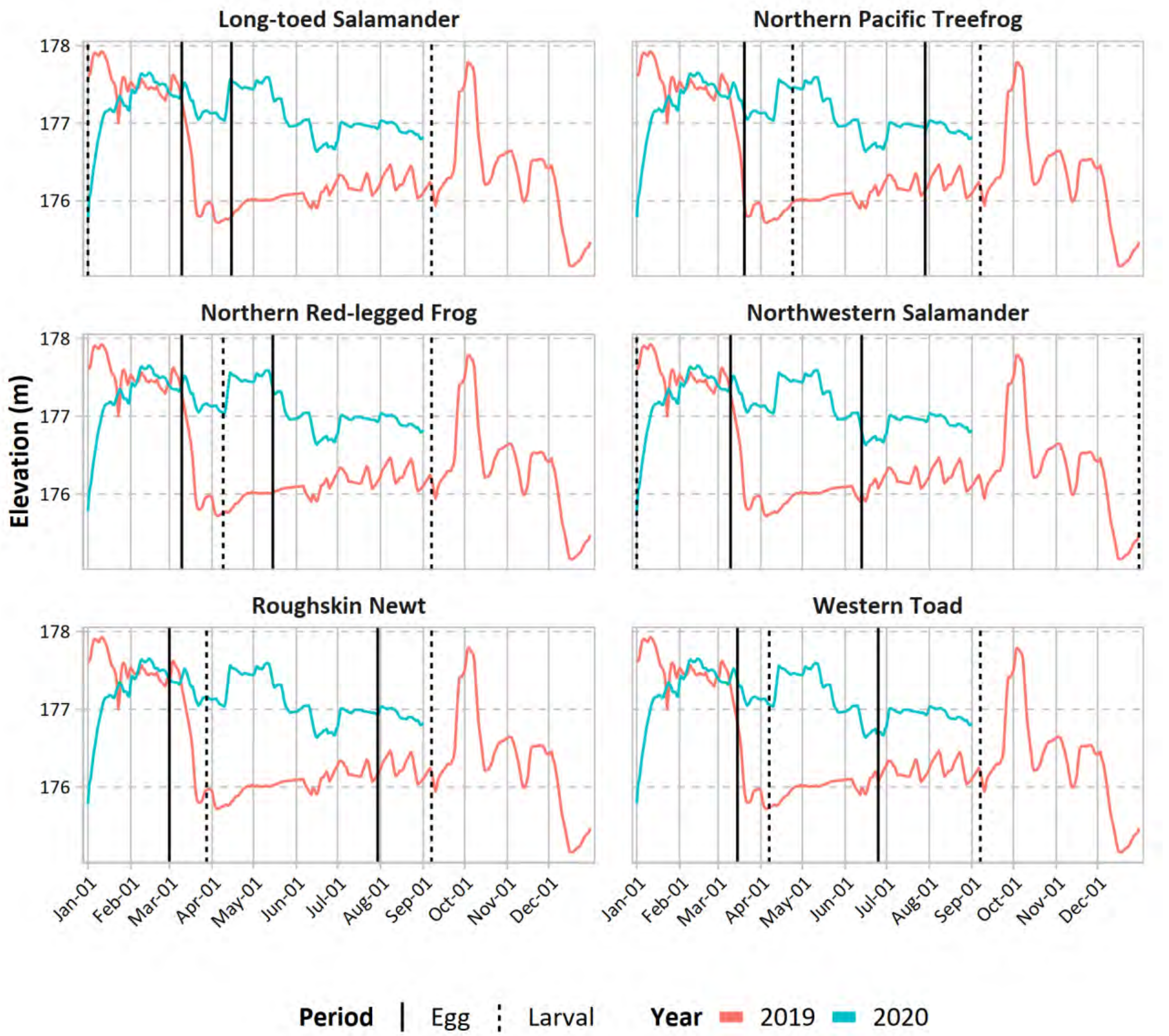


Figure 9. Reservoir water levels in the Lower Campbell Reservoir in 2019 and 2020 in relation to the egg and larval periods of amphibian species.



3.3.2. Amphibian Breeding Surveys

Results from amphibian breeding surveys are presented below, organized by occurrences and distribution and timing of breeding. Detailed results from amphibian breeding surveys (amphibian detections by survey site, year, life stage, and site visit), along with the field visitation schedule, are presented in Appendix E. Results from broad scale and fine scale habitat assessment, which was conducted coincident with breeding surveys, are presented in Section 3.3.3.

3.3.2.1. Species Occurrences and Distribution

Field survey data on amphibian species occurrences and distribution are presented in Map 2, Map 3, Map 4, and Appendix E. In addition, spatial characteristics of breeding observations are summarized by species in Table 9, and information on abundance of life stages recorded and size of Drawdown

Zone Habitats selected by amphibians are summarized in Table 10, Table 11, and Table 12. A comparison of elevations of ponds at which amphibian breeding was detected is presented by study area, species, and pond permanence in Figure 10.

During both years combined (2019 and 2020), amphibians were detected at 61% of the 51 sites surveyed (24 and 7 sites in the UCR and LCR, respectively) (Map 2, Map 3, Map 4, Appendix E). In total, breeding amphibians were detected in 14% of the Reservoir Shoreline Habitats (2 of the 14 sites) and 70% of the Drawdown Zone Habitats (26 of the 37 sites). The two occupied Reservoir Shoreline Habitat survey sites were JHT-PBA52S (where Western Toads were found) and JHT-PBA46S (where Northern Red-legged Frogs, Northwestern Salamanders, Northern Pacific Treefrogs, and Western Toad were found) (Map 2). Overall, amphibian breeding occurred at 20 sites in 2019 and at 22 sites in 2020.

Among amphibian species anticipated to be present, only Long-toed Salamanders were not detected. In general, the most abundant species (in terms of individuals counted; i.e., eggs, larvae, juveniles, and adults) was the Western Toad, followed by the Northern Pacific Treefrog (Table 10, Table 11). No Rough-Skinned Newt eggs or larvae were observed (only adults were found). Western Toad breeding was documented at the highest number of sites (19 sites, including 17 in the UCR and two in the LCR) (Map 2, Map 3, Map 4, Appendix E, Table 9). Northern Pacific Treefrog was confirmed breeding at 16 sites, Northwestern Salamander at seven, and Northern Red-legged Frog at three. Relatively few eggs and larvae were observed for Northern Red-legged Frog, and no larvae were observed for Northwestern Salamander.

Little difference in the abundance of amphibians was apparent between the two years of the study (Table 10, Table 11, Appendix E). For some species, observed numbers were higher in 2019 (Northern Red-legged Frog, Northwestern Salamander), whereas in others, numbers were higher in 2020 (Western Toad) or differed by life stage (Northern Pacific Treefrog). Although overall abundance was greater for Western Toad in 2020, the pattern was not consistent among sites (Appendix E). For example, abundance was greater in 2020 at some sites (especially at JHT-PBA09, but also at JHT-PBA03 and JHT-PBA19) but was greater in 2019 at other sites (e.g., JHT-PBA01, JHT-PBA11).

The locations of breeding sites differed among species (Map 2, Map 3, Map 4, Appendix E, Table 9). All documented Northern Red-legged Frog breeding sites (100%) and most Northwestern Salamander breeding sites (71%) were in the LCR, while most Northern Pacific Treefrog (63%) and Western Toad (89%) breeding sites were in the UCR. Virtually all (99% to 100%) of Western Toad eggs, larvae, metamorphs were found in the UCR, and most (81% to 93%) of all Northern Pacific Treefrog eggs and tadpoles were found in the UCR. Thus, although more sites were surveyed in the UCR (73% of all sites were in the UCR), higher numbers of individuals were still detected in the UCR than expected based on survey effort.

The number of species detected breeding at individual survey sites ranged from one to four. Only one species was found at 15 sites (i.e., in 54% of all sites where breeding was documented only one species was found). Two species were confirmed breeding at 10 sites, most of which were in the UCR and all of which were observed in Drawdown Zone Habitats (at most of these sites, the two species were Western Toad and Northern Pacific Treefrog). Three species were found at two sites (JHT-PBA22 and JHT-PBA20) and four species were found at one site (JHT-PBA46S), all within the LCR (Appendix E).

Both ephemeral and permanent Drawdown Zone Habitats were used by breeding amphibians and in similar proportions. Breeding was confirmed in 11 of 17 (66%) ponds classified as ephemeral and 14 of 20 (70%) ponds classified as permanent (Appendix E). However, use of ephemeral and permanent ponds differed by species. Western Toad and Northern Pacific Treefrog were found in similar numbers in ephemeral and permanent ponds, Northern Red-legged Frogs were found only in permanent ponds, and Northwestern Salamanders were found almost exclusively in permanent ponds (12 egg masses were identified in one ephemeral pond in the LCR (JHT-PBA70) in 2020, but this record may have represented a poor habitat choice by several individuals).

The four amphibian species detected breeding in the study areas also differed in their reuse of sites across years. Considering only sites surveyed in both years, the percentage of sites reused by Northern Pacific Treefrogs, Northern Red-legged Frogs, Western Toads, and Northwestern Salamanders were 25% (12 sites), 33% (three sites), 64% (14 sites), and 100% (5 sites), respectively (Appendix E).

Amphibians generally bred in ponds at similar elevations in 2019 and 2020, in spite of dramatically different reservoir water elevations in these two years early in the breeding period (Figure 10; see also elevation bands in which each species life stage was documented shown in Appendix D). The three documented Northern Red-legged Frog breeding sites, which were all permanent ponds, spanned from low to high elevations in the drawdown zone of the LCR. Northwestern Salamander breeding sites (also virtually all permanent ponds) also spanned the full range of elevations in the drawdown zone of the LCR in both years, but in the UCR, Northwestern Salamander breeding was detected only in two high elevation permanent ponds. Northern Pacific Treefrog breeding sites were found below ~218.5 mASL in the UCR and in the full range of elevations in the LCR; no difference was apparent in the elevations used for ephemeral ponds by this species between years in the UCR: all were below 217 mASL. In the LCR, Northern Pacific Treefrog used both high and low elevation ponds for breeding in 2019, whereas middle elevation ponds were used in 2020. However, middle elevation ponds had not been surveyed in 2019 due to time constrainsts, thus their use in this year is unknown. Western Toads bred in ponds at a variety of elevations in both years. Similar to Northern Pacific Treefrog, there was no apparent inter-annual difference in the elevation of ephemeral ponds used by Western Toads for breeding in the UCR (all were below 217 mASL), and the high elevation ponds used were permanent ponds (in the LCR, breeding was detected at only one permantent pond in both years). In summary, highest elevation ponds used for amphibian breeding generally were permanent ponds in both study areas, most ephemeral ponds used were in the lower elevations in the UCR, and in the LCR, only three of the ponds with amphibian breeding were ephemeral, and these were only surveyed in 2020.

Although there was no apparent difference in the elevations of the ponds within which amphibians bred in 2019 and 2020, reservoir water level elevations at the time of breeding (when eggs were observed) differed by year (Figure 11), which reflects water depths within hydrologically connected ponds and timing of breeding. Differences in reservoir water levels between years were apparent for all species where breeding was observed in both years. For example, Northern Red-legged Frog and Northwestern Salamander eggs in the LCR were found only when reservoir water elevations were at or below 176 mASL in 2019 and above 177 mASL in 2020. Similarly, Western Toad eggs were observed only when UCR reservoir water levels were above 216 mASL in 2020 but between 214 mASL and 216 mASL in 2019.

The average size of Drawdown Zone Habitats where breeding was confirmed was generally greater than where breeding was not confirmed; however, the average size of ephemeral ponds in the LCR where breeding occurred was substantially greater than where it did not, and size ranges within ephemeral and permanent ponds were large (Table 12, Appendix E). The smallest pond where amphibians were confirmed breeding was 97 m^2 and the largest was 102,300 m^2 (note that minimum size of mapped ponds was 1 m^2; Section 2.2.1).

Table 9. Summary of spatial characteristics of breeding observations documented during amphibian breeding surveys in the Upper Campbell Reservoir and Lower Campbell Reservoir in 2019 and 2020 for the species for which breeding was confirmed.

Species	Spatial Characteristics of Breeding Observations				
	Abundance	Study Area	Type of Reservoir Habitat	Drawdown Zone Habitat permanence	Elevation Range
Western Toad	Detected at a large number (37%) of survey sites (most common and abundant species detected)	Confirmed breeding predominantly in the UCR (89% of sites where breeding was detected were in the UCR, and 99% of all egg masses, tadpoles, and metamorphs were found in the UCR); confirmed breeding at similar numbers of sites in the UCR between years (44% and 43% of sites in 2019 and 2020, respectively)	Almost all detections were in Drawdown Zone Habitats (tadpoles were found in one Reservoir Shoreline Habitat in each year, but at one of these they may have moved from a Drawdown Zone Habitat)	Occurrences were documented in similar numbers in permanent and ephemeral sites in the UCR (42% of 12 sites in 2019, and 54% of 13 sites in 2020 were ephemeral)	Breeding was detected between 215.5 to 220.0 mASL in the UCR and at 176.5 mASL in the LCR
Northern Pacific Treefrog	Detected at a large number (31%) of survey sites (commonly encountered and abundant)	Found in slightly higher proportion of sites surveyed in the LCR (36% in 2019 and 27% in 2020) than the UCR (26% in 2019 and 18% in 2020); 63% of all sites were breeding was detected were in the UCR; however, more sites were surveyed in the UCR (73% of all sites were in the UCR)	Breeding was observed in approximately equal proportions in Reservoir Shoreline Habitats and Drawdown Zone Habitats in the LCR (breeding was not documented in Reservoir Shoreline Habitats in the UCR)	In the LCR, found breeding only in permanent ponds in 2019 (at three sites) and only in ephemeral ponds in 2020 (at two sites); in the UCR, the proportion of use of ephemeral ponds was greater in 2020 (75 % of 4 sites) than in 2019 (57 % of 7 sites) and over twenty times as many egg masses and tadpoles were found in ephemeral ponds than in permanent ponds	Breeding was detected between 215.5 and 218.0 mASL in the UCR and between 176.0 and 178.0 mASL in the LCR
Northwestern Salamander	Confirmed breeding at six sites in each year	Most breeding sites (67% and 83% in 2019 and 2020, respectively) were in the LCR	All sites except one were Drawdown Zone Habitats (one Reservoir Shoreline Habitat was used for breeding in the LCR in 2019)	All Drawdown Zone Habitat sites, except one, were permanent; 12 egg masses were identified in one ephemeral pond in the LCR (at JHT-PBA70) in 2020	Breeding was detected between 219.5 and 220.0 mASL in the UCR and between 176.0 and 178.0 mASL in the LCR
Northern Red-legged Frog	Detected breeding at three sites in all years combined	Only detected breeding in the LCR (although adults were found at two sites in the UCR)	Two of the three sites where breeding was detected were Drawdown Zone Habitats and one was a Reservoir Shoreline Habitat	All confirmed breeding sites were permanent	Breeding was detected between 176.0 and 178.0 mASL in the LCR

Table 10. Number of egg masses, larvae, metamorphs, juveniles, and adults detected in Drawdown Zone Habitats for all survey sites combined in the Upper Campbell and Lower Campbell reservoirs (numbers include only counts when each species was first detected at a site; for survey-specific counts, see Appendix E).

Amphibian Species	Year	Number Detected per Age Class[1]				
		Egg Masses	Larvae[2]	Metamorphs	Juveniles	Adults
Northern Red-legged Frog	2019	10	2	0	1	7
	2020	4	0	0	0	0
Northwestern Salamander	2019	53	0	0	0	4
	2020	27	0	0	0	0
Northern Pacific Treefrog	2019	55	2,743	0	1	13
	2020	173	1,462	300	100	15
Rough-skinned Newt	2019	0	0	0	0	2
	2020	0	0	0	0	2
Western Toad	2019	37	58,253	11,000	25,001	82
	2020	132	10,933,702	0	1,358	55

[1] Numbers reflect the occurrences observed the first time the occurrence was detected (e.g., if egg masses were detected during a survey, then tadpoles were observed in place of egg masses during a later survey of the same area, the occurrence was documented but is not included in the above totals).

[2] One additional salamander larvae of unconfirmed species (uncaptured) was observed in 2020.

Table 11. Number of egg masses, larvae, metamorphs, juveniles, and adults detected in Reservoir Shoreline Habitats for all survey sites combined in the Upper Campbell and Lower Campbell reservoirs (numbers include only counts when each species was first detected at a site; for survey-specific counts, see Appendix E).

Amphibian Species	Year	Number Detected per Age Class[1]				
		Egg Masses	Larvae	Metamorphs	Juveniles	Adults
Northern Red-legged Frog	2019	0	0	0	0	0
	2020	4	0	0	0	0
Northwestern Salamander	2019	1	0	0	0	0
	2020	18	0	0	0	0
Northern Pacific Treefrog	2019	43	0	0	0	2
	2020	2	0	0	0	1
Rough-skinned Newt	2019	0	0	0	0	0
	2020	0	0	0	0	0
Western Toad	2019	0	0	0	0	0
	2020	0	120	0	1	0

[1] Numbers reflect the occurrences observed the first time the occurrence was detected (e.g., if egg masses were detected during a survey, then tadpoles were observed in place of egg masses during a later survey of the same area, the occurrence was documented but is not included in the above totals).

Table 12. Size (surface area) of ephemeral and permanent Drawdown Zone Habitats where breeding amphibians were and were not recorded.

Study Area	Pond Permanence[1]	Breeding Recorded (Yes/No)	Number of Sites[2]	Area (m)			
				Average	Std. Dev.	Min	Max
LCR	Permanent	Yes	4	7,013	8,425	97	18,589
		No	2	2,119	55	2,080	2,158
	Ephemeral	Yes	2	398	137	301	495
		No	2	10,999	9,873	4,018	17,980
UCR	Permanent	Yes	10	13,048	31,613	185	102,300
		No	4	758	378	216	1,041
	Ephemeral	Yes	9	1,828	2,032	655	7,149
		No	4	874	735	212	1,924

[1] One site (JHT-PBA05) was not mapped and was not included in permanent or ephemeral classification. Data for this site are not included in averages.

Figure 10. **Elevations of Drawdown Zone Habitats (ponds) and their permanence (ephemeral or permanent) used by breeding amphibians in 2019 and 2020 in the Upper Campbell and Lower Campbell reservoirs for all ponds where amphibians were confirmed breeding (left side) and for ponds only surveyed in both years (right side).**

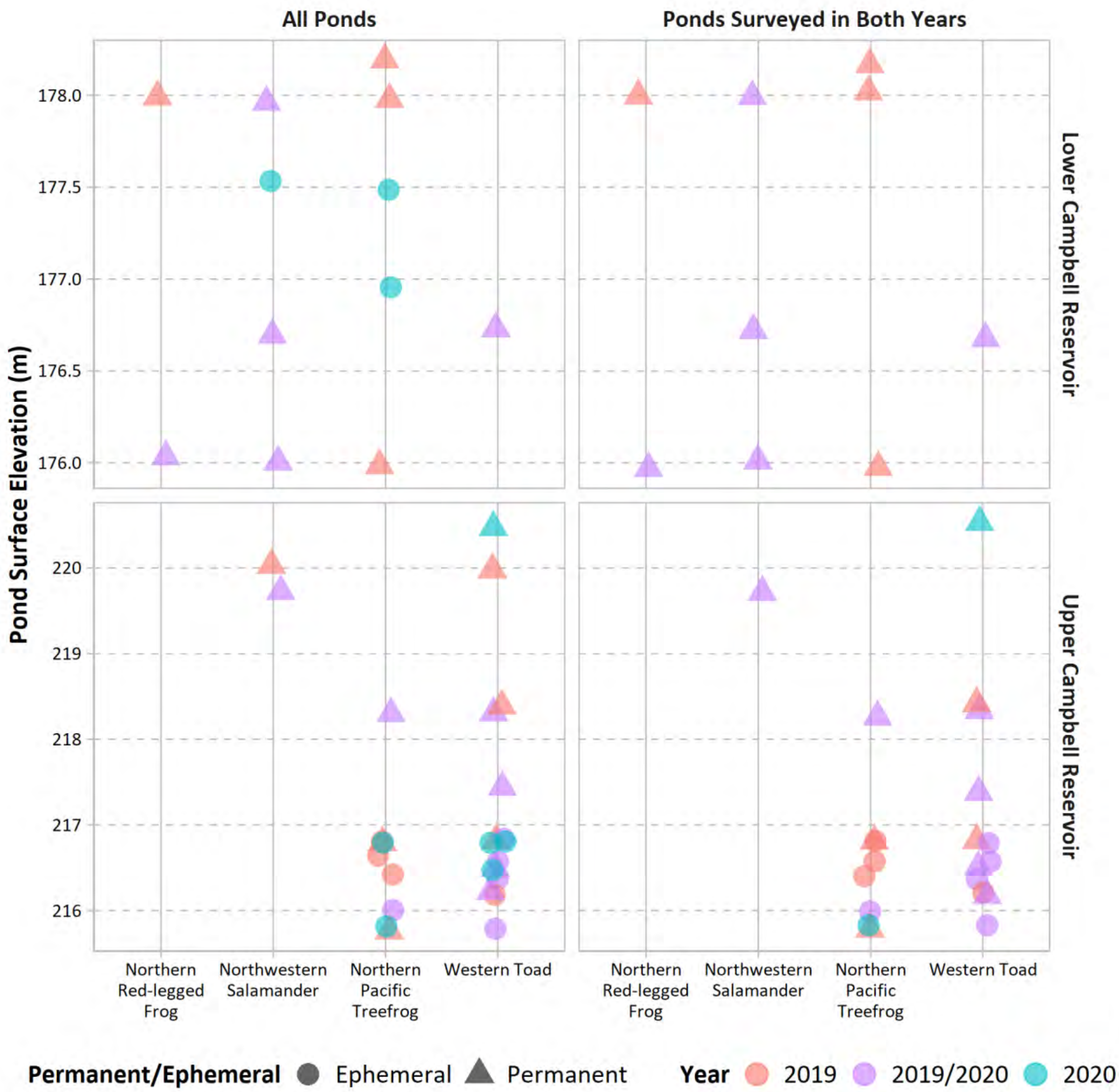
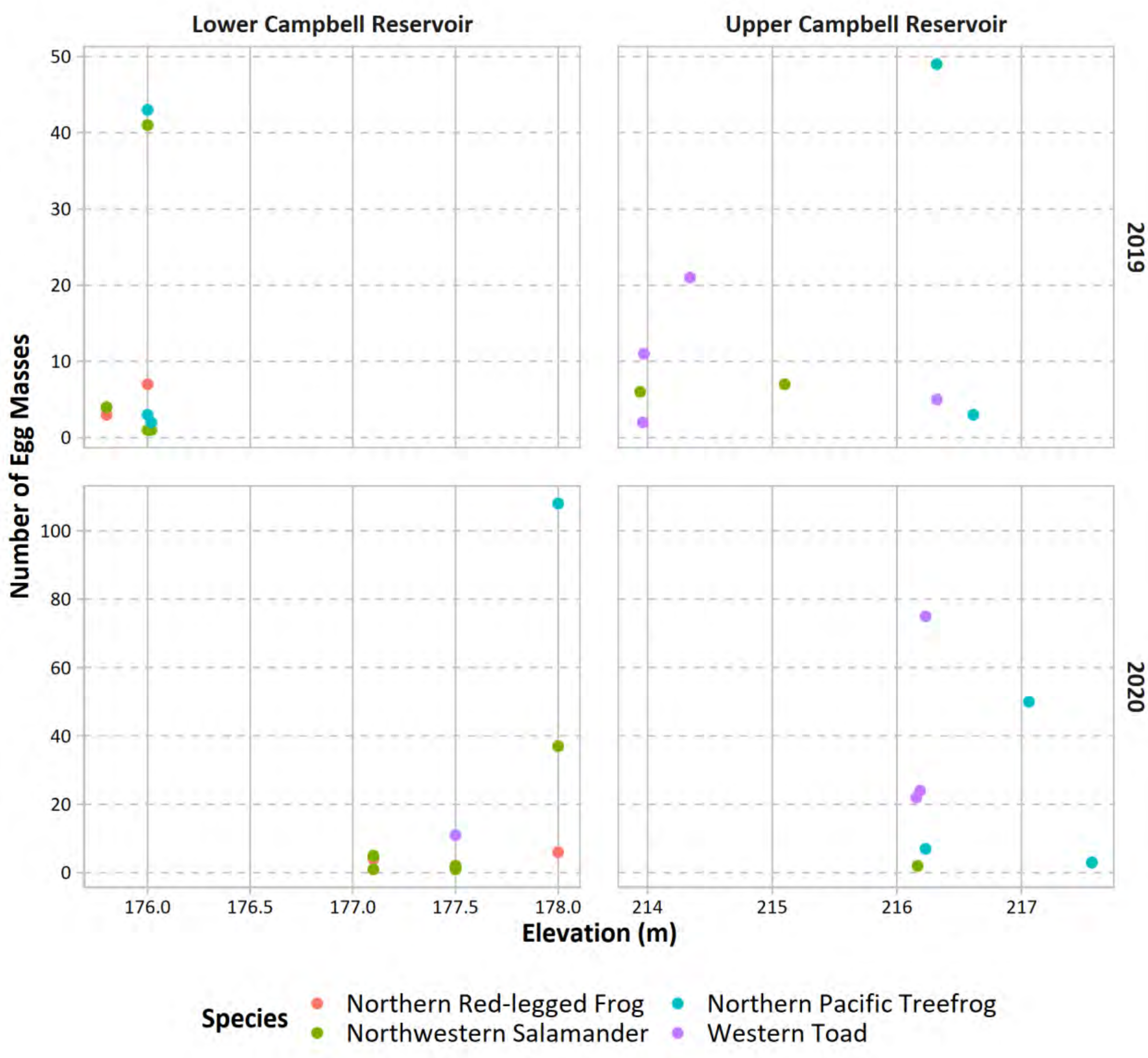


Figure 11. Number of egg masses detected in relation to reservoir water elevation for each species in 2019 and 2020 in the Upper Campbell and Lower Campbell reservoirs for all survey sites combined (Drawdown Zone and Reservoir Shoreline habitats).



3.3.2.2. Timing of Breeding

Amphibian eggs or larvae were detected in the UCR between March 28 and August 9 in 2019 and between April 9 and August 13 in 2020, and in the LCR between April 2 and June 11 in 2019 and between March 30 and June 11 in 2020 (Appendix E). For both study areas combined, amphibian eggs were observed between March 28 and July 4 in 2019 and March 30 and June 11 in 2020 (Table 13). It was estimated that the larval period ended for all species by September 7, except for Northwestern Salamander, for which the larvae overwinter.

Eggs were not detected after May 15 in the LCR in either year while roughly half of all egg detections in the UCR occurred on or after this date (Figure 12). However, the timing of egg residency recorded partly reflects the visitation schedule and surveys tended to extend later into the breeding season for the UCR than the LCR (Appendix E).

The timing of egg observations was earlier in 2020 than 2019 for some species (Figure 12). For example, Northern Pacific Treefrog eggs were first observed in the UCR in July in 2019, whereas they were observed in April in 2020. Western Toad eggs were observed between late March and mid-June in the UCR in 2019 and no later than late April in 2020. Field observations also indicated that Western Toad breeding was extended in 2019 relative to 2020, with breeding occurring within ponds as they became wetted by reservoir inundation (breeding was documented within ponds that had been dry during earlier surveys).

Figure 12. Number of egg masses detected for each amphibian species by date in 2019 and 2020 in the Upper Campbell and Lower Campbell reservoirs for all survey sites combined (Drawdown Zone and Reservoir Shoreline habitats).

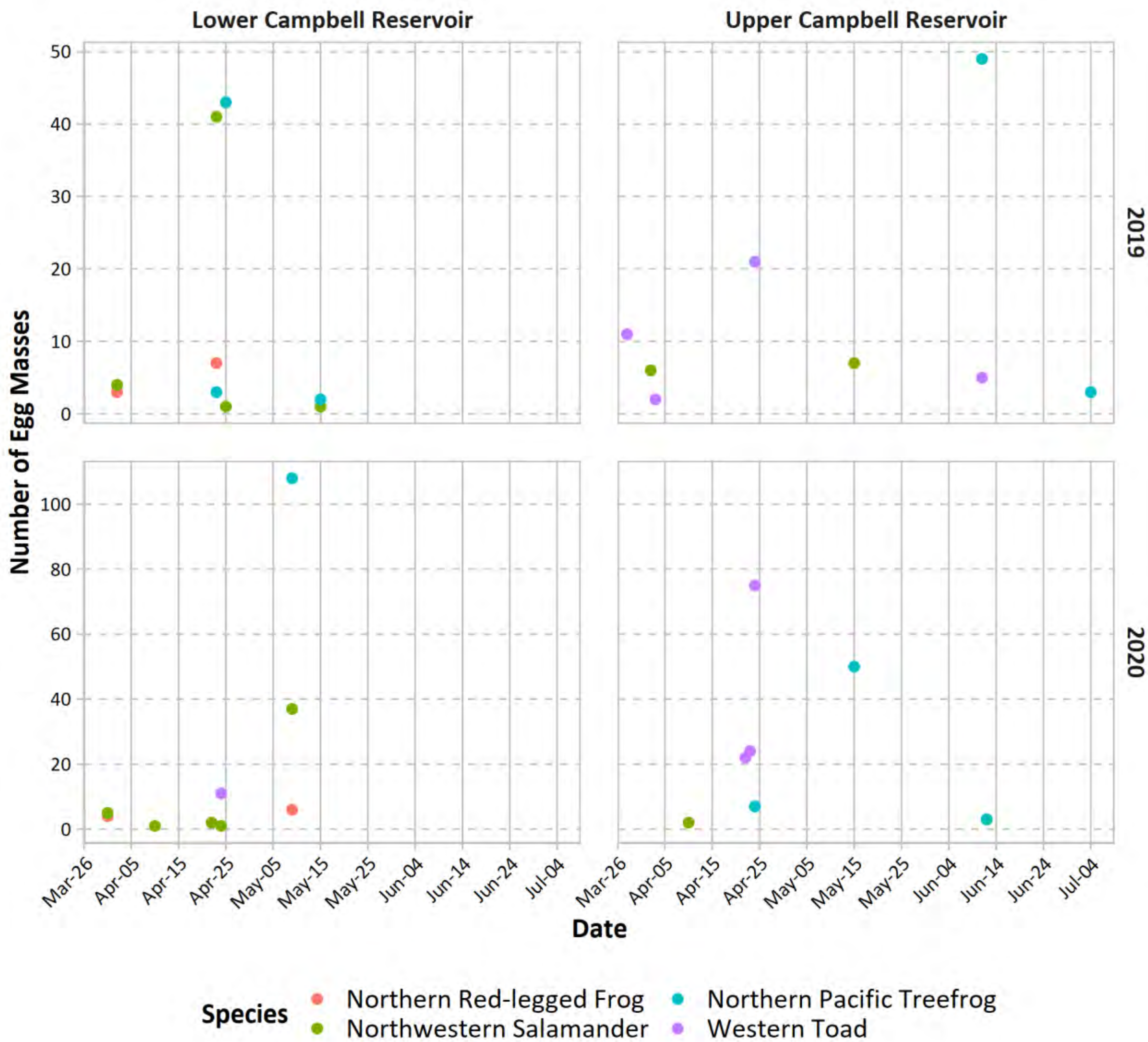


Table 13. Timing of detections of eggs masses for amphibian species breeding in the Upper Campbell and Lower Campbell reservoirs in 2019 and 2020 in this study.

Amphibian Species	Year	# of Sites Egg Masses or Tadpoles Observed	# of Sites with Individuals Observed	Observed Egg Laying Period
Northern Pacific Treefrog	2019	11	17	March 28 - July 4
	2020	8	12	April 23 - June 11
Northern Red-legged Frog	2019	2	4	April 2 - May 15
	2020	2	2	March 30 - June 11
Northwestern Salamander	2019	6	6	April 2 - July 4
	2020	6	6	April 23 - June 11
Rough-skinned Newt	2019	-	2	-
	2020	-	2	-
Western Toad	2019	13	16	March 28 - June 11
	2020	15	16	April 21 - 23

3.3.3. Amphibian Habitat Assessments

Results from amphibian habitat assessments are presented below, organized by broad scale (site-level) and fine-scale (occurrence-level). Detailed results from amphibian habitat assessments are presented in the tables of Appendix F.

3.3.3.1. Broad Scale Habitat Assessment

Broad scale (site-level) habitat characteristics are summarized by survey site in relation to species-specific breeding records (presence, absence) in Appendix F. Habitat characteristics that were not expected to differ over the season (e.g., substrate, American Beaver activity) are qualitatively compared between breeding sites (where amphibian breeding was detected) and non-breeding sites (where breeding was not detected) below. This is followed by a qualitative comparison of water temperature and water depth of the survey area which changes between field visits.

Substrate differed little when breeding sites were compared among species (Table 2 in Appendix F). For all species combined, the most common dominant and sub-dominant substrates at amphibian breeding sites generally were mineral soil and organic matter, respectively. At non-breeding sites, both rock and mineral soil were common dominant substrates and both organic matter and decaying wood were common sub-dominant substrates. More American Beaver activity was recorded at breeding than non-breeding sites (28% and 17% American Beaver activity was documented in at least one year at breeding and non-breeding sites, respectively). Berm heights (height of land between the pond and reservoir, as measured from the pond surface) of up to 6 m were recorded at non-breeding sites, whereas the maximum berm height was 3.1 m at breeding sites. In addition, higher berms (up to 3.1

m) were documented for breeding sites of Western Toad and Northern Pacific Treefrog than for Northern Red-legged Frog and Northwestern Salamander (maximum berm heights were 1.8 m at breeding sites for the latter two species). Lowest shoreline slopes (maximum of 7%) were recorded for Northern Red-legged Frog breeding sites (maximum slopes at breeding sites for other species were up to 20%, 30%, and 40% for Northwester Salamander, Northern Pacific Treefrog, and Western Toad). Distance to forest cover was generally less for breeding than non-breeding sites, and this distance was greater for Western Toad breeding sites than for those of other species. Fetch (wave action categorized as high, medium, low, or none, relative to potential wave action across the survey sites) was similar among breeding sites of amphibian species, although it was generally lower at sites where Northern Red-legged Frog and Northwestern Salamander were detected, and it was classified as medium or high at more sites where breeding was not detected than where it was detected. Little difference in fish presence (86% of all sites and of breeding sites had fish present in at least one year; Table 2 in Appendix F) or shade (most breeding and non-breeding sites had low shade) was apparent between breeding and non-breeding sites, and water source was not noticeably different among breeding and non-breeding sites.

No differences were apparent in the qualitative comparison of vegetation cover by species or between breeding and non-breeding sites (Table 3 in Appendix F). In general, highest cover of submergent and emergent vegetation at survey sites was small herb (cover ranged from 0% to 75%), and low amounts of graminoid cover were observed at some sites. Slightly lower ranges of percent graminoid cover were detected at non-breeding (highest rank was 2 (5-25%)) than breeding (highest rank was 3 (25-50%)) sites for submerged and emergent vegetation. Percent cover of CWD was typically classified as less than 5% although at some sites it was classified as 5-25%. Most survey sites had low amounts of organic substrate material, and Spearwort Lakeflat and Hairgrass-Water Sedge were the most common vegetation communities at both breeding and non-breeding sites.

Average water temperature and average and maximum water depth of the survey area, which changes across the season, are shown for the third week of April in Table 14, along with average reservoir water elevation at the time of the surveys. Average water temperatures were 0.7 ºC to 4.0 ºC warmer in the third week of April at sites where breeding was confirmed than where it was not (Table 14). The comparison could not be made for the LCR in 2020 because no surveys occurred at non-breeding sites during this period. Average and maximum water depths tended to be slightly shallower at sites where breeding was confirmed during the third week of April (Table 14); however, average water depth of all sites was generally under 0.5 m (Table 1 in Appendix F). An exception was one Western Toad breeding site (JHT-PBA09; see description of this site in Section 4.5) that had an average depth of 3.5 m, whereas the maximum average depth of breeding sites for other species was 1.3 m (Table 1in Appendix F). Maximum water depth at non-breeding sites was 15 m; thus, average water depth was more variable where breeding was not confirmed (ranging between 0.05 m and 15 m) than where it was (ranging between 0.1 m and 1.98 m).

Table 14. Average water temperature and average and maximum water depth of the survey area, in relation to average reservoir water level, for breeding and non-breeding survey sites that were surveyed in the third week of April in the Upper Campbell and Lower Campbell reservoirs.

Study Area	Year	Breeding Recorded (Yes/No)	Date Range	Number of Survey Sites	Average Water Temperature (°C)	Average Water Depth (m)	Maximum Water Depth (m)	Average Reservoir Elevation (mASL)
LCR	2019	Yes	April 23 - 25	5	16.6	0.4	0.8	176.0
		No	April 23 - 25	4	12.6	0.8	2.7	176.0
	2020	Yes	April 21 - 23	2	15.6	0.5	1.6	177.5
UCR	2019	Yes	April 24 - 25	6	15.5	0.4	0.5	214.3
		No	April 24 - 25	6	12.8	0.4	0.7	214.3
	2020	Yes	April 21-23	15	15.4	0.3	0.8	216.2
		No	April 21-23	6	14.7	0.3	0.8	216.2

3.3.3.2. Fine Scale Habitat Assessment

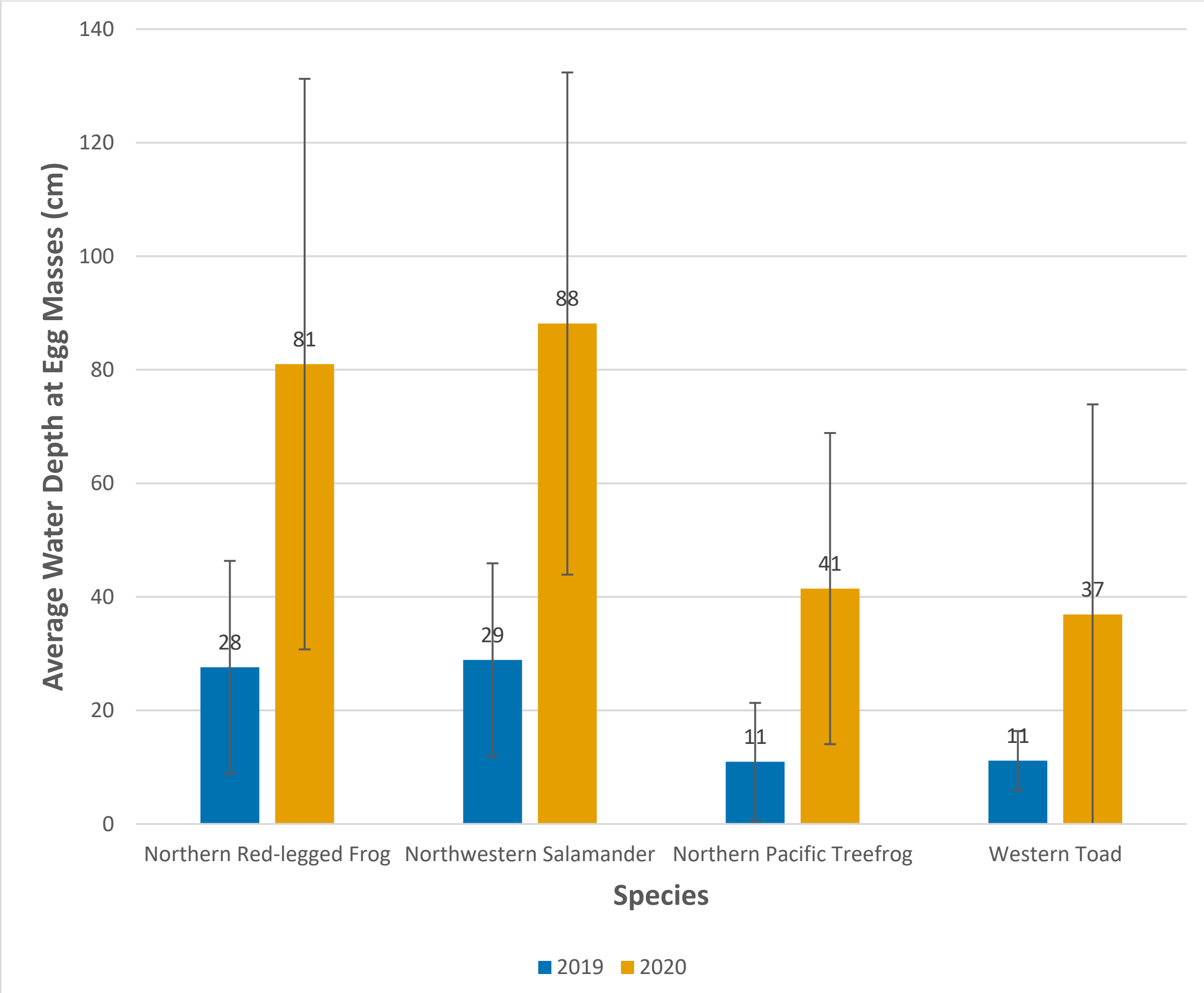
The average depth of egg masses differed by amphibian species and by year (Table 15). In both years, average egg mass depth was deeper, and the range of depths more variable, for Northern Red-legged Frog and Northwestern Salamander than Northern Pacific Treefrog and Western Toad. Depth of egg masses was greater in 2020 (when reservoir water levels were higher) than 2019 (when reservoir water levels were lower) for all species except Western Toad (for which it was similar between years). In both years, some egg masses were detected for all four species at or just below the surface (0 cm to 1 cm depth); however, maximum depths were greater and more variable in 2020 than 2019.

The average water depth of the location where eggs were laid also varied within and across years for each species (Figure 13). The depth of the water, and the range of depths, was less in 2019 than in 2020 (for all species combined, depth ranges were 11 cm to 29 cm in 2019 and 37 cm to 88 cm in 2020).

Table 15. Average, minimum, and maximum depth of egg masses observed by amphibian species in 2019 and 2020 in the Upper Campbell and Lower Campbell reservoirs for all survey sites combined.

Species	2019				2020			
	Number	Minimum Depth (cm)	Average Depth (cm)	Maximum Depth (cm)	Number	Minimum Depth (cm)	Average Depth (cm)	Maximum Depth (cm)
Northern Red-legged Frog	5	1	12.4	35	10	0	62.9	150
Northwestern Salamander	36	0	12.6	35	35	0	59.8	175
Northern Pacific Treefrog	12	0	3.8	14	24	1	16.6	48
Western Toad	26	0	7.2	20	12	0	6.3	13

Figure 13. Average water depth (± SD) for each species at the location where egg masses were recorded in the Upper Campbell and Lower Campbell reservoirs for all survey sites combined. Average values are shown above bars.



4. DISCUSSION

4.1. Overview

The overall objective of JHTMON-9 was to improve understanding of amphibian distribution and habitat use within the UCR and LCR study areas and to identify potential effects of reservoir operations on amphibian habitats. This was accomplished through a combination of desktop mapping and modeling of potential amphibian habitat in Drawdown Zone Habitat ("ponds"), and amphibian and habitat surveys conducted at survey sites in Drawdown Zone Habitat and along the shorelines of the reservoir (Reservoir Shoreline Habitat). Potential effects of reservoir water level fluctuations on amphibian breeding habitat were evaluated through two broad effects pathways: inundation of habitat when reservoir water levels rise, and exposure of habitat when reservoir water levels drop. Results confirmed that amphibians are breeding within both study areas (UCR and LCR) at some sites within Drawdown Zone and Reservoir Shoreline habitats. Because reservoir water levels change throughout the amphibian breeding season, and the timing of breeding periods (egg and larval periods) differ by species, inundation and exposure of potential breeding habitat depend on timing of water level changes relative to the timing of amphibian breeding periods, the condition of the habitat (wetted or dry) when it is inundated or exposed (whether previously wet or dry), and characteristics of ponds in relation to their tendency to hold water (ephemeral or permanent). The following sections highlight the main conclusions of the study in relation to study's management questions and objectives (outlined in Section 1.4). In addition, management implications are discussed for two specific species at risk confirmed breeding in the study areas.

4.2. Management Question 1a: Location, Distribution, and Extent of Drawdown Zone Habitats in the UCR and LCR

The first management question ("*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?"*) was addressed through the assessment of potential amphibian breeding habitat availability, in terms of pond number and surface area, relative to pond elevation. This management question is broadly aligned with the third study objective, which is to determine the degree to which Drawdown Zone and Reservoir Shoreline habitats are influenced by reservoir operations. Desktop mapping and modeling of habitat was limited to Drawdown Zone Habitats (ponds).

Mapping of Drawdown Zone Habitats (ponds) within the UCR and LCR study areas identified differences in their sizes and locations. In general, the UCR study area contained many ponds that were small (<1 ha) and the LCR contained fewer but larger ponds. In total, 370 ponds were mapped within the drawdown zones of the two study areas, of which 334 were in the UCR (297 ephemeral and 37 permanent), and 36 were in the LCR (27 ephemeral and 9 permanent). The total surface area represented by these ponds was calculated to be 33.8 ha (23.8 ha in the UCR and 10.0 ha in the LCR). A key result of this analysis was that substantially more potential amphibian breeding habitat was located within the UCR than the LCR study areas, both by total number of ponds (90% of 370 ponds) and by surface area (70% of 33.7 ha total area).

The distribution of Drawdown Zone Habitat relative to elevation also differed between the two study areas. In the UCR, 70% of ponds (by number) and 26% of habitat (by surface area) occurred in the mid-range of drawdown zone elevations (215 to 217 mASL). In the LCR, although most ponds (by number) were also located in the mid-ranges of the drawdown zone elevations, most habitat (by surface area) was found in the upper elevations of the reservoir.

4.3. Management Question 1b: Impacts of Water Level Fluctuations on Drawdown Zone Habitats during the Amphibian Breeding Season

The second management question ("*Based on modeling, 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)?"*) was addressed by using modeling to quantify the effect of reservoir water level fluctuations on Drawdown Zone Habitats (ponds) through the calculation of probabilities related to inundation or exposure of ponds by elevation and species-specific breeding periods. This management question is directly aligned with the third and fourth study objectives, which are to determine the degree to which amphibian habitats are influenced by reservoir operations and to consider the potential influence of reservoir operations on amphibian breeding success.

Modeling results indicted that there is considerable variability in the system, with potential effects differing among years. The nature and magnitude of potential impacts on amphibian Drawdown Zone Habitats from water level fluctuations due to reservoir operations reflected a complex interaction of reservoir water level (based largely on the operational drawdown regime along with climate/weather), the elevation of potential habitat, and the species-specific timing and duration of egg and larval periods. The characteristics of the ponds in relation to their tendency to hold water (whether ephemeral or permanent) were also an important consideration for the interpretation of model results. Nevertheless, several patterns were identified during this modeling analysis that address the second management question and key results have been summarized in the sections below. Modeling was conducted using data reflecting the WUP regime and was applied to all ponds identified during mapping and all six amphibian species potentially present; thus, modeling results apply to the current water management regimes and certain assumptions/limitations apply (see Section 2.2.3).

Probability of inundation and non-inundation

In both reservoirs, modeling results indicated that probability of inundation of Drawdown Zone Habitat was strongly related to elevation, and habitats at low elevations had higher probabilities of inundation than those at high elevations during all amphibian species egg and larval time periods. Where probabilities of inundation were consistently low (and probabilities of non-inundation were consistently high), such as at high elevations, Drawdown Zone Habitats were more likely to remain dry (i.e., not become inundated) and habitats that are wetted only by the reservoir were therefore rarely available for amphibian breeding (remain dry). Similarly, habitats at low elevations tended to stay inundated during most amphibian breeding periods and may therefore not have provided suitable breeding habitat because they were continuously flooded by the reservoir. Habitats in middle elevation ranges varied in their potential to become inundated based on the timing and duration of the egg or larval period considered and transitioned frequently between inundation and exposed conditions (see below).

Probability of inundation was also strongly associated with time of year, reflecting seasonal reservoir water level fluctuations in both reservoirs. For most Drawdown Zone Habitats in the UCR, reservoir water levels decreased early in the amphibian egg period and increased later in the egg period, but the overall probability of inundation within the egg period depended on timing and duration of species-specific egg periods along with the elevation of the potential habitat. The probability of inundation remained relatively low across most elevations for most of the egg period for species with brief and early egg periods (i.e., Long-toed Salamander, Northwestern Salamander, and Northern Red-legged Frog); the probability of inundation increased in the latter portion of the egg period for species with longer egg periods (e.g., Northern Pacific Treefrog).

The extent of Drawdown Zone Habitat available for amphibian breeding also depended on the annual maximum rise of the reservoir water level because higher reservoir water levels have the potential to inundate more habitat. Based on modeling results, in the LCR, low water levels such as those documented in 2019 (see Section 3.3.1) would have inundated 23 ponds (39.7 ha of habitat), whereas the higher 2020 water levels would have inundated 33 ponds. Thus, an additional 5.5 ha of habitat would have been available for amphibian breeding in a year with reservoir water levels such as those that occurred in 2020 relative to a year such as 2019. In the UCR, where water levels were more variable, 2019 water levels would have inundated 19 to 47 ponds (14.3 ha) and 2020 water levels would have inundated 162 to 287 ponds.

Low probabilities of inundation during amphibian breeding periods (e.g., egg period) may be associated with a risk of desiccation for Drawdown Zone Habitats that have ephemeral qualities (do not hold water when reservoir water elevations drop below the pond elevation) when breeding is initiated at a time when reservoir levels are typically dropping (early in spring). Ponds classified as ephemeral were relatively evenly distributed throughout the elevation bands and tended to occur at lower elevations than permanent ponds, especially in the UCR. However, permanent ponds at high elevations may be valuable habitats because they are rarely inundated by the reservoir and therefore may develop and maintain suitable micro-climates (e.g., water temperature, water depth). Studies have shown that drawdown zone ponds that are least frequently inundated by the reservoir, such as high elevation ponds that become exposed as water levels decrease and are late to become inundated again, provide particularly suitable habitat (Swan *et al.* 2015). Most high elevation ponds used by breeding amphibians in this study were permanent ponds (Figure 10).

Modeling results predicted that the elevation of Drawdown Zone Habitats was related to their potential to be productive for amphibian breeding. In the UCR, 7% of ponds (by number) and 12% of habitat (by surface area) were located at and below ~214 mASL and were inundated most of the time; these ponds therefore would have rarely provided suitable breeding habitat. Conversely, 14% of ponds (by number) and 14% of habitat (by surface area) were located above ~218 mASL where inundation was uncommon. Ponds in these upper regions can, however, provide productive amphibian breeding habitat if they are permanent (e.g., have alternate water sources and remain wetted during the breeding season). Water levels fluctuate to the greatest extent between 214.5 to 217.5 mASL (Figure 1), where about 77% of all drawdown zone ponds (70% by surface area) were located, suggesting that most ponds in the UCR see substantial variation in water levels within and among years during the egg and larval periods.

Probability of inundation varied less over the breeding season in the LCR than the UCR and differed less among amphibian egg and larval periods due to lower variability in reservoir water levels (Figure 2). In the LCR, Drawdown Zone Habitat is inundated most of the time at and below ~176 mASL and is dry (exposed) most of the time above ~178 mASL. Most variation in water levels is observed between 176.5 and 177.5 mASL. Most ephemeral habitat (64% of habitat by number of ponds and 40% of habitat by surface area) was documented at or below 176 mASL. Thus, most ephemeral ponds were inundated most of the time. Further, a sizeable proportion of ephemeral ponds in the drawdown zone were at elevations that, due to frequent inundation, were unlikely to be valuable for breeding amphibians. At or below 176 mASL, the probability of habitat not being inundated was 7% or less for almost all egg and larval periods. Most permanent habitat by surface area (58%) but not by pond number (22%) was located at or above 178 mASL, suggesting most permanent ponds in the LCR were not inundated most of the time.

Probability of habitat transitioning between inundated and exposed

The probability of habitat transitioning from exposed (isolated from the reservoir) to inundated (flooded by water from the reservoir), or from inundated to exposed, at some point during the egg and larval period of amphibian species can be an important determinant of amphibian habitat availability and suitability, although the type and magnitude of the effect depends on pond characteristics (e.g., whether ephemeral or permanent), direction and timing of the transition relative to the timing of the breeding period, the rate of water level change, and the condition of the habitat when it is inundated or exposed (whether previously wet or dry).

When habitats transition from inundated to exposed at some point during a species' egg or larval period, eggs and larvae may become at risk of desiccation if ponds have ephemeral characteristics, although the rate of water level change in relation to the egg or larval development times, along with the depth of the pond, will determine whether ephemeral ponds provide suitable habitat long enough for larvae to achieve metamorphosis. For permanent ponds or deep ephemeral ponds that continue to hold water for long time periods as reservoir water levels drop, transitioning from inundated to exposed is likely to be associated with increased habitat availability and suitability because ponds that become isolated, while continuing to hold water, may develop and retain favourable habitat characteristics. The probability of habitat transitioning from inundated to exposed was generally low during amphibian egg periods because water levels were rising in spring, and, as shown in Figure 3 of Appendix C, this probability was not highly variable among the egg periods of amphibian species in the UCR because most egg periods begin at similar times (Table 3, Figure 5). The probability of habitat transitioning from inundated to exposed was highest for early breeding periods and when the habitat was at relatively high elevations, because such habitats would have been inundated during winter and were likely to become exposed as reservoir water levels dropped early in spring (e.g., for the Northern Red-legged Frog egg period this probability was 36% at mASL 217.5; Table 5 of Appendix D). The transition from inundated to exposed could also have occurred later in the breeding period when water levels were dropping, and because water levels were dropping later in summer, there was a greater probability of this transition during the larval periods of amphibian species that extend later into the season (e.g., for the Northwestern Salamander larval period, this probability was 64% at 217.5 mASL whereas for the Northern Red-legged Frog larval period it was 29% at this elevation; Table 8 and Table 6 of Appendix D). In the LCR (Figure 4 of Appendix C), the probability of this transition was similar for egg and larval periods owing to less variable reservoir water levels (Figure 2). For both egg and larval periods of all species, there was a relatively high probability for elevation bands between 176 and 177.5 mASL to transition from inundated to exposed.

The probability that habitats transition from exposed to inundated varied more among egg periods than the probability of transitioning from inundated to exposed for a given elevation, and the greatest differences were observed at the highest elevations. This is because water levels typically do not rise until late spring/early summer. Thus, for an egg period of short duration, such as that of Northern Red-legged Frog, there was little opportunity for exposed habitats to become inundated, regardless of elevation, because the breeding period does not extend into summer when water levels rise (maximum probability is 21% in both reservoirs; Table 5 and Table 17 in Appendix D). In contrast, the egg period of the Northern Pacific Treefrog extends into the summer; thus, the probability of having exposed habitat becoming inundated was high, especially at high elevations in both reservoirs (maximum probability is 64% in the UCR and 100% in the LCR; Table 3 and Table 15 in Appendix D).

Reservoir water levels in the UCR change markedly and continuously throughout the entire amphibian breeding period, thus even small differences in the timing and duration of breeding among amphibian species can lead to large differences in the probability that habitat will transition from exposed to inundated or inundated to exposed. In addition, the relationship between the breeding periods (e.g., egg period) and development time (e.g., time it takes for an egg to hatch) differs among species. In general, habitat for species with short breeding periods has the least potential to be affected by reservoir water level fluctuations, especially in the UCR where water levels are quite variable. For example, the probabilities of transitioning from exposed to inundated was greater at most elevations for habitat of species with longer egg and larval period (Appendix C and in Appendix D). In addition, there are substantial differences among species in the length of breeding periods in relation to development times. For species with long breeding periods but short development times, although the probability of habitat transition may be high for the period, the likelihood for the transition to have a biological impact may be low. For example, Western Toad has an egg period that is 103 days long, but the estimated egg development time is only 3 to 12 days (COSEWIC 2012). Thus, although substantial changes in water level are anticipated during the egg period, rapid water level changes would be required to desiccate or flood eggs within a few days. Even though larvae are mobile and therefore less vulnerable to water level changes than eggs, larval development times must also be considered if changes in habitat have the potential to be substantial (e.g., pond dries, or exposure or inundation causes substantial changes in habitat suitability such as water temperature). Because reservoir water levels in the LCR change less overall than water levels in the UCR and are also relatively constant for periods of time during the amphibian breeding period, reservoir water level changes have less potential to alter habitats within the drawdown zone in a manner that can affect amphibian breeding.

4.4. Management Question 2a: Drawdown Zone Habitats and Reservoir Shoreline Habitats used by Breeding Amphibians

The third management question ("*Which Drawdown Zone Habitats and Reservoir Shoreline Habitats do each amphibian species utilize for laying eggs?*") was addressed by conducting amphibian breeding surveys at select survey sites within Drawdown Zone Habitats (ponds) and Reservoir Shoreline Habitats in the UCR and LCR. This management question is directly aligned with the first two study objectives, which are to expand our knowledge of amphibian breeding in Drawdown Zone and Reservoir Shoreline habitats and to determine which habitats are used for egg laying and whether there are differences in habitat selection by species.

Results indicated that among amphibian species anticipated to be present, only Long-toed Salamanders were not detected in 2019 and 2020. Breeding was confirmed for Western Toad, Northern Pacific Treefrog, Northwestern Salamander, and Northern Red-legged Frog, and among these, Western Toad and Northern Pacific Treefrog were most common. Rough-Skinned Newt was documented present, but breeding was not observed (only adults were detected). Online databases broadly support the finding that Western Toad, Northern Red-legged Frog, and Northern Pacific Treefrog tend to be more numerous within the Campbell River watershed than other species identified for this study (BC Frogwatch Atlas 2021; E-Fauna BC 2021; iNaturalist 2021; B.C. Conservation Data Centre 2021a).

For all species combined, most confirmed breeding sites were within Drawdown Zone Habitats (71% of 38 sites; compared to 15% of 13 Reservoir Shoreline Habitat sites). Amphibian use of habitat in drawdown zones is well documented in BC (Boyle 2012; Swan *et al.* 2015; Hawkes *et al.* 2017, 2018). Elevated temperatures and reduced predator pressure typical of habitat within drawdown zones is thought to create suitable amphibian breeding habitat, although a preference for ponds that promote rapid larval development and/or that are least frequently inundated by the reservoir has also been documented (Swan *et al.* 2015).

Although most breeding was observed in Drawdown Zone Habitats, Reservoir Shoreline Habitat was also documented to provide valuable breeding habitat for amphibian species. While amphibians were only documented breeding at one Reservoir Shoreline Habitat site in each reservoir, the highest number of species observed at any site was at a Reservoir Shoreline Habitat site in the LCR (JHT-PBA46S in 2020). Further, the same Reservoir Shoreline Habitat site had the most number species (four) observed breeding at a site. This site was an approximately 27 ha small bay connected to the LCR via a 40 m wide channel (Map 2). The shoreline had a low gradient with abundant emergent vegetation and a potential year-round water source, thus the site provided suitable breeding conditions, such as relatively high temperatures and the presence of emergent vegetation, throughout the egg and larval periods for all species, including Northwestern Salamanders (whose larvae persist year-round). Breeding may have also occurred at one Reservoir Shoreline Habitat site in the UCR. Tadpoles were confirmed at JHT-PBA52S (Map 4), which was located near the south end of Buttle Lake. The site had a low gradient shoreline and was connected, at least at high water, to a complex of permanent ponds, including JHT-PBA09 (located near the Ralph River Provincial Park Campground). Eggs were not documented at JHT-PBA52S and surveyors noted that dispersed tadpoles may have swum out from JHT-PBA09, which was connected to the site by a channel; thus, confirmation of breeding at this site is considered uncertain.

Similar use was detected for ephemeral (63%) and permanent (68%) ponds for all species combined; however, the apparent preference for permanent or ephemeral habitats differed among species. Western Toad and Northern Pacific Treefrog were found in similar numbers in ephemeral and permanent ponds. Western Toad are known to use both types of ponds (Boyle 2012, COSEWIC 2012; Species at Risk Committee 2014). The largest pond in this study, a permanent pond in the drawdown zone of the UCR (JHT-PBA09), contained large numbers of Western Toad eggs, larvae, metamorphs, and juveniles (Appendix E). Other studies of Drawdown Zone Habitats adjacent to hydropower reservoirs have also found a high proportion of permanent pond use (90%) by amphibians, including Western Toad, relative to ephemeral waterbody use (Swan *et al.* 2015). The finding that Northwestern Salamanders were found almost exclusively in permanent ponds was anticipated since the larvae of this species overwinter (Blaustein *et al.* 1995). Northern Red-legged Frogs were also found breeding only in permanent ponds, although the species is known to use both permanent and ephemeral ponds (Sendak 2008; COSEWIC 2002b; Bunnell *et al.* 2016; B.C. Conservation Data Centre 2021b), and our results likely reflect small sample size for this species (only three breeding sites found).

For all species combined, similar use, in terms of the proportion of sites where breeding was confirmed, was documented in each study area (65% and 50% of sites in the UCR and LCR, respectively). However, differences among species in distribution by study area suggest that the two reservoir systems may disproportionately support different species. During the two years of surveys, Western Toad were more abundant in the UCR study area, whereas Northern Red-legged Frog and Northwestern Salamander were found breeding largely in the LCR study area. Northern Pacific Treefrog were relatively common in both study areas but were more common in the UCR. These results tentatively suggest that the UCR has greater importance as breeding habitat for Western Toad and Northern Pacific Treefrog, while the LCR is more important for Northern Red-legged Frog and Northwestern Salamander. However, Northern Red-legged Frog and Northwestern Salamander were only detected at a small number of sites (three and seven, respectively). Further, more adults were detected in the UCR than the LCR for both species (Appendix E), suggesting that breeding may be more common in the UCR than documented in this study. In particular, five adult Northern Red-legged Frogs were identified at JHT-PBA50 and JHT-PBA51, both of which were permanent ponds within the Drawdown Zone Habitats of the UCR. These sites were at the western end of the UCR, at the outlet of the Elk River, approximately 18 km from the upper end of the LCR and approximately 20 km from the closest known breeding sites (JHT-PBA20 and JHT-PBA22) (Map 2). Juvenile dispersal and adult migration are not well understood for this species but individuals have been documented far from water (COSEWIC 2002b) and adults have been found at distances of up to 4.2 km from their breeding habitat (Hayes and Rombough 2007). Juvenile dispersal or adult migration of 18 to 20 km from breeding habitat is considered highly unlikely, supporting the notion that Northern

Red-legged Frogs were breeding successfully within or adjacent to the UCR. Further investigation may be warranted to confirm breeding sites.

4.5. Management Question 2b: Attributes that Characterize Habitats used by Amphibians for Breeding

The fourth management question ("*What attributes characterize Drawdown Zone Habitats and Reservoir Shoreline Habitats used for egg laying by each amphibian species?"*) was addressed by relating the results of breeding surveys to habitat characteristics. This included both broad scale (site level) habitat characteristics, and fine scale habitat characteristics associated with breeding occurrences, specifically water depth. This management question is directly aligned with the second study objective, which is to determine which habitats are used for egg laying and whether there are differences in habitat selection by species.

Overall, few habitat attributes measured at the broad (site-level) scale appeared to be clearly associated with presence of breeding amphibians (of any species), and even fewer could be associated with specific species. Water temperature, breeding site substrate, and presence of American Beaver activity appeared to differ generally between amphibian breeding and non-breeding sites. Average water temperature was consistently warmer at breeding than non-breeding sites in the third week of April, and given the link between temperature and developmental rate (Smith-Gill and Berven 1979; Berven and Gill 1983), selection of habitats with warmer water temperatures was not unexpected. American Beaver activity was documented at more sites with amphibian breeding than without, suggesting that wetland properties may be enhanced by American Beaver activity (e.g., increasing an ephemeral pond's tendency to hold water). Also, some differences in substrate were observed, with mineral soil and organic matter more commonly documented at breeding sites and rock more commonly documented (along with mineral soil) at non-breeding sites. Only slight among-species differences in habitat characteristics were noted; these were related to Drawdown Zone Habitat berm heights, shoreline slopes, and distance to forest cover; however, sample sizes for some species were small making comparison results tentative. Lower slopes tended to be preferred in both Drawdown Zone Habitats and Reservoir Shoreline Habitats, but this was not universal. Habitat attributes such as permanence, size, and depth of ponds used for breeding were also documented to vary by species and year (see Section 4.4).

Breeding amphibian presence was not associated with fish presence, which was surprising, given that fish are often predators of amphibians (Licht 1974; COSEWIC 2015). However, the presence of fish differed between years at some sites and thus fish presence at a site may not be highly predictable; in addition, most survey sites had fish present. Responses of amphibians to the presence of predatory species vary by species; although many amphibians have been shown to avoid ponds with predatory fish (Hartel *et al.* 2007; e.g., Davenport *et al.* 2017; Kloskowski 2020), toads (*Bufo* spp.) have been shown to occur at similar (Kloskowski 2020) or higher (Hirner and Cox 2007; Kloskowski *et al.* 2020) densities in ponds with fish. The presence of predatory fish may also have effects that may not be apparent from amphibian densities, such as the avoidance of high-quality habitat within a pond (Bylak 2018) or changes to development rates (Smith *et al.* 2016).

Water depth did not appear to relate strongly to breeding amphibian presence within the sites surveyed, although most sites were shallow given that areas considered most suitable for breeding were selected for field surveys. There was evidence that all species laid eggs in deeper water in 2020 than 2019; however, this may simply reflect the higher reservoir water levels in 2020, which would have caused water depth at many sites to be greater. In some cases in both years, depth may have changed between the date when eggs were laid and when they were observed.

Although clear patterns in breeding habitat characteristics were not evident, it is worthwhile to examine the attributes of those sites where multiple species bred or where high numbers of one or more species were observed. In the LCR, JHT-PBA08, JHT-PBA20, JHT-PBA22 and JHT-PBA46S, meet these criteria (Appendix E). JHT-PBA08 was relatively unique in that it was a small (0.15 ha) pond located in a disturbed area just downstream of the Strathcona Dam (Map 2). JHT-PBA20 and JHT-PBA22 were somewhat larger (0.8 and 1.8 ha, respectively) permanent ponds located in the Drawdown Zone Habitat of the LCR. Both were located within relatively low-gradient areas and had low-gradient shorelines (5% and 3%, respectively). Emergent vegetation was present at both of these sites and there was a substantial amount of large woody debris at JHT-PBA20. JHT-PBA46S was a Reservoir Shoreline Habitat site connected to the reservoir by a 40 m wide open water channel. The shoreline had a low gradient, and there was abundant emergent vegetation and a potentially perennial water source. Thus, highly suitable breeding conditions appeared to exist here for multiple species throughout their egg and larval periods, as previously described (Section 4.4). Few other locations in the LCR Reservoir Drawdown Zone or Reservoir Shoreline habitats provided these relatively large areas of low gradient habitat, suggesting these sites had relatively high value for amphibian breeding.

In the UCR, five sites (JHT-PBA03, JHT-PBA09, JHT-PBA11, JHT-PBA19, and JHT-PBA21) either contained relatively large numbers of Western Toad (JHT-PBA09) or both Western Toad and Northern Pacific Treefrog eggs and/or larvae. JHT-PBA09 was a large (102,300 m^2) permanent pond with a low gradient shoreline and was connected, at least at high water, to a complex of permanent ponds. The four other sites were both permanent (JHT-PBA11) and ephemeral (JHT-PBA03, JHT-PBA19, JHT-PBA21) ponds, ranging in size between 1,150 m^2 and 102,300 m^2 and between 214.4 and 218 mASL in elevation, with shoreline slopes ranging from 5 to 30%. Three of the ponds (all except JHT-PBA21) had large (50-75%) amounts of submerged and emergent vegetation cover (JHT-PBA21 had only 1-5% cover).

The lack of obvious association between measured habitat characteristics and presence of breeding amphibians may be related to several factors. Selection of survey sites may mask some obvious relationships because survey sites were selected for amphibian breeding suitability; thus, there was little variability in some habitat characteristics among sites (e.g., water depth). For habitat characteristics that were more variable, such as shoreline slope or substrate, weak associations with breeding were observed and it is possible that relatively small sample sizes for some species, along with potentially different species-specific preferences, made the detection of patterns difficult. For example, if Northern Red-legged Frogs are more particular about shoreline slope and distance to forest cover, this would be difficult to detect given that only three breeding sites were found, particularly if this habitat characteristic is less important to other species. In some cases, high variability in habitat characteristics may be indicative of flexibility (at least for the species most commonly detected) or may suggest that other habitat characteristics may be more important or that some habitat characteristics, if present, may compensate for others that are lacking. Comparison of breeding and non-breeding sites through presence/absence (which is indicative of attempted breeding rather than success) may also reduce detectability of habitat characteristics important for breeding success, and consideration of species abundance and diversity, when data are sufficient, could be used to identify characteristics that make habitats particularly suitable if some flexibility exists (e.g., some breeding may occur in sites with a wide variety of characteristics but the most successful sites may have more specific characteristics). For example, as described above, the presence of vegetation (submerged, emergent, and shoreline) appeared to be associated breeding sites when sites with the greatest abundance or species diversity were considered.

4.6. Management Question 2c: Evidence for Reservoir Operations Influencing Amphibian Habitat Suitability

The fifth management question ("*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 success of amphibians breeding in these locations?"*) was addressed in two ways: 1) through field observations of the response of pond water level to reservoir water level (which was also used to classify ponds as ephemeral or permanent); and 2) through comparison of results of amphibian breeding surveys and habitat assessments between two years that differed substantially in reservoir water levels. This management question is directly aligned with the third and fourth study objectives, which are to determine the degree to which Drawdown Zone and Reservoir Shoreline habitats are influenced by reservoir operations and to consider the potential influence of reservoir operations on amphibian breeding success.

Inundation and exposure of breeding ponds due to water management in hydroelectric reservoirs have been documented to potentially affect amphibian breeding, either directly through the study of breeding amphibians in a drawdown zone environment (e.g., Swan *et al.* 2015) or indirectly through study of the effects of habitat alterations known to be associated with reservoir water level fluctuations (e.g., water level or water temperature changes) (Semlitsch and Caldwell 1982; Denver *et al.* 1998). Although little direct evidence of the effects of reservoir operations on amphibian habitat suitability was obtained during this study, and quantification of breeding success was not an objective of the study, field observations provide evidence on the relationship between pond water elevations and reservoir water elevations, as well as responses of breeding amphibians to differences in reservoir water levels. Establishing these relationships is an important step in evaluating the potential effects of reservoir operations on amphibian breeding habitat. Further, field results also refined estimates of breeding periods and the length of development times which are key variables when assessing potential effects. The sections below discuss two lines of evidence related to reservoir water levels influencing habitat suitability for breeding amphibians obtained during this study and their implications.

4.6.1. Response of Pond Water Levels to Reservoir Water Levels and Implications for Breeding Amphibians

The extent to which exposure of ponds (Drawdown Zone Habitats) after inundation can impact amphibian breeding success depends on a variety of factors, including the response of pond water level to reservoir water level. This relationship was investigated for a subset of ponds through field observation. Results indicated that water levels in many ponds were closely linked to water levels in the reservoir for both reservoir systems, and thus reservoir operations directly influenced amphibian habitat suitability by affecting water depth. Many ponds were found to respond relatively rapidly to dropping reservoir water levels, even where shoreline berms had not been overtopped, which suggests that ponds were hydrologically connected to the reservoir through groundwater flow. Based on these observations, these ponds were classified as ephemeral.

The large number of ephemeral ponds identified in the two study areas (88% of ponds in the UCR and 75% of ponds in the LCR) suggests that desiccation of ponds is likely to be a key amphibian management consideration, especially because most amphibian breeding sites were identified in the Drawdown Zone Habitat especially in the UCR where most ephemeral ponds were within the 215.5 and 216.5 mASL elevation bands (i.e., within the corrective zone for water level management, see Figure 1). Thus, when reservoir water levels dropped through these elevation bands, these amphibian breeding habitats may have been at greater risk of desiccation. However, the risk of desiccation within ephemeral ponds differs not only in relation to relative elevations (pond and reservoir), but also by rate of water level drop, other pond features (e.g., alternative water sources, substrate), and species-specific life history characteristics. Although amphibians can accelerate metamorphosis or metamorphose earlier at a smaller size in response to decreasing water levels (Wilbur and Collins 1973; Denver *et al.* 1998; Merilä *et al.* 2000; Maciel and Juncá 2009), they may not be able to adjust quickly enough when water level changes are rapid, and the risk of desiccation is greater in shallow ponds where even larvae can get stranded. Desiccation risk also differs based on egg laying behaviour and development times. For example, Western Toads lay their eggs in relatively shallow water and so are vulnerable to even small changes in water levels (e.g., 25 cm), whereas other species lay in deeper water. However, Western Toad eggs hatch quickly (3 to 12 days; COSEWIC 2012) relative to other species, decreasing the risk that ponds will dry during the brief egg development period. In the LCR, a high proportion of ponds were located at low elevations where they were inundated most of the time; thus, desiccation would be generally less of a management concern although it could still occur in higher elevation ponds. Further, most ponds in which breeding was documented in the LCR were permanent ponds (Figure 10).

Desiccation of egg masses was observed during this study in three Drawdown Zone Habitat sites and one Reservoir Shoreline Habitat site, confirming that some desiccation of amphibian eggs occurred due to reservoir water level decreases, and stranded, dead fish were found at five sites, suggesting that desiccation of amphibian life stages may have occurred in more locations than were observed. Egg mass desiccation was observed in the UCR on April 24, 2019 and April 21, 2020. Observations of egg mass desiccation were also made in the LCR between April 23 and 25, 2019. Assuming eggs were initially oviposited underwater, they likely became exposed during sharp drops in water levels in mid-March or early April (Figure 9). It is likely these eggs were oviposited in late March or early April, prior to the reservoirs reaching annual minima. The clustering of all observations of egg mass desiccation in late April suggests that amphibians that oviposit relatively early in their breeding season (e.g., Northern Red-legged Frog) are at higher risk of desiccation than those that oviposit later in the breeding season when reservoir water levels are rising.

The classification of ponds as ephemeral and permanent was preliminary and not all ponds were assessed in the field to verify classification or establish depth. In addition, ponds were classified as permanent based on several factors (depth, substrate, alternative water sources) and field observations suggested that alternative water sources, such as inflows and outflows, as well as factors related to water-holding tendencies (e.g., associated with American Beaver activity), were related to amphibian use. Thus, the characteristics that cause pond permanence can reduce potential impacts of inundation and exposure and increase the pond's suitability as quality amphibian breeding habitat (e.g., risk of desiccation from inundation to exposure transition can be mitigated by alternative water sources). Additional effort could be expended to classify ponds as ephemeral or permanent to improve the assessment of the effect of water level changes on ponds previously inundated or ponds rarely inundated. In addition, modeling did not consider Reservoir Shoreline Habitats, which are more difficult to delineate and characterize for modeling; however, an important result of this study was that these can also be valuable amphibian breeding habitats that can be positively or negatively affected by reservoir water level management.

Inundation of previously isolated ponds from rising reservoir water levels is, in principle, expected to negatively effect amphibians (e.g., reducing water temperature, introducing predatory fish; see Section 1.3), and the classification of ponds as ephemeral or permanent is not relevant to the likelihood of inundation or associated effects. Observations of negative effects on amphibians resulting from inundation were not made during this study. Nonetheless, it is expected that inundation of previously wetted amphibian habitat due to increasing reservoir water levels will influence amphibian habitat suitability.

4.6.2. Amphibian Response to Differing Annual Reservoir Water Levels

Apparent responses in amphibian breeding to differences in reservoir water levels in 2019 (when reservoir water levels were unusually low; Section 3.3.1) and 2020 (when reservoir water levels were typical) provide evidence of potential operational effects on amphibian habitat. The atypical reservoir water levels in 2019 indicated that there was an unusually high proportion of potential amphibian breeding ponds within the Drawdown Zone Habitat that would have been dry earlier in the breeding season because habitats even at relatively low elevations were not being inundated. Evidence for reservoir operations influencing amphibian habitat was documented through changes in the behaviour and habitat choices of amphibians between these two years.

Timing of breeding differed between the two years for some species, in accordance with the different reservoir water levels early in the breeding season. Field results suggested that some species, such as Western Toad and Northern Pacific Treefrog, delayed egg laying in 2019, when reservoir water elevations were very low early in the breeding period, relative to 2020, when they were more typical (Figure 12). The dates on which eggs were observed for these two species were later in 2019 than 2020, and field observations indicated that Western Toads bred in ponds as they became available for breeding, thus extending their egg laying period relative to 2020 (Table 13). Field observations also suggested that Western Toads and Northern Red-legged Frogs responded by laying eggs relatively quickly following the inundation of previously exposed (dry) habitat. However, amphibian species differ in potential flexibility of adjusting timing of breeding, and some species, such as Western Toad which have a relatively long egg period (i.e., egg residency period), especially in relation to their egg development times, are likely to have greater flexibility than a species with a short egg period and longer egg development time, such as Northern Red-legged Frog.

Although little difference was documented between years in the elevations of ponds selected for breeding (Figure 10), differences in site reuse between species, and differences in the proportion of permanent and ephemeral ponds used between years, also provide evidence for reservoir operations influencing amphibian habitat. Amphibians are known to predominantly have strong site fidelity for natal breeding ponds (Sinsch 1990; Blaustein *et al.* 1994; Berry 2001), although this varies by species (Smith and Green 2005) and potentially habitat type (Semlitsch 2008). High levels of site fidelity have been demonstrated or assumed for the four species documented breeding in this study (Maxcy and Richardson 2000; COSEWIC 2012, 2015; Green *et al.* 2020). Our results suggested variability in species reuse of sites across years, which appeared to be loosely associated with the preference for pond type and was consistent with the potential differential impact of reservoir water elevations on the two pond types. Because water levels in reservoir systems can be highly variable among years, and because ephemeral ponds are more likely to be influenced by reservoir operations than permanent ponds, breeding site reuse would be expected to be lower for species that use ephemeral ponds in a reservoir system if reservoir operations are influencing amphibian habitat. Excluding Northern Red-legged Frog for which only three breeding sites were found, the proportion of sites reused was lowest for Northern Pacific Treefrogs (25%), which were detected breeding in more ephemeral than permanent ponds, moderate for Western Toads (64%), which used ephemeral and permanent ponds in approximately equal proportions, and highest for Northwestern Salamander (100%), which use permanent ponds almost exclusively and for which some life stages persist in the aquatic environment year-round (neotenic adults and larvae). Thus, species that selected ephemeral ponds, which are more likely to be affected by reservoir operations, had the lowest site fidelity. Additionally, Northern Pacific Treefrogs were detected breeding in a higher proportion of ephemeral ponds in 2020, when reservoir water levels were higher, than in 2019, when reservoir water levels were unusually low. This suggests that ephemeral ponds may be selected for breeding more frequently in typical years (i.e., some ephemeral ponds would not have been available early in the spring due to low reservoir water levels).

The depth of eggs within the water column during two years with differing water levels provides additional evidence of reservoir operations influencing amphibian habitat suitability. Some species delayed breeding in 2019 relative to 2020 (Figure 12) which would have allowed time for suitable breeding conditions to arise (e.g., reservoir water elevations to rise, wetting ephemeral ponds and achieving sufficient depth to make breeding possible in ponds that were dry at the beginning of the egg laying period). However, water depth was shallower overall in 2019 than in 2020 (depth of egg masses and water in the locations where egg masses were recorded were lower in 2019; Section 3.3.3.2); thus, it was apparent that delaying breeding did not fully avoid or reduce potential effects of lower reservoir water elevations in 2019.

Field observations provide indirect evidence of effects of reservoir operations on amphibian habitat; however, these observations also provide evidence for the potential for some amphibian species to adapt to different or changing conditions associated with reservoir operations, although relative breeding success was not determined and could therefore not be linked to such amphibian responses. Despite differences in water levels between years, all species were confirmed breeding in nearly identical number of sites in 2019 and 2020, and no clear between-year differences in the abundance of life stages were apparent. However, species will differ in their ability to adapt to changing conditions, and in the means by which they are able to adapt (e.g., modifying timing or habitat types). Further, this study was not designed to quantify breeding success; thus, the relative outcomes of the differing strategies could not be compared, and it is not possible to evaluate if, and how, differences in breeding behaviour (e.g., timing) and habitat (e.g., pond type, water depth) between years may have affected breeding success, or to relate modeling results to breeding outcomes. In addition, climatic factors that affect reservoir water levels may also affect amphibian breeding behaviour directly (e.g., air temperature, precipitation), and thus may confound the relationship between amphibian response and reservoir water level to some extent. If breeding success could be linked to adaptability by species, this has implications for modeling because the models used in this study assume static breeding periods regardless of environmental conditions.

4.7. Species-specific Management Implications

Two species at risk, Northern Red-legged Frog and Western Toad, were confirmed breeding in the two study areas and species-specific management implications are considered for these species in more detail. Evaluation of management implications could be specifically applied to Northwestern Salamander and Northern Pacific Treefrog in a manner similar to that applied to Northern Red-legged Frog and Western Toad below.

Northern Red-legged Frog

The Northern Red-legged Frog is provincially blue-listed and is federally listed as Special Concern (B.C. Conservation Data Centre 2021b), and is therefore considered a priority species. Breeding was only confirmed in the LCR at three sites, and all confirmed breeding sites were permanent (one was a Reservoir Shoreline Habitat). However, adults were found in the UCR suggesting that breeding may also occur in this location (see Section 4.4), and the species is known to utilize both permanent and ephemeral water bodies for breeding although permanent ponds have been found to be preferred habitats due to long larval development time (Sendak 2008; Bunnell *et al.* 2016; B.C. Conservation Data Centre 2021b). Thus, although the species was only observed breeding in permanent habitats in the LCR in this study, management considerations should extend to potential effects of water level fluctuations on ephemeral ponds and to the UCR.

Seasonal reservoir water level changes during the Northern Red-legged Frog breeding period create the potential for egg stranding and desiccation in ephemeral ponds, with the likelihood depending on habitat elevation and annual reservoir water levels. Water levels in the LCR were typically decreasing during the relatively short egg period (i.e., egg residency period) (Figure 6), and first increasing, then decreasing, during the relatively long larval period. This pattern was also observed for the UCR, although within-year variability was higher and there was a greater drop in water level in the latter part of the larval period. Eggs usually take much longer than 9 days to develop (i.e., egg development time is ≥ 9 days; COSEWIC 2015) and are attached to emergent vegetation; thus, they are vulnerable to pond water level changes. Given the short duration of the egg period, the probability of a habitat transitioning from inundated to exposed during the egg period was moderate and highest for habitats at intermediate elevations (maximum of 43% at 177.0 mASL in the LCR and 36% at 217.5 mASL in the UCR). In addition, adverse effects associated with pond exposure (egg desiccation) are associated more with ephemeral ponds; in permanent ponds, exposure may improve habitat suitability. Due to the duration of the egg period during which water levels are typically dropping, inundation of eggs is unlikely to be a management concern for this species.

All three sites where Northern Red-legged Frog were detected breeding were between 176.0 and 178.0 mASL in the LCR (Table 17 in Appendix D); thus, modeling results can be used to predict potential effects of reservoir water level changes in that elevation range. Modeling results show that ponds between 176.0 and 178.0 mASL were inundated between 21% and 93% of years during the egg period and between 0% and 93% during the larval period. Further, ponds within this elevation range transitioned from inundated to exposed in 7% to 43% of years during the egg period. This suggests that, although there was substantial variability in the probability of inundation at this elevation range, the probability of habitat becoming exposed after having been inundated, which may be associated with egg stranding and desiccation, was relatively low, and was highest in the middle elevations within this range. The probability of habitat transitioning from exposed to inundated, which may be associated with egg flooding, was even lower during the egg period (21% or less) and increased little during the larval period (maximum of 29% at 177.5 mASL). Similar assessments could be made for the UCR if or when breeding locations are documented.

The probability of potential habitat becoming inundated and transitioning from inundated to exposed during the Northern Red-legged Frog egg period also varies by year. For water levels, such as those experienced in 2019 which dropped quickly in March in the LCR then remained stable throughout the remainder of the egg and larval periods (albeit at a lower level ~ 176 mASL), this could cause desiccation of some ephemeral ponds above 176 mASL and potentially some early egg mortality. However, for a year like 2020, water levels remain relatively high and stable at around 176.5 to 177.5

mASL in the LCR in March, reducing the likelihood of pond exposure following inundation, and therefore of desiccation risk. For breeding in permanent ponds, where inundation is more likely to cause adverse effects to habitat suitability than exposure, high elevation ponds which are inundated prior to the egg period but then are not inundated again would be expected to be highly suitable (e.g., at and above 177.5 mASL in the LCR and at and above 218 mASL in the UCR), provided that other habitat characteristics are also suitable. Breeding was detected (eggs found) at such a high elevation site in the LCR in 2019.

Western Toad

Western Toads (federally listed of Special Concern) were detected breeding predominantly in the UCR where water levels were generally low at the beginning of the egg period (i.e., egg residency period), rose throughout the egg period, then began to decrease again at the end of the egg period (Figure 5). Thus, there was considerable potential for habitat in the low and middle elevations to transition between inundated and exposed during the egg period. Egg periods for Northern Pacific Treefrog and Northwestern Salamanders begin at similar times; thus, these species will have similar management considerations. However, the egg period of Northern Pacific Treefrog is of longer duration, so that probability of inundation and transition from exposed to inundated is increased, and Northwestern Salamanders breed only in permanent ponds (and more breeding sites were found in the LCR), so that desiccation is a less likely adverse effect than inundation.

Most sites where Western Toads were detected breeding in the UCR appeared to have a moderate risk of not retaining water (desiccating) and of becoming inundated during the egg period. Western Toads were detected breeding in the middle to high elevations of the UCR (215.5 to 220.0 mASL) where, based on model results, the probability of inundation during the egg period ranged between 7% and 93% and the probability of transitioning from exposed to inundated, and inundated to exposed, reached 57% and 36%, respectively (depending on elevation) (Table 11 in Appendix D). In addition, most ephemeral ponds, where risk of desiccation is greatest, occurred in the 215.5 and 216.5 mASL elevation bands, and this was where much of the Western Toad breeding was observed (Figure 10). However, the probability of transitioning from inundated to exposed may not lead to egg or larval mortality. The egg development time for Western Toad is very short (COSEWIC 2012), reducing risk of egg desiccation, and although the larval development time is longer, it is also short relative to other species. Thus, rapid water level changes and shallow ponds would be most likely to cause egg or larval mortality when ponds become exposed. There was a high probability of inundation throughout the egg period at middle elevations which is important for creating breeding habitat; however, inundation of ponds within the latter part of the egg period and the larval period may lead to reduced habitat suitability at the elevations where breeding was observed for both ephemeral and permanent ponds, given the relatively high probabilities of transitioning from exposed to inundated during both periods.

In the LCR, Drawdown Zone Habitat was inundated most of the time at and below ~176 mASL and is dry (exposed) most of the time above ~178 mASL (Section 4.3). Western Toad breeding was observed only at 176.5 mASL in the LCR where there was a moderate probability (57%) of transitioning from inundated to exposed conditions and zero probability of transitioning from exposed to inundated (0%) conditions during the egg period, and moderate probabilities of either transition during the larval period.

Potential effects on potential Western Toad Drawdown Zone Habitat in the UCR can be estimated from current operational policy and elevations of documented breeding sites. The lower end of the UCR operational preferred zone (Figure 1) decreases from about 215 mASL in early March (the beginning of the egg period) to about 214 mASL at the beginning of May (within the egg period), then increases to a minimum of about 217 mASL by June 21, which is maintained until September 10 (approximately the end of the larval period). According to this operational regime and our modeling results, 23 ponds totalling about 6,300 m^2 are expected to become exposed between early March and early May if minimum levels are maintained. This time period encompasses a substantial portion of the Western Toad and Northern Pacific Treefrog egg periods. At a slightly higher water level of 216.0 mASL, the number of ponds that may be inundated is predicted to increase from 24 to 162 and the area of available habitat to increase from 27.7 to 167.8 ha.

5. KNOWLEDGE GAPS

The results of this study have improved our understanding of amphibian distribution and habitat use in Drawdown Zone and Reservoir Shoreline habitats within and adjacent to the UCR and LCR. The study was conducted within a relatively narrow time frame (two field seasons) and on modeling conducted with certain assumptions. This work has identified the following knowledge gaps that may be worthy of investigation in future to further improve our understanding of amphibian habitat use of UCR and the LCR and the potential effects of reservoir operations on amphibians:

- Relationship between reservoir water levels and ephemeral or permanent pond characteristics. The relationship between reservoir water levels and ephemeral or permanent pond characteristics (tendency to hold water) is critical to interpreting the biological significance of transitioning between inundated and exposed conditions for Drawdown Zone Habitats. For example, if a pond is permanent because it has alternative water sources, inundation by the reservoir will be less important in influencing the suitability of the amphibian breeding habitat, whereas if a pond is permanent due to impermeable substrate, inundation is required to create suitable habitat. Although this study identified the need to classify ponds in relation to their tendency to hold water, classification of ponds was preliminary.

- Relationship between reservoir water levels and amphibian breeding success. The relationship between amphibian habitat selection at different reservoir water levels, that vary within and between years, and amphibian breeding success, is a critical consideration for identifying management priorities and informing management decisions.

- Relationships between habitat characteristics and use by breeding amphibians. Relationships likely exist between habitat characteristics and amphibian use for breeding that were not observed during this study, likely partly due to small sample sizes for some species, limited variability in some characteristics, and because the study was not designed to quantitatively analyze links between habitat characteristics and amphibian abundance or diversity.

- Species presence and breeding sites. Knowledge gaps related to species presence and distribution were identified during this study: no Long-toed Salamanders were observed, Roughskin Newts were confirmed present, but no breeding sites were identified, and Northern Red-legged Frogs were only detected breeding at three sites in the LCR (although there was evidence for likely breeding in the UCR).
- Value of Reservoir Shoreline Habitats. Although this study documented some valuable breeding sites along the shorelines of reservoirs, the relative value of Reservoir Shoreline Habitats for amphibians is still not well understood.
- Effect of egg and larval development times and species-specific habitat preferences on modeling predictions. Given that egg and larval development times can be substantially different from egg and larval periods (e.g., Western Toad), amphibian effects metrics calculated from modeling for egg and larval breeding periods during this study may differ from probabilities of effects on developmental periods (e.g., link between pond transitioning from inundated to exposed to likelihood of desiccation of eggs). Similarly, modeling predictions may change if species-specific preferences for pond types (ephemeral or permanent) or habitats (e.g., elevations), such as those documented during this study, were incorporated into modeling.

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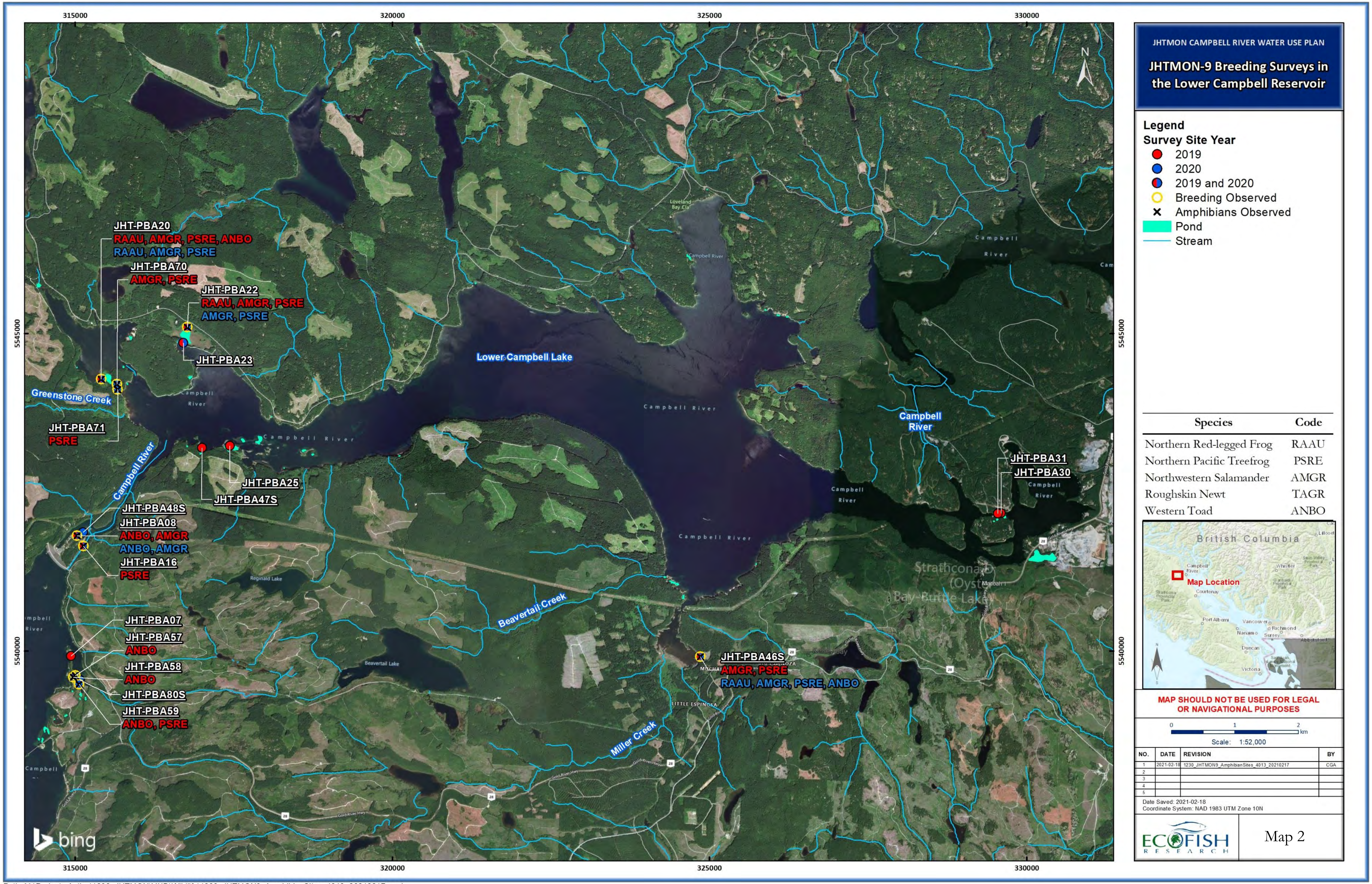
PROJECT MAPS


JHTMON CAMPBELL RIVER WATER USE PLAN
JHTMON-9 Breeding Surveys in the Lower Campbell Reservoir
Legend
Survey Site Year
2019
2020
2019 and 2020
Breeding Observed
Amphibians Observed
Pond
Stream
Species | Code
Northern Red-legged Frog | RAAU
Northern Pacific Treefrog | PSRE
Northwestern Salamander | AMGR
Roughskin Newt | TAGR
Western Toad | ANBO
British Columbia
Map Location
MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES
Scale: 1:52,000
NO. | DATE | REVISION | BY
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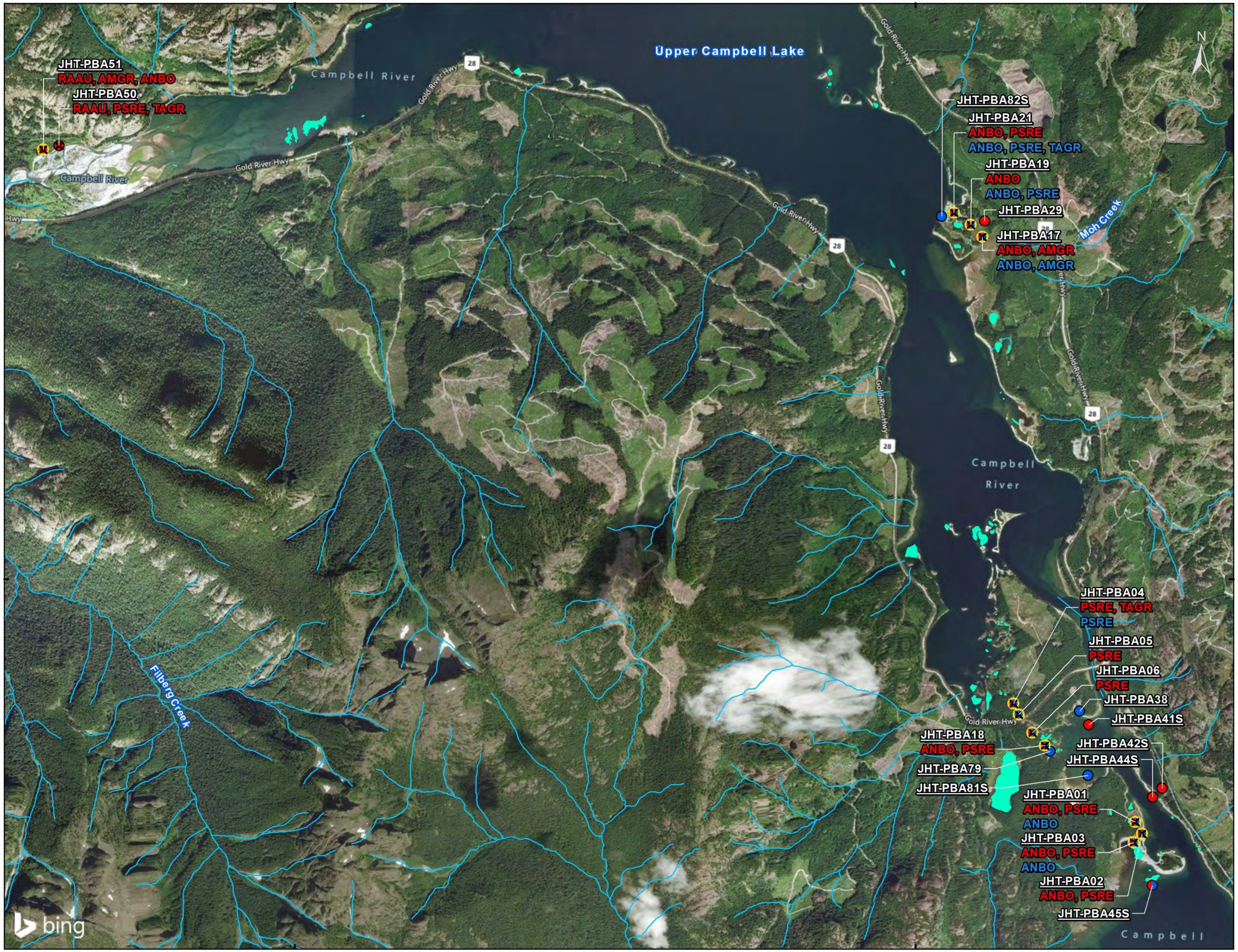
Date Saved: 2021-02-18
Coordinate System: NAD 1983 UTM Zone 10N
ECOFISH RESEARCH
Map 2
315000
320000
325000
330000
5545000
5540000
Lower Campbell Lake
Greenstone Creek
Campbell River
Beavertail Creek
Miller Creek
JHT-PBA20
RAAU, AMGR, PSRE, ANBO
RAAU, AMGR, PSRE
JHT-PBA70
AMGR, PSRE
JHT-PBA22
RAAU, AMGR, PSRE
AMGR, PSRE
JHT-PBA23
JHT-PBA71
PSRE
JHT-PBA25
JHT-PBA47S
JHT-PBA48S
JHT-PBA08
ANBO, AMGR
ANBO, AMGR
JHT-PBA16
PSRE
JHT-PBA07
JHT-PBA57
ANBO
JHT-PBA58
ANBO
JHT-PBA80S
JHT-PBA59
ANBO, PSRE
JHT-PBA46S
AMGR, PSRE
RAAU, AMGR, PSRE, ANBO
JHT-PBA31
JHT-PBA30
bing



JHTMON CAMPBELL RIVER WATER USE PLAN

JHTMON-9 Breeding Surveys in the Upper Campbell Reservoir

Legend

Survey Site Year

- 2019
- 2020
- 2019 and 2020
- Breeding Observed
- Amphibians Observed
- Pond
- Stream

Species	Code
Northern Red-legged Frog	RAAU
Northern Pacific Treefrog	PSRE
Northwestern Salamander	AMGR
Roughskin Newt	TAGR
Western Toad	ANBO

MAP SHOULD NOT BE USED FOR LEGAL OR NAVIGATIONAL PURPOSES

0 0.75 1.5 km

Scale: 1:30,000

NO.	DATE	REVISION	BY
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2			
3			
4			
5			

Date Saved: 2021-02-18
Coordinate System: NAD 1983 UTM Zone 10N

ECOFISH RESEARCH

Map 3

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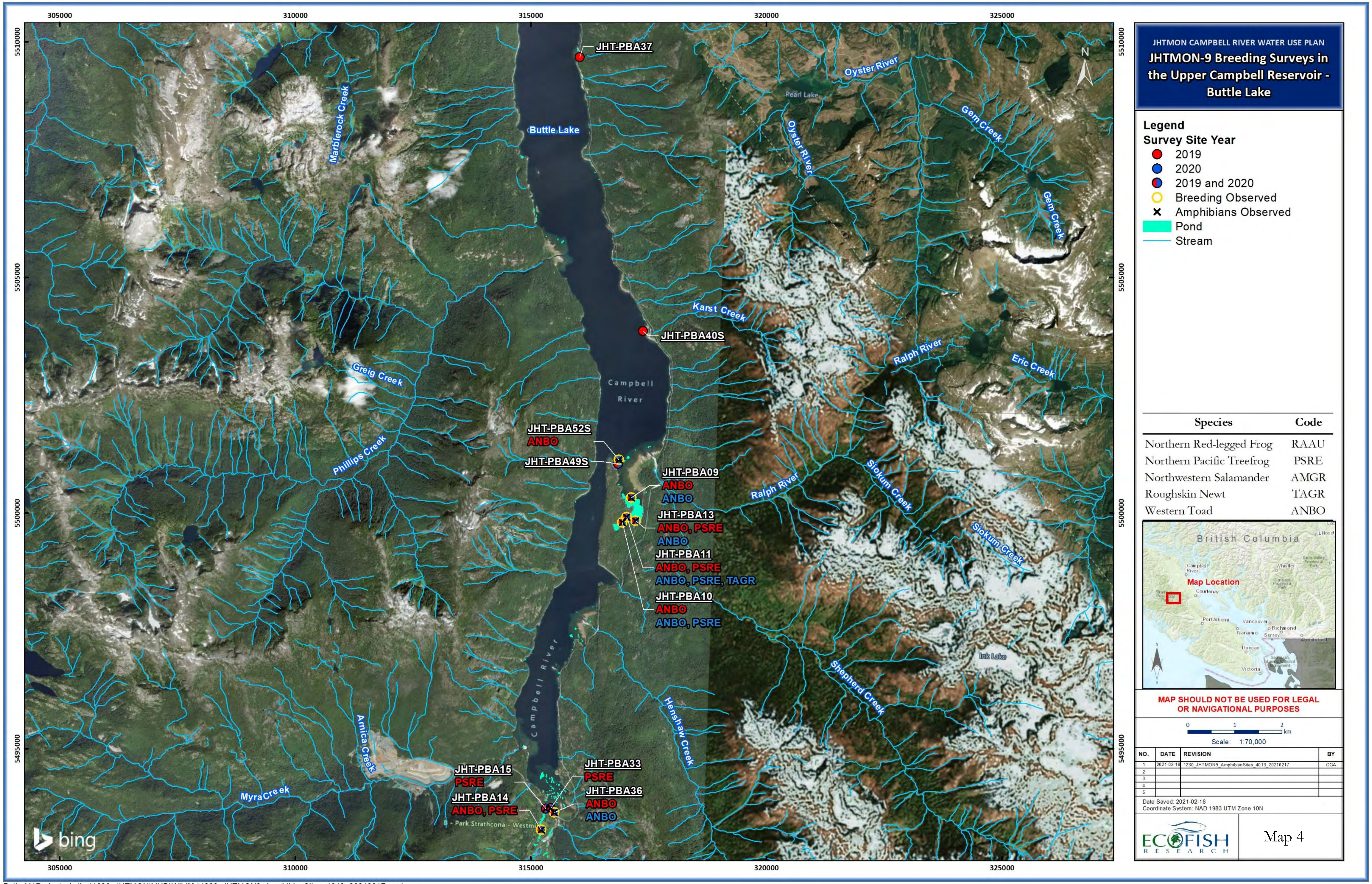

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Appendix A. Summary of habitat, range, and status of amphibian species in the Project area

LIST OF TABLES

Table 1. Amphibian species summaries (CDC 2021).

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Habitat	Range
Long-toed Salamander	*Ambystoma macrodactylum*	Yellow	Not at Risk		Found in a wide variety of habitats, from semiarid sagebrush deserts to sub-alpine meadows, including dry woodlands, humid forests, and rocky shores of mountain lakes. Adults are subterranean except during the breeding season. Breeds in temporary or permanent ponds, or in quiet water at the edge of lakes and streams. During the breeding season adults may be found under logs, rocks, and other debris near water. Eggs are attached to vegetation or loose on bottom.	Range extends from southeastern Alaska southward to Tuolumne County, California, east to Rocky Mountains (east to east-central British Columbia, west-central Alberta, western Montana, and central Idaho).
Northern Pacific Treefrog	*Pseudacris regilla*	Yellow			Occupy a wide variety of habitats, including grassland, shrubland, woodland, forest, and farmland. Females deposit eggs in shallow water of marshes, lakes, ponds, ditches, reservoirs and slow-moving streams (Stebbins 2003).	Range extends from southern British Columbia in Canada southward through the United States to southern Baja California, Mexico, and east to Montana, Idaho, and Nevada.
Northern Red-legged Frog	*Rana aurora*	Blue	Special Concern	Special Concern	Habitat includes the vicinity of permanent waters of stream pools, marshes, ponds, and other quiet bodies of water. This frog regularly occurs in damp woods and meadows some distance from water, especially during wet weather. Individuals (especially juveniles) seasonally can be found in and near ephemeral pools. Breeding sites most often are in permanent water; eggs are attached to stiff submerged stems at the surface of the water.	Range extends from southwestern British Columbia, including Vancouver Island in Canada, south along the coast of the United States (primarily west of Cascade-Sierran crest), to northwestern California.

Table 1. Continued.

English Name	Scientific Name	BC List	COSEWIC	SARA Status	Habitat	Range
Northwestern Salamander	*Ambystoma gracile*	Yellow	Not at Risk		Open grassland, woodland, and forest near breeding ponds. Nonpaedomorphic adults are underground most of the year. During the breeding season, they often are found under rocks and logs. Eggs are laid in ponds, lakes, and slow-moving streams; usually attached to vegetation in shallows (Blaustein *et al.* 1995) or deeper water (e.g., 0.5-1.0 m below water surface) (Nussbaum *et al.* 1983).	Range includes the Pacific coast of North America from extreme southeastern Alaska south through western Canada and the northwestern United States (mainly west of the Cascades) to the Gualala River, California, at elevations from sea level to about 10,200 feet (3,110 meters) (Stebbins 2003).
Roughskin Newt	*Taricha granulosa*	Yellow			Rough-skinned newts inhabit various wooded and open valley habitats that include the required aquatic breeding habitat, such as lakes, reservoirs, ponds, and stream pools or backwaters. They generally spend most of their lives on land, but in some areas adults may be aquatic throughout the year or during the dry season. Breeding females attach eggs singly on aquatic plants or submerged twigs.	Range includes the Pacific coast of North America from southeastern Alaska to Santa Cruz County, California.
Western Toad	*Anaxyrus boreas*	Yellow	Special Concern	Special Concern	Western toads occur in a wide variety of habitats ranging from desert springs to mountain wetlands. They range into various upland habitats around ponds, lakes, reservoirs, and slow-moving rivers and streams; sometimes they move up to a few kilometers through uplands. Egg laying sites include shallow areas of ponds, lakes, or reservoirs, or pools of slow-moving streams.	Extends along the Pacific Coast from southern Alaska to Baja California, and eastward through the Rocky Mountains to west-central Alberta, Montana, Wyoming, Utah and Colorado.

Appendix B. Drawdown Zone Pond Attributes

LIST OF TABLES

Table 1. Attributes of drawdown zone ponds in the Lower Campbell Reservoir.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
388	JHT-PBA25	175.8	17,980	Ephemeral
389	JHT-PBA55	176.1	61	Ephemeral
390	n/a	180.0	138	Ephemeral
391	n/a	176.2	322	Ephemeral
392	n/a	176.0	507	Ephemeral
393	n/a	176.0	172	Ephemeral
394	n/a	176.0	1,023	Ephemeral
395	n/a	176.1	720	Ephemeral
396	n/a	176.0	103	Ephemeral
397	JHT-PBA30	175.2	2,158	Permanent
398	n/a	175.2	920	Ephemeral
399	JHT-PBA31	175.2	2,080	Permanent
400	n/a	175.2	253	Ephemeral
401	n/a	175.2	320	Ephemeral
402	n/a	177.0	140	Ephemeral
403	n/a	175.8	50	Ephemeral
404	n/a	177.0	490	Ephemeral
405	n/a	176.7	261	Ephemeral
406	n/a	176.4	130	Ephemeral
407	n/a	177.0	33	Ephemeral
408	JHT-PBA23	174.5	4,018	Ephemeral
410	n/a	177.0	22	Ephemeral
411	n/a	176.5	885	Ephemeral
412	n/a	176.3	36	Ephemeral
417	n/a	175.0	1,405	Ephemeral
418	n/a	175.0	5,191	Ephemeral
419	n/a	177.5	2,107	Permanent
426	JHT-PBA25	176.5	139	Ephemeral
427	n/a	177.2	424	Ephemeral
428	n/a	176.3	895	Ephemeral

Table 1. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
429	n/a	176.3	487	Ephemeral
430	n/a	178.0	36,209	Permanent
431	n/a	178.5	138	Permanent
432	n/a	176.5	416	Permanent
433	n/a	176.5	496	Permanent
434	JHT-PBA22	177.7	18,589	Permanent
435	n/a	176.5	1,004	Permanent

Table 2. Attributes of drawdown zone ponds in the Upper Campbell Reservoir.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
1	JHT-PBA07	215.7	1,924	Ephemeral
2	JHT-PBA57	216.8	1,227	Ephemeral
3	n/a	211.8	82	Ephemeral
4	JHT-PBA58	216.5	716	Ephemeral
5	n/a	212.9	28	Ephemeral
6	n/a	214.4	76	Ephemeral
7	JHT-PBA59	216.8	655	Ephemeral
8	n/a	219.9	96	Ephemeral
9	n/a	215.8	678	Ephemeral
10	n/a	219.9	17	Ephemeral
11	n/a	215.8	424	Permanent
12	n/a	220.0	53	Ephemeral
13	n/a	220.1	381	Ephemeral
14	n/a	216.8	48	Ephemeral
15	n/a	213.6	2,133	Ephemeral
16	n/a	211.8	383	Ephemeral
17	n/a	213.7	548	Ephemeral
18	n/a	213.7	79	Ephemeral
19	n/a	218.4	87	Ephemeral
20	n/a	214.0	87	Ephemeral
21	n/a	215.6	38	Ephemeral
22	n/a	214.5	21	Ephemeral
23	n/a	215.7	0	Ephemeral
24	n/a	215.7	0	Ephemeral
25	n/a	215.7	0	Ephemeral
26	n/a	212.2	859	Ephemeral
27	n/a	211.9	859	Ephemeral
28	n/a	211.8	315	Ephemeral
29	n/a	212.0	72	Ephemeral
30	n/a	211.9	18	Ephemeral
31	n/a	215.8	578	Ephemeral
32	n/a	212.3	75	Ephemeral
33	n/a	215.8	10	Ephemeral
34	n/a	212.0	9,176	Ephemeral
35	n/a	212.0	19	Ephemeral

Table 2. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
36	n/a	215.8	7	Ephemeral
37	n/a	213.1	56	Ephemeral
38	n/a	215.8	13	Ephemeral
39	n/a	212.3	1,887	Ephemeral
40	n/a	212.3	47	Ephemeral
41	n/a	212.1	40	Ephemeral
42	n/a	212.4	1,496	Ephemeral
44	n/a	212.4	66	Ephemeral
46	n/a	212.4	15	Ephemeral
51	n/a	215.9	12	Ephemeral
64	n/a	215.7	27	Ephemeral
65	n/a	215.6	2	Ephemeral
71	n/a	215.9	3	Ephemeral
94	JHT-PBA19	215.8	1,150	Ephemeral
95	JHT-PBA60	217.9	1,418	Ephemeral
96	JHT-PBA29	220.4	719	Ephemeral
97	JHT-PBA21	216.8	1,816	Ephemeral
98	JHT-PBA17	219.7	784	Permanent
99	n/a	217.7	63	Ephemeral
100	n/a	219.0	846	Ephemeral
101	n/a	211.9	545	Ephemeral
102	n/a	212.1	347	Ephemeral
103	n/a	218.9	3,742	Permanent
104	n/a	219.8	92	Ephemeral
105	n/a	219.1	2,180	Permanent
106	n/a	220.1	475	Ephemeral
107	n/a	214.5	30	Ephemeral
108	n/a	214.9	30	Ephemeral
109	n/a	216.8	285	Ephemeral
110	n/a	215.7	54	Ephemeral
111	n/a	211.9	535	Ephemeral
112	n/a	211.9	115	Ephemeral
113	n/a	211.9	817	Ephemeral
114	n/a	211.9	529	Ephemeral
115	n/a	211.9	3,357	Ephemeral
116	n/a	211.9	4,301	Ephemeral

Table 2. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
117	n/a	212.9	6,570	Ephemeral
118	n/a	216.8	12	Ephemeral
119	n/a	216.8	101	Ephemeral
120	n/a	216.8	89	Ephemeral
121	n/a	216.8	155	Ephemeral
122	n/a	216.8	42	Ephemeral
123	n/a	211.9	312	Ephemeral
124	n/a	216.8	285	Ephemeral
125	n/a	211.9	147	Ephemeral
126	n/a	217.2	38	Ephemeral
127	n/a	215.8	459	Ephemeral
128	n/a	212.0	54	Ephemeral
129	n/a	212.2	1,241	Ephemeral
130	n/a	216.3	211	Ephemeral
131	n/a	216.3	103	Ephemeral
132	n/a	212.2	2,664	Ephemeral
133	JHT-PBA61	215.7	2,476	Ephemeral
134	n/a	215.8	139	Ephemeral
135	n/a	213.0	67	Ephemeral
137	n/a	216.8	42	Ephemeral
138	n/a	216.8	15	Ephemeral
409	n/a	175.0	356	Ephemeral
413	n/a	176.0	54	Ephemeral
414	n/a	176.0	1,274	Permanent
415	JHT-PBA20	176.0	7,864	Permanent
416	n/a	175.8	514	Ephemeral
420	n/a	176.2	214	Ephemeral
421	JHT-PBA70	177.5	495	Ephemeral
422	JHT-PBA71	176.9	301	Ephemeral
423	n/a	176.6	88	Permanent
424	JHT-PBA08	176.7	363	Permanent
425	JHT-PBA16	178.2	97	Permanent
436	n/a	215.6	1,483	Ephemeral
438	n/a	217.6	61	Ephemeral
445	JHT-PBA51	220.0	819	Permanent
446	JHT-PBA50	219.5	785	Permanent

Table 3. Attributes of drawdown zone ponds in the Upper Campbell Reservoir - Buttle Lake.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
136	JHT-PBA38	215.8	212	Ephemeral
139	JHT-PBA06	215.8	1,043	Permanent
140	JHT-PBA18	215.8	1,101	Permanent
141	n/a	215.8	10	Permanent
142	n/a	216.8	90	Ephemeral
143	n/a	216.8	8	Ephemeral
144	JHT-PBA18	216.8	875	Ephemeral
145	n/a	216.8	62	Ephemeral
146	JHT-PBA79	216.8	544	Ephemeral
147	n/a	216.8	86	Ephemeral
148	n/a	216.8	48	Ephemeral
149	n/a	216.8	16	Ephemeral
150	JHT-PBA79	216.8	98	Ephemeral
151	n/a	215.8	8	Ephemeral
152	n/a	215.8	47	Ephemeral
153	n/a	215.8	663	Ephemeral
154	n/a	218.3	361	Ephemeral
155	n/a	216.1	98	Ephemeral
156	JHT-PBA01	216.4	1,655	Ephemeral
157	JHT-PBA02	216.2	1,135	Ephemeral
158	n/a	217.2	50	Ephemeral
159	n/a	217.2	173	Ephemeral
160	JHT-PBA03	216.6	7,149	Ephemeral
161	n/a	215.8	132	Ephemeral
162	n/a	216.8	10	Ephemeral
163	n/a	215.7	64	Ephemeral
164	n/a	215.7	2,606	Ephemeral
165	n/a	216.8	118	Ephemeral
166	n/a	214.9	251	Ephemeral
167	n/a	215.7	2,572	Ephemeral
168	n/a	216.9	32	Ephemeral
169	n/a	216.9	79	Ephemeral
170	n/a	217.6	79	Ephemeral
171	n/a	215.7	87	Ephemeral
172	n/a	215.8	567	Ephemeral

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
173	n/a	215.6	89	Ephemeral
174	n/a	215.6	508	Ephemeral
175	n/a	215.7	278	Ephemeral
176	n/a	216.8	20	Ephemeral
177	n/a	216.8	31	Ephemeral
178	n/a	215.6	1,969	Ephemeral
179	n/a	215.6	29	Ephemeral
180	n/a	215.6	311	Ephemeral
181	n/a	216.8	24	Ephemeral
182	n/a	215.6	110	Ephemeral
183	n/a	215.7	0	Ephemeral
184	n/a	215.6	82	Ephemeral
185	n/a	216.8	234	Ephemeral
186	n/a	216.8	87	Ephemeral
187	n/a	216.8	49	Ephemeral
188	n/a	216.8	150	Ephemeral
189	n/a	215.6	20	Ephemeral
190	n/a	215.6	326	Ephemeral
191	n/a	216.8	38	Ephemeral
192	n/a	216.8	16	Ephemeral
193	n/a	216.8	8	Ephemeral
194	n/a	216.8	27	Ephemeral
195	n/a	216.8	40	Ephemeral
196	n/a	216.8	61	Ephemeral
197	n/a	216.8	26	Ephemeral
198	n/a	216.8	127	Ephemeral
199	n/a	216.8	33	Ephemeral
200	n/a	216.8	18	Ephemeral
201	n/a	216.8	247	Ephemeral
202	n/a	215.6	32	Ephemeral
203	n/a	215.6	27	Ephemeral
204	n/a	215.6	96	Ephemeral
205	n/a	215.6	27	Ephemeral
206	n/a	215.8	61	Ephemeral
207	n/a	215.6	96	Ephemeral

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
208	n/a	216.8	77	Ephemeral
209	n/a	215.8	34	Ephemeral
210	n/a	215.8	47	Ephemeral
211	n/a	216.8	55	Ephemeral
212	n/a	216.8	132	Ephemeral
213	n/a	216.8	89	Ephemeral
214	n/a	216.8	10	Ephemeral
215	n/a	216.8	131	Ephemeral
216	n/a	215.8	46	Ephemeral
217	n/a	215.1	565	Ephemeral
218	n/a	215.2	88	Ephemeral
219	n/a	214.6	29	Ephemeral
220	n/a	214.6	29	Ephemeral
221	n/a	218.2	67	Ephemeral
222	n/a	216.3	311	Ephemeral
223	n/a	217.3	979	Ephemeral
224	n/a	216.7	28	Ephemeral
225	n/a	214.6	10	Ephemeral
226	n/a	214.6	19	Ephemeral
227	n/a	217.2	19	Ephemeral
228	n/a	217.3	135	Ephemeral
229	n/a	215.8	54	Ephemeral
230	n/a	217.4	80	Ephemeral
231	n/a	218.2	79	Ephemeral
232	n/a	216.8	59	Ephemeral
233	n/a	215.8	92	Ephemeral
234	n/a	215.8	697	Ephemeral
235	n/a	215.8	53	Ephemeral
236	n/a	215.8	102	Ephemeral
237	n/a	215.8	10	Ephemeral
238	JHT-PBA54	215.8	1,091	Ephemeral
239	n/a	215.8	157	Ephemeral
240	n/a	215.8	194	Ephemeral
241	n/a	220.1	44	Ephemeral
242	n/a	214.6	7	Ephemeral

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
243	n/a	214.6	12	Ephemeral
244	n/a	217.6	30	Ephemeral
246	JHT-PBA11	218.3	2,874	Permanent
247	JHT-PBA13	216.5	633	Permanent
248	JHT-PBA10	220.5	13,025	Permanent
249	n/a	215.6	44	Ephemeral
250	n/a	216.8	3	Ephemeral
251	n/a	214.9	7	Ephemeral
252	n/a	219.5	232	Ephemeral
253	n/a	216.9	10	Ephemeral
254	n/a	216.8	26	Ephemeral
255	n/a	216.8	92	Ephemeral
256	n/a	216.9	319	Ephemeral
257	n/a	216.8	13	Ephemeral
258	n/a	216.8	6	Ephemeral
259	n/a	216.8	13	Ephemeral
260	n/a	214.9	772	Ephemeral
261	n/a	216.8	12	Ephemeral
262	n/a	216.8	6	Ephemeral
263	n/a	216.8	5	Ephemeral
264	n/a	216.1	5	Ephemeral
265	n/a	216.8	52	Ephemeral
266	n/a	216.8	21	Ephemeral
267	n/a	214.6	12	Ephemeral
268	n/a	215.8	15	Ephemeral
269	n/a	214.6	33	Ephemeral
270	n/a	214.6	7	Ephemeral
272	n/a	214.6	17	Ephemeral
273	n/a	214.6	7	Ephemeral
274	n/a	215.5	226	Ephemeral
275	n/a	218.7	184	Ephemeral
276	n/a	215.8	30	Ephemeral
277	n/a	215.8	59	Ephemeral
278	n/a	215.7	46	Ephemeral
279	n/a	214.5	4,207	Ephemeral

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
280	n/a	215.7	18	Ephemeral
281	n/a	215.7	8	Ephemeral
282	n/a	215.7	11	Ephemeral
283	n/a	214.8	138	Ephemeral
284	n/a	215.7	267	Ephemeral
285	n/a	215.7	6	Ephemeral
286	n/a	215.7	28	Ephemeral
287	n/a	215.7	17	Ephemeral
288	n/a	215.7	45	Ephemeral
289	n/a	215.7	51	Ephemeral
290	n/a	215.7	40	Ephemeral
291	n/a	215.7	42	Ephemeral
292	n/a	215.7	52	Ephemeral
293	n/a	215.7	9	Ephemeral
294	n/a	215.7	62	Ephemeral
295	n/a	215.7	27	Ephemeral
296	n/a	215.8	23	Ephemeral
297	n/a	215.7	16	Ephemeral
298	n/a	215.8	38	Ephemeral
299	n/a	215.8	5	Ephemeral
300	n/a	215.8	49	Ephemeral
301	n/a	215.8	5	Ephemeral
302	n/a	215.8	8	Ephemeral
303	n/a	215.8	11	Ephemeral
304	n/a	215.8	9	Ephemeral
305	n/a	215.9	54	Ephemeral
306	n/a	215.3	21	Ephemeral
307	n/a	215.3	11	Ephemeral
308	n/a	216.8	25	Ephemeral
309	n/a	216.8	9	Ephemeral
310	n/a	216.8	5	Ephemeral
311	n/a	215.9	30	Ephemeral
312	n/a	215.7	25	Ephemeral
313	n/a	216.8	3	Ephemeral
314	n/a	216.8	33	Ephemeral

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
315	n/a	215.8	61	Ephemeral
316	n/a	215.8	26	Ephemeral
317	n/a	216.8	108	Ephemeral
318	n/a	215.8	6	Ephemeral
319	n/a	216.8	27	Ephemeral
320	n/a	215.9	123	Ephemeral
321	n/a	216.8	14	Ephemeral
322	n/a	216.8	74	Ephemeral
323	n/a	216.8	3	Ephemeral
324	n/a	216.8	3	Ephemeral
325	n/a	215.8	60	Ephemeral
326	n/a	216.8	21	Ephemeral
327	n/a	216.8	8	Ephemeral
328	n/a	215.8	10	Ephemeral
329	n/a	216.8	1	Ephemeral
330	n/a	215.8	13	Ephemeral
331	n/a	216.0	33	Ephemeral
332	n/a	216.8	97	Ephemeral
333	n/a	215.8	61	Ephemeral
334	n/a	216.8	2	Ephemeral
335	n/a	215.8	38	Ephemeral
336	n/a	216.8	300	Ephemeral
337	n/a	216.8	26	Ephemeral
338	n/a	217.3	59	Ephemeral
339	n/a	216.8	36	Ephemeral
340	n/a	216.8	14	Ephemeral
341	n/a	216.8	50	Ephemeral
342	n/a	217.0	393	Ephemeral
343	n/a	216.8	11	Ephemeral
344	n/a	216.7	9	Ephemeral
345	n/a	216.7	29	Ephemeral
346	JHT-PBA15	217.3	1,041	Permanent
347	n/a	217.3	37	Ephemeral
348	n/a	216.9	28	Ephemeral
349	n/a	217.0	22	Ephemeral

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
350	n/a	217.0	28	Ephemeral
351	JHT-PBA33	217.3	216	Permanent
352	JHT-PBA36	217.4	185	Permanent
353	JHT-PBA32	217.2	218	Permanent
354	n/a	217.2	29	Ephemeral
355	JHT-PBA14	218.4	6,840	Permanent
356	n/a	220.0	25	Ephemeral
357	n/a	220.0	24	Ephemeral
358	JHT-PBA14	218.7	651	Permanent
359	n/a	220.0	57	Ephemeral
360	n/a	220.0	15	Ephemeral
361	n/a	218.9	356	Permanent
362	n/a	220.0	506	Permanent
363	n/a	219.2	563	Permanent
364	n/a	220.0	39	Permanent
365	n/a	220.0	301	Permanent
366	n/a	219.5	1,477	Permanent
367	n/a	220.0	7	Ephemeral
368	n/a	220.0	4	Ephemeral
370	n/a	220.0	61	Permanent
371	n/a	220.0	63	Permanent
372	n/a	220.0	50	Permanent
373	n/a	220.0	28	Permanent
374	n/a	220.0	179	Permanent
375	n/a	220.0	36	Permanent
376	n/a	219.4	94	Ephemeral
377	n/a	220.0	276	Permanent
378	n/a	220.2	59	Ephemeral
379	n/a	220.0	76	Permanent
380	n/a	220.2	8	Ephemeral
381	n/a	220.0	6	Ephemeral
382	n/a	220.0	26	Ephemeral
383	n/a	220.3	263	Permanent
384	n/a	220.0	327	Permanent
385	n/a	220.4	1,968	Permanent

Table 3. Continued.

Pond ID	Site	Mapped Elevation (masl)	Area (m^2)	Permanency
386	JHT-PBA04	216.0	950	Ephemeral
387	JHT-PBA09	216.2	102,300	Permanent
437	n/a	0.0	63,117	Permanent
439	n/a	216.5	1,641	Ephemeral
440	JHT-PBA37	220.5	989	Permanent
441	JHT-PBA63	216.6	404	Ephemeral
442	n/a	217.0	206	Ephemeral
443	n/a	216.9	262	Ephemeral

Appendix C. Amphibian effects metrics for Drawdown Zone Habitats (ponds) in the Upper Campbell and Lower Campbell reservoirs calculated for the post Water Use Plan period (2006 to 2018) by 0.5 m elevation bands

LIST OF FIGURES

Figure 1. Percentage of years (grey bars) that each water elevation zone (0.5 m) in the Upper Campbell Reservoir study area was inundated at some point during species-specific egg and larval periods during the post-WUP period (2006-2018). The distribution of ponds by type and elevation strata are shown as coloured bars.

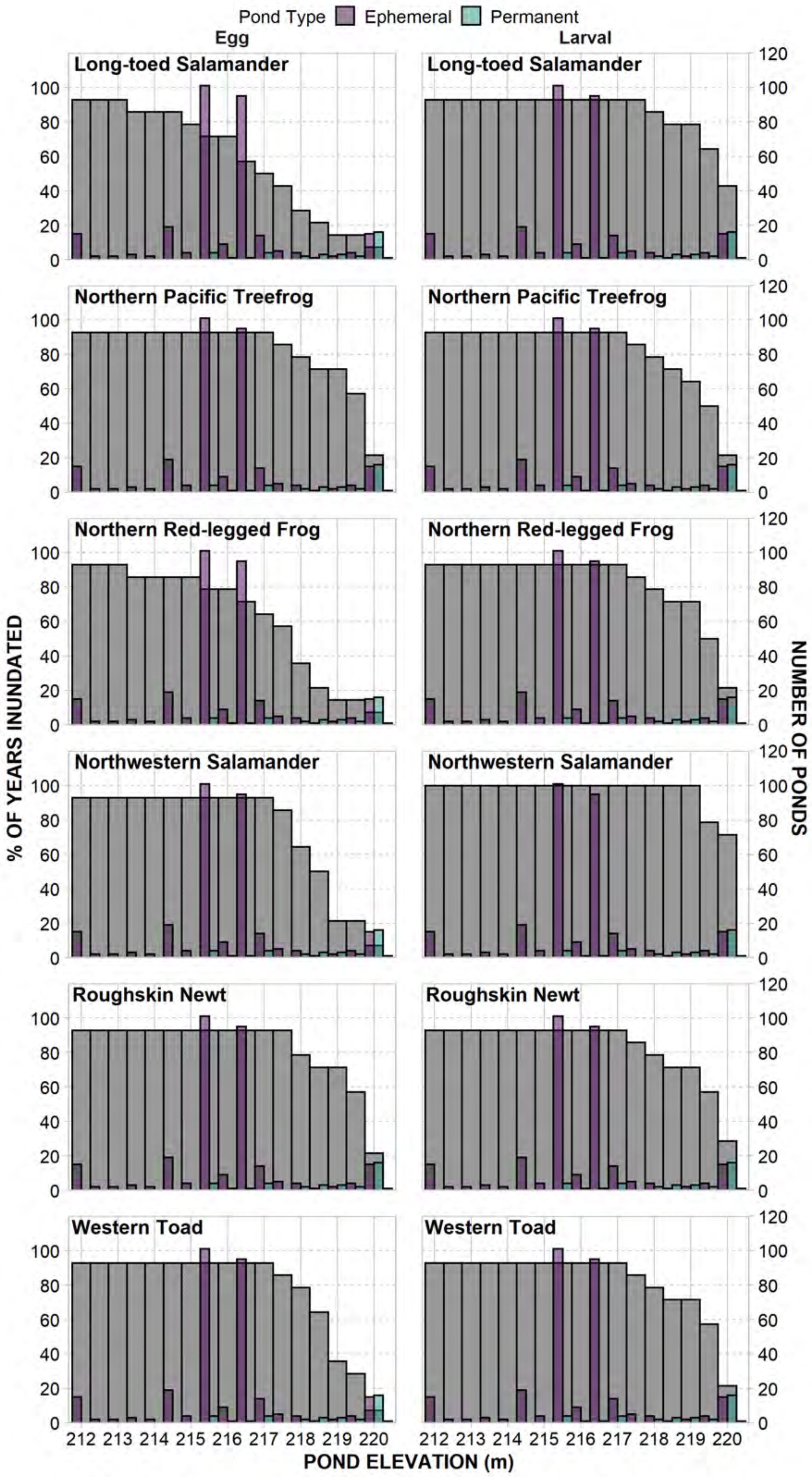


Figure 2. Percentage of years that each water elevation zone (0.5 m) in the Lower Campbell Reservoir study area was inundated at some point during species-specific egg and larval periods during the post-WUP period (2006-2018; grey bars). The distribution of ponds by type and elevation strata are shown as coloured bars.

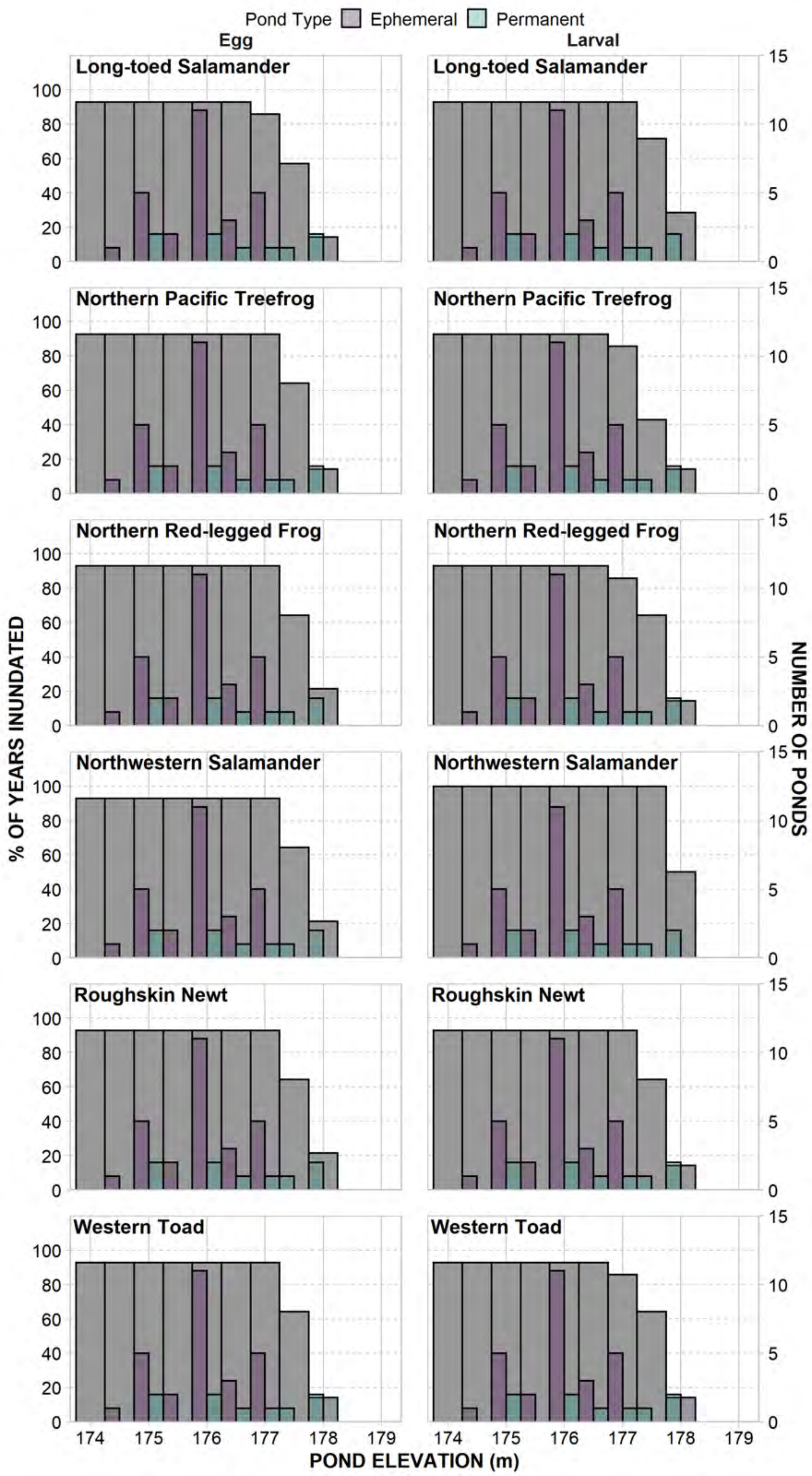


Figure 3. **Percentage of years that each water elevation zone (0.5 m) in the Upper Campbell Reservoir study area transitioned from inundated to exposed during species-specific egg and larval periods during the post-WUP period (2006-2018; grey bars). The distribution of ponds by type and elevation strata are shown as coloured bars.**

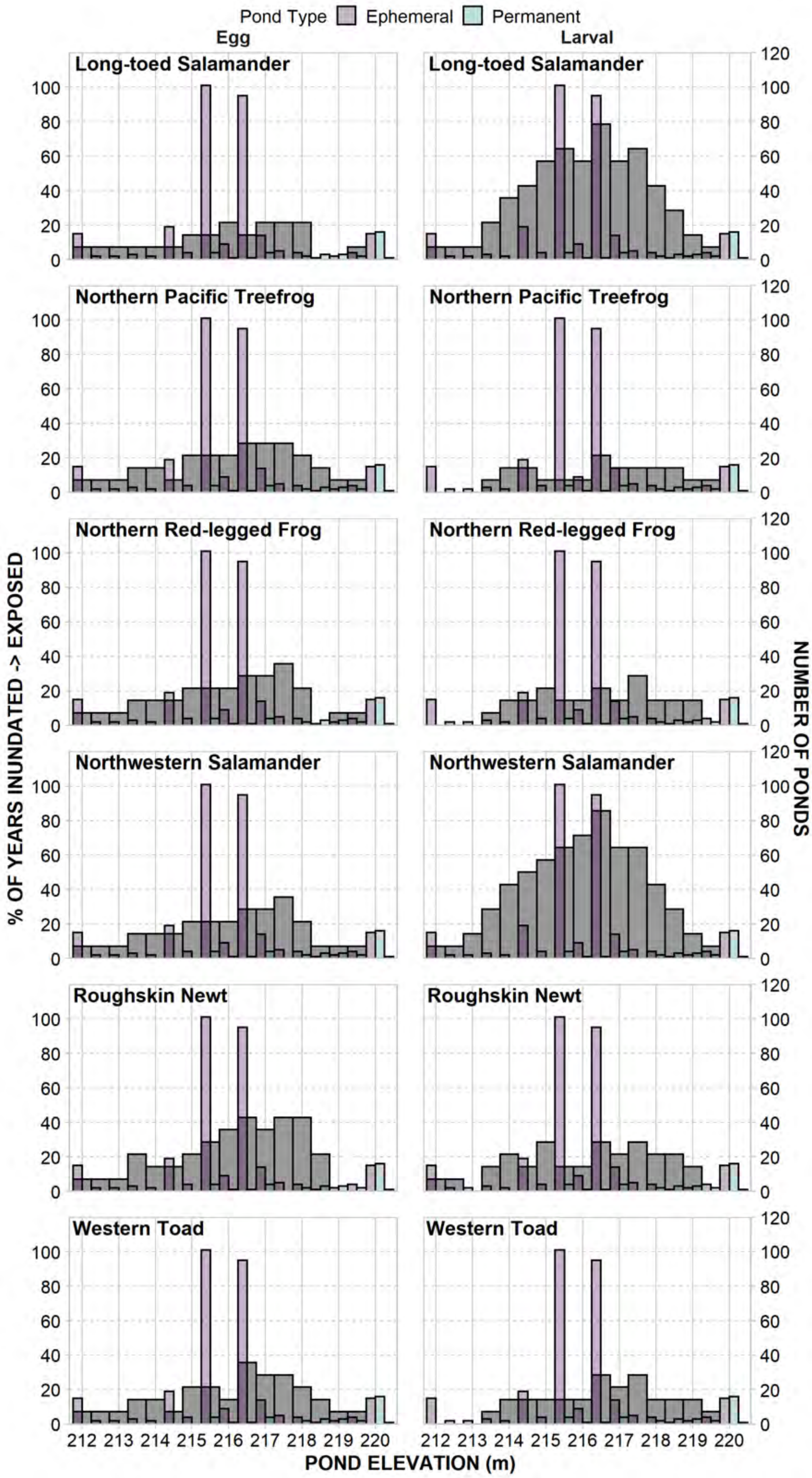


Figure 4. **Percentage of years that each water elevation zone (0.5 m) in the Lower Campbell Reservoir study area transitioned from inundated to exposed during species-specific egg and larval periods during the post-WUP period (2006-2018; grey bars). The distribution of ponds by type and elevation strata are shown as coloured bars.**

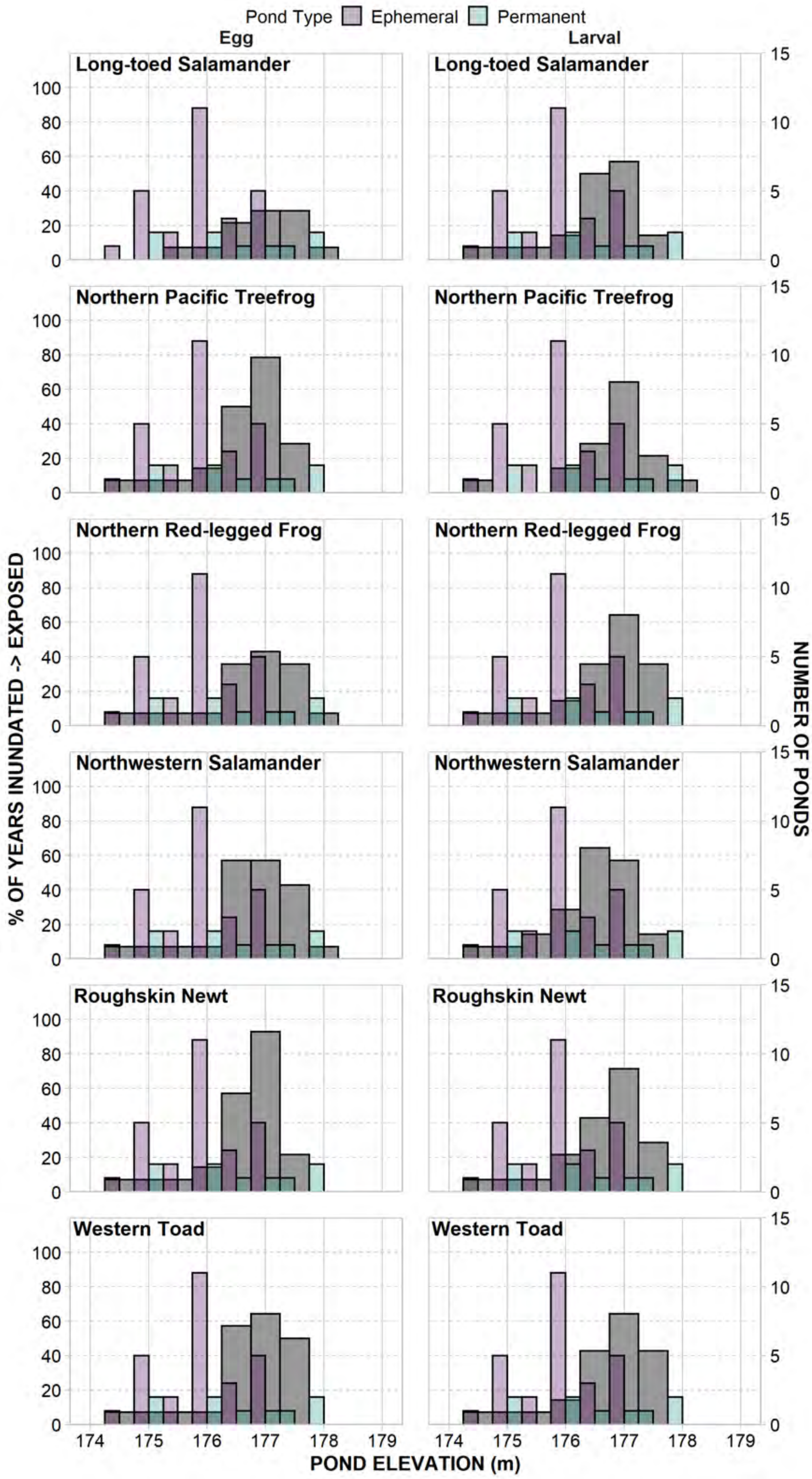


Figure 5. Percentage of years that each water elevation zone (0.5 m) in the Upper Campbell Reservoir study area transitioned from exposed to inundated during species-specific egg and larval periods during the post-WUP period (2006-2018; grey bars). The distribution of ponds by type and elevation zone are shown as coloured bars.

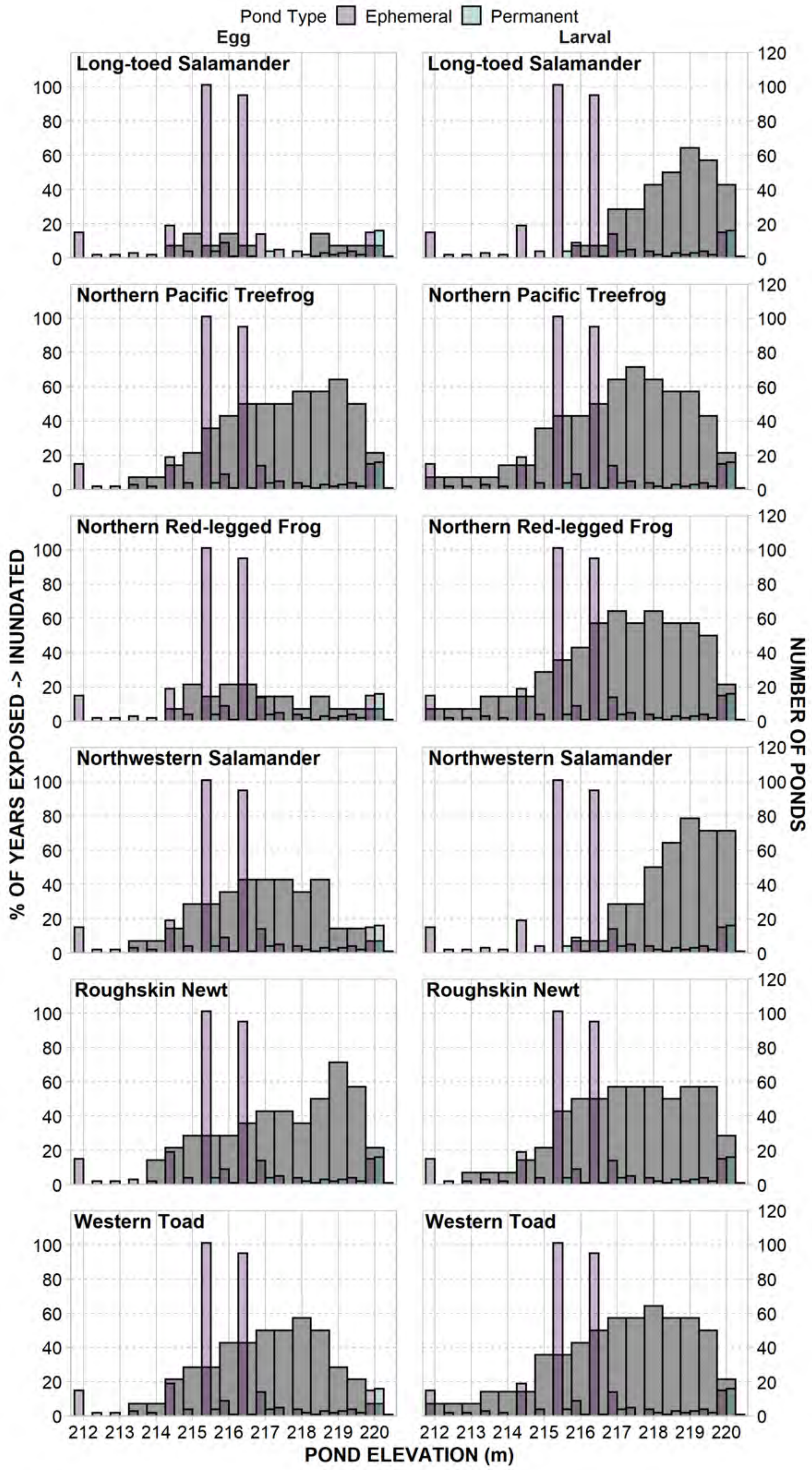


Figure 6. Percentage of years that each water elevation zone (0.5 m) in the Lower Campbell Reservoir study area transitioned from exposed to inundated during species-specific egg and larval periods during the post-WUP period (2006-2018; grey bars). The distribution of ponds by type and elevation strata are shown as coloured bars.

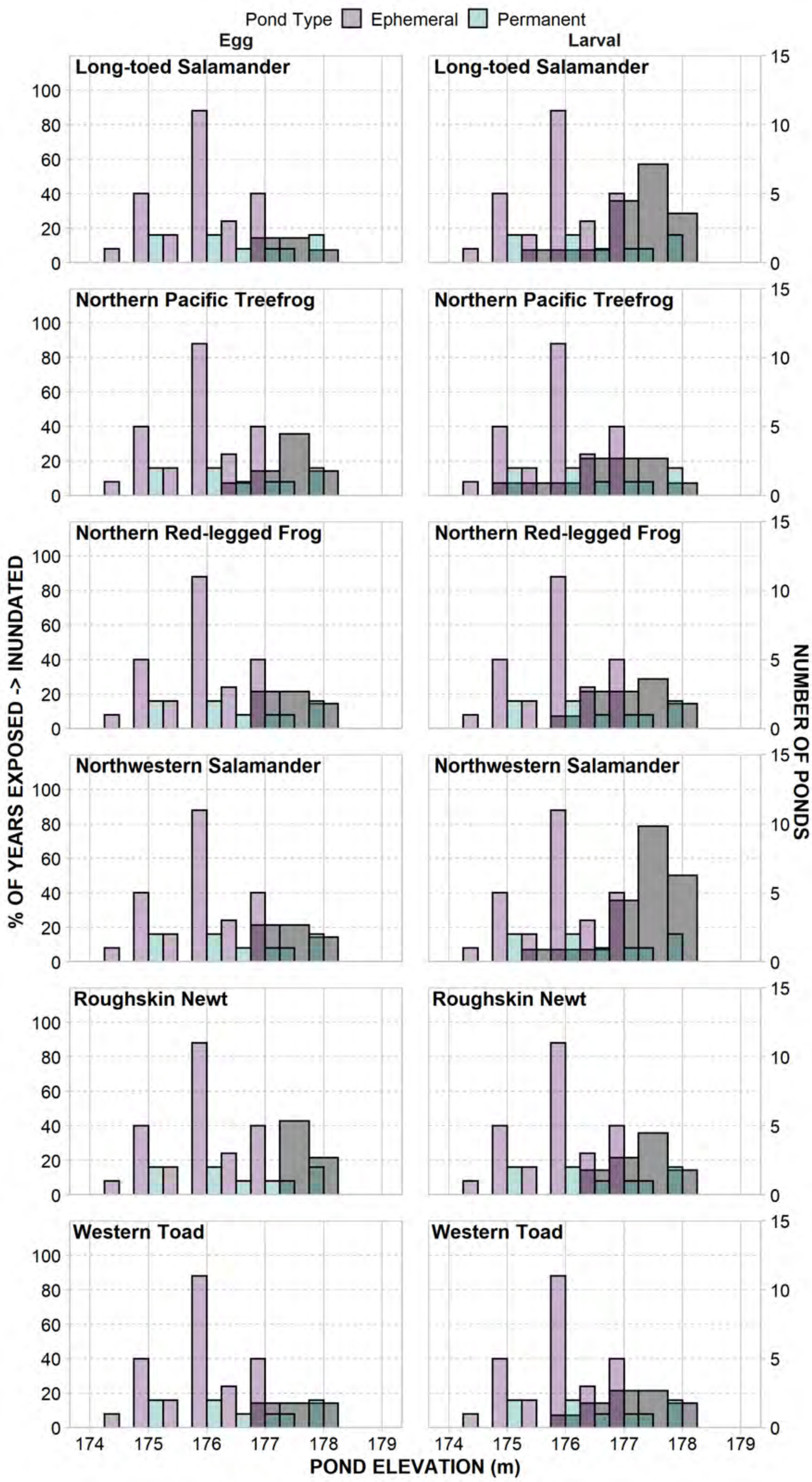


Figure 7. **Minimum (purple points) and maximum (green points) dates of the first annual transition from inundated to exposed for each water level zone (0.5 m) in Upper Campbell Reservoir within each species-specific breeding period. Results are shown for years when a transition occurred, calculated for the post-WUP period (2006-2018). Solid vertical lines delineate species-specific egg and larval periods.**

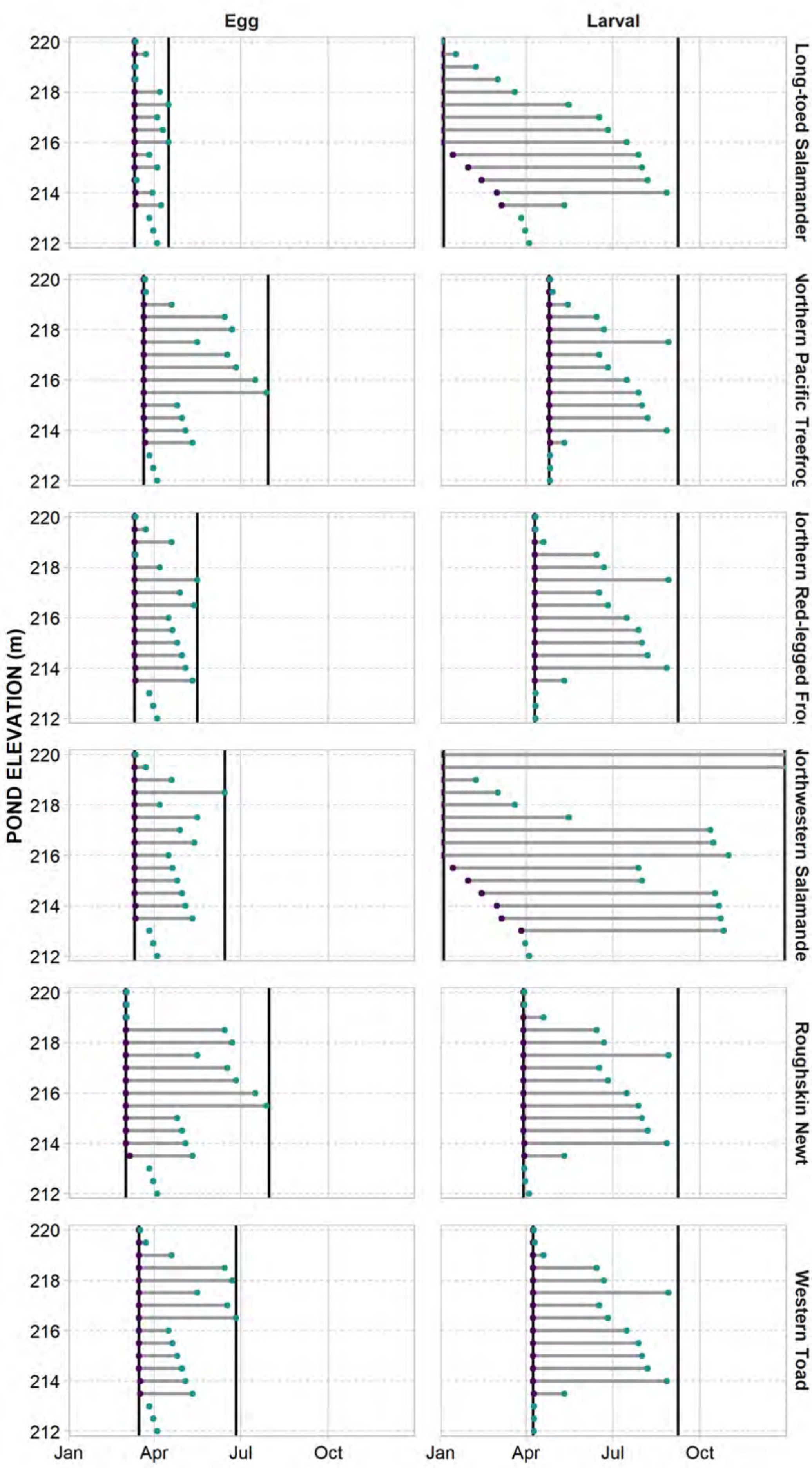


Figure 8. **Minimum (purple points) and maximum (green points) dates of the first annual transition from inundated to exposed for each water level zone (0.5 m) in Lower Campbell Reservoir within each species-specific breeding period. Results are shown for years when a transition occurred, calculated for the post-WUP period (2006-2018). Solid vertical lines delineate species-specific egg and larval periods.**

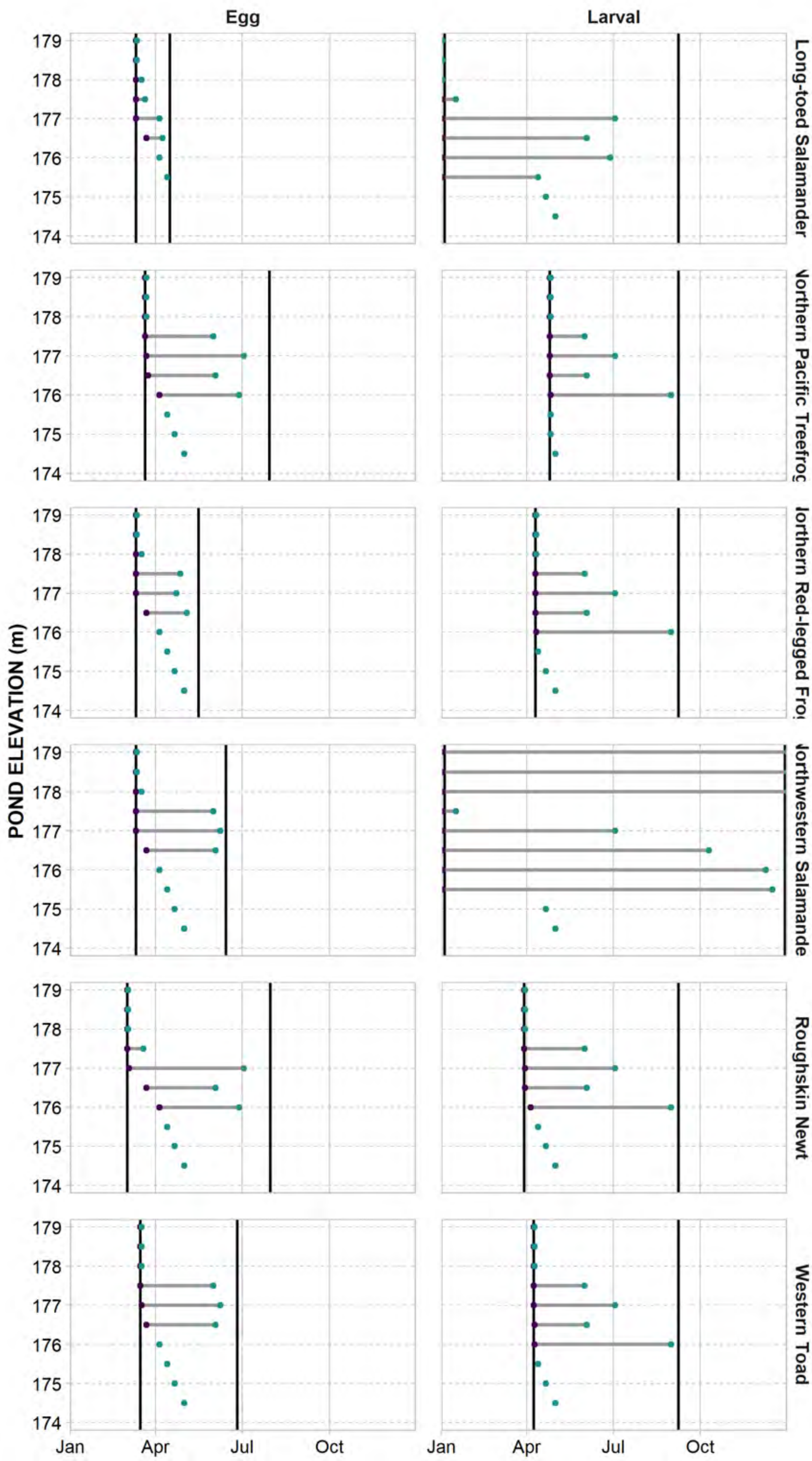


Figure 9. **Minimum (purple points) and maximum (green points) dates of the first annual transition from exposed to inundated for each water level zone (0.5 m) in Upper Campbell Reservoir within each species-specific breeding period. Results are shown for years when a transition occurred, calculated for the post-WUP period (2006-2018). Solid vertical lines delineate species-specific egg and larval periods.**

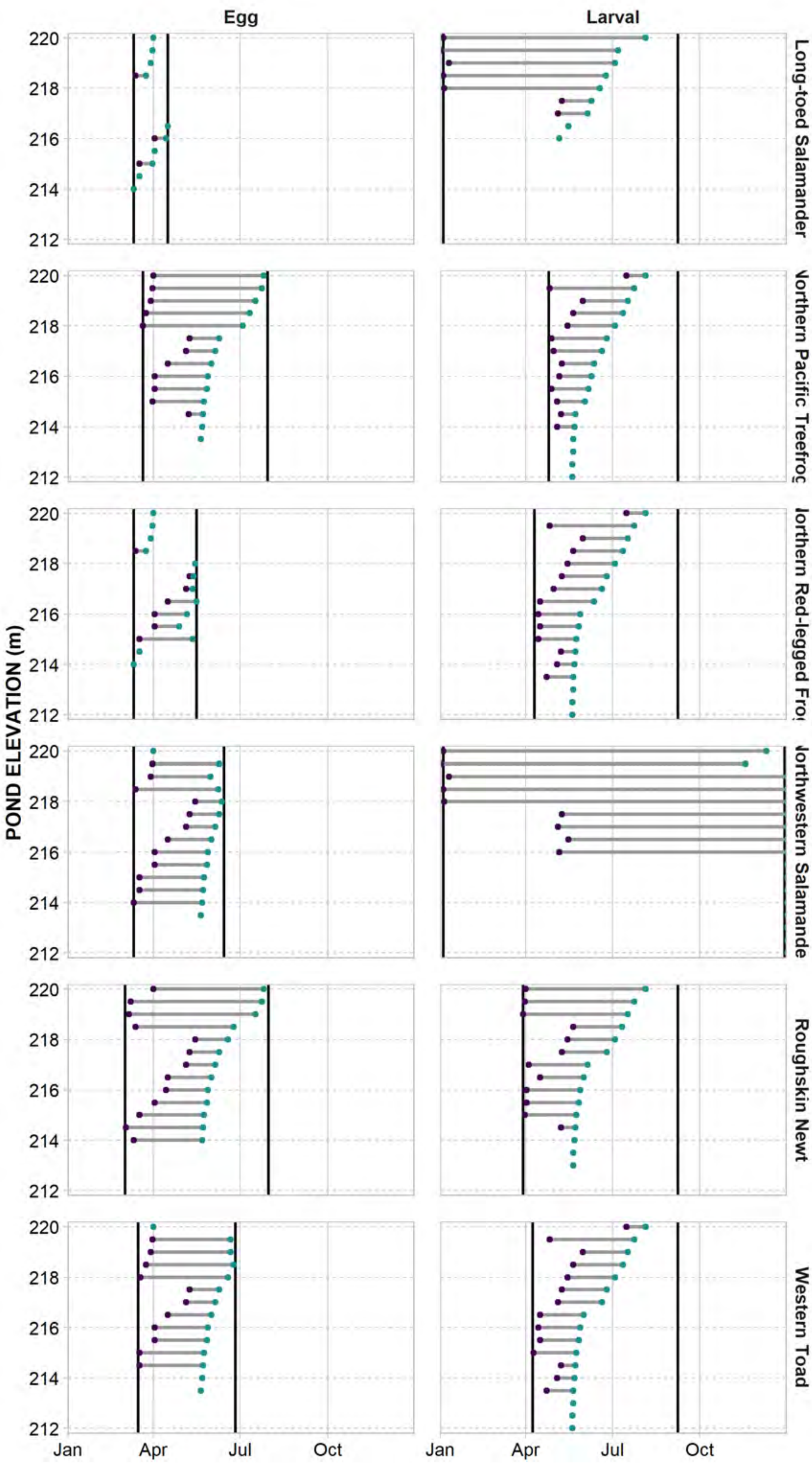
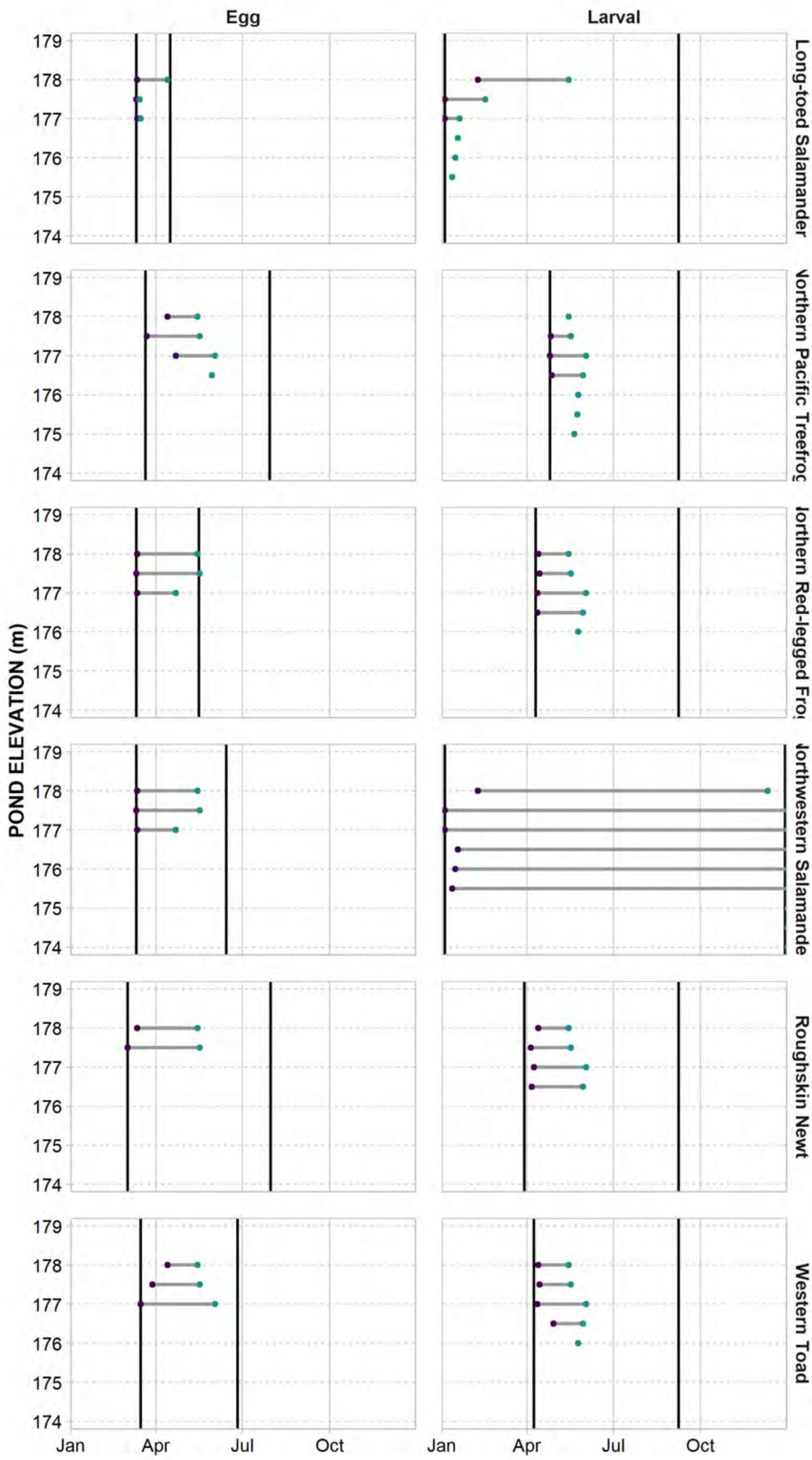


Figure 10. Minimum (purple points) and maximum (green points) dates of the first annual transition from exposed to inundated for water level strata (0.5 m bins) in Lower Campbell Reservoir within each species-specific breeding period. Results are shown for years when a transition occurred, calculated for the post-WUP period (2006-2018). Solid vertical lines delineate species-specific egg and larval periods.



Appendix D. Amphibian effect metrics for Drawdown Zone Habitats (ponds) in the Upper Campbell and Lower Campbell reservoirs calculated for the post Water Use Plan period (2006 to 2018) by 0.5 m elevation bands

TABLE OF CONTENTS

LIST OF TABLES

OVERVIEW

The tables in this appendix provide the probability of non-inundation, the probabilities of transitioning between inundated condition (flooded by water from the reservoir) and exposed condition (isolated from the reservoir), and the average, minimum, and maximum timing of making such transitions for the post-WUP period by 0.5 m elevation band for each study area and for each life stage of each amphibian species. To interpret the data provided in the following tables, please note that probability of inundation is the inverse of probability of non-inundation. Please also note that the values for % years in the tables are equivalent to probablilities, as they are referred to in the body of the report.

1. UPPER CAMPBELL RESERVOIR

1.1. Long-toed Salamander

1.1.1. Egg Period

Table 1. Amphibian effect metrics for Long-toed Salamander calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Long-toed Salamanders were not detected in the Upper Campbell Reservoir in the egg period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	93	7	0	01-Apr	01-Apr	01-Apr	11-Mar	11-Mar	12-Mar
219.5	86	7	7	31-Mar	31-Mar	31-Mar	11-Mar	12-Mar	23-Mar
219.0	86	7	0	29-Mar	29-Mar	29-Mar	11-Mar	11-Mar	12-Mar
218.5	79	14	0	13-Mar	18-Mar	24-Mar	11-Mar	11-Mar	12-Mar
218.0	71	0	21	NA	NA	NA	11-Mar	14-Mar	07-Apr
217.5	57	0	21	NA	NA	NA	11-Mar	16-Mar	16-Apr
217.0	50	0	21	NA	NA	NA	11-Mar	15-Mar	04-Apr
216.5	43	7	14	16-Apr	16-Apr	16-Apr	11-Mar	15-Mar	10-Apr
216.0	29	14	21	02-Apr	08-Apr	14-Apr	11-Mar	17-Mar	16-Apr
215.5	29	7	14	02-Apr	02-Apr	02-Apr	11-Mar	15-Mar	27-Mar
215.0	21	14	14	17-Mar	24-Mar	31-Mar	11-Mar	18-Mar	04-Apr
214.5	14	7	7	17-Mar	17-Mar	17-Mar	11-Mar	12-Mar	13-Mar
214.0	14	0	7	11-Mar	11-Mar	11-Mar	12-Mar	21-Mar	30-Mar
213.5	14	0	7	NA	NA	NA	12-Mar	25-Mar	08-Apr
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.1.2.Larval Period

Table 2. Amphibian effect metrics for Long-toed Salamander calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Long-toed Salamanders were not detected in the Upper Campbell Reservoir in the larval period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	57	43	0	04-Jan	20-Mar	05-Aug	02-Jan	02-Jan	02-Jan
219.5	36	57	7	02-Jan	15-Mar	07-Jul	02-Jan	03-Jan	17-Jan
219.0	21	64	14	10-Jan	15-Mar	04-Jul	02-Jan	06-Jan	07-Feb
218.5	21	50	29	04-Jan	16-Mar	24-Jun	02-Jan	11-Jan	02-Mar
218.0	14	43	43	05-Jan	18-Apr	18-Jun	02-Jan	26-Jan	20-Mar
217.5	7	29	64	09-May	21-May	09-Jun	02-Jan	14-Feb	16-May
217.0	7	29	57	05-May	18-May	05-Jun	02-Jan	21-Feb	17-Jun
216.5	7	7	79	16-May	16-May	16-May	02-Jan	02-Mar	26-Jun
216.0	7	7	57	06-May	06-May	06-May	02-Jan	02-Mar	16-Jul
215.5	7	0	64	NA	NA	NA	14-Jan	10-Mar	28-Jul
215.0	7	0	57	NA	NA	NA	30-Jan	26-Mar	01-Aug
214.5	7	0	43	NA	NA	NA	13-Feb	03-Apr	07-Aug
214.0	7	0	36	NA	NA	NA	01-Mar	24-Apr	27-Aug
213.5	7	0	21	NA	NA	NA	06-Mar	08-Apr	11-May
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.2. Northern Pacific Treefrog

1.2.1. Egg Period

Table 3. Amphibian effect metrics for Northern Pacific Treefrog calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	79	21	0	01-Apr	14-Jun	26-Jul	21-Mar	21-Mar	22-Mar
219.5	43	50	7	31-Mar	21-Jun	24-Jul	21-Mar	21-Mar	23-Mar
219.0	29	64	7	29-Mar	18-Jun	17-Jul	21-Mar	23-Mar	19-Apr
218.5	29	57	14	24-Mar	02-Jun	11-Jul	21-Mar	28-Mar	14-Jun
218.0	21	57	21	21-Mar	29-May	04-Jul	21-Mar	02-Apr	22-Jun
217.5	14	50	29	09-May	27-May	09-Jun	21-Mar	31-Mar	16-May
217.0	7	50	29	05-May	23-May	05-Jun	21-Mar	03-Apr	17-Jun
216.5	7	50	29	16-Apr	16-May	01-Jun	21-Mar	10-Apr	26-Jun
216.0	7	43	21	02-Apr	06-May	28-May	21-Mar	06-Apr	16-Jul
215.5	7	36	21	02-Apr	07-May	27-May	21-Mar	10-Apr	28-Jul
215.0	7	21	21	31-Mar	02-May	24-May	21-Mar	31-Mar	25-Apr
214.5	7	14	7	08-May	15-May	23-May	21-Mar	03-Apr	30-Apr
214.0	7	7	14	22-May	22-May	22-May	22-Mar	08-Apr	04-May
213.5	7	7	14	21-May	21-May	21-May	22-Mar	13-Apr	11-May
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.2.2.Larval Period

Table 4. Amphibian effect metrics for Northern Pacific Treefrog calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	79	21	0	16-Jul	26-Jul	05-Aug	25-Apr	25-Apr	26-Apr
219.5	50	43	7	26-Apr	25-Jun	24-Jul	25-Apr	25-Apr	29-Apr
219.0	36	57	7	31-May	29-Jun	17-Jul	25-Apr	26-Apr	15-May
218.5	29	57	14	21-May	15-Jun	12-Jul	25-Apr	29-Apr	14-Jun
218.0	21	64	14	15-May	06-Jun	04-Jul	25-Apr	30-Apr	22-Jun
217.5	14	71	14	28-Apr	27-May	25-Jun	25-Apr	06-May	29-Aug
217.0	7	64	14	30-Apr	23-May	20-Jun	25-Apr	30-Apr	17-Jun
216.5	7	50	21	09-May	24-May	12-Jun	25-Apr	04-May	26-Jun
216.0	7	43	7	06-May	23-May	09-Jun	25-Apr	06-May	16-Jul
215.5	7	43	7	28-Apr	18-May	06-Jun	25-Apr	08-May	28-Jul
215.0	7	36	7	04-May	16-May	02-Jun	25-Apr	19-May	01-Aug
214.5	7	14	14	08-May	15-May	23-May	25-Apr	22-May	07-Aug
214.0	7	14	14	04-May	13-May	22-May	25-Apr	28-May	27-Aug
213.5	7	7	7	21-May	21-May	21-May	26-Apr	03-May	11-May
213.0	7	7	0	21-May	21-May	21-May	26-Apr	26-Apr	26-Apr
212.5	7	7	0	20-May	20-May	20-May	26-Apr	26-Apr	26-Apr
212.0	7	7	0	20-May	20-May	20-May	26-Apr	26-Apr	26-Apr

1.3. Northern Red-legged Frog

1.3.1. Egg Period

Table 5. Amphibian effect metrics for Northern Red-legged Frog calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Northern Red-legged Frogs were not detected in the Upper Campbell Reservoir in the egg period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	93	7	0	01-Apr	01-Apr	01-Apr	11-Mar	11-Mar	12-Mar
219.5	86	7	7	31-Mar	31-Mar	31-Mar	11-Mar	12-Mar	23-Mar
219.0	86	7	7	29-Mar	29-Mar	29-Mar	11-Mar	14-Mar	19-Apr
218.5	79	14	0	13-Mar	18-Mar	24-Mar	11-Mar	11-Mar	12-Mar
218.0	64	7	21	15-May	15-May	15-May	11-Mar	14-Mar	07-Apr
217.5	43	14	36	09-May	11-May	13-May	11-Mar	24-Mar	16-May
217.0	36	14	29	05-May	08-May	12-May	11-Mar	20-Mar	28-Apr
216.5	29	21	29	16-Apr	03-May	16-May	11-Mar	27-Mar	13-May
216.0	21	21	21	02-Apr	17-Apr	06-May	11-Mar	17-Mar	16-Apr
215.5	21	14	21	02-Apr	15-Apr	28-Apr	11-Mar	20-Mar	20-Apr
215.0	14	21	21	17-Mar	09-Apr	12-May	11-Mar	24-Mar	25-Apr
214.5	14	7	14	17-Mar	17-Mar	17-Mar	11-Mar	24-Mar	30-Apr
214.0	14	0	14	11-Mar	11-Mar	11-Mar	12-Mar	04-Apr	04-May
213.5	14	0	14	NA	NA	NA	12-Mar	10-Apr	11-May
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.3.2.Larval Period

Table 6. Amphibian effect metrics for Northern Red-legged Frog calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Northern Red-legged Frogs were not detected in the Upper Campbell Reservoir in the larval period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	79	21	0	16-Jul	26-Jul	05-Aug	10-Apr	10-Apr	11-Apr
219.5	50	50	0	26-Apr	25-Jun	24-Jul	10-Apr	10-Apr	11-Apr
219.0	29	57	14	31-May	29-Jun	17-Jul	10-Apr	11-Apr	19-Apr
218.5	29	57	14	21-May	15-Jun	12-Jul	10-Apr	16-Apr	14-Jun
218.0	21	64	14	15-May	06-Jun	04-Jul	10-Apr	17-Apr	22-Jun
217.5	14	57	29	09-May	30-May	25-Jun	10-Apr	25-Apr	29-Aug
217.0	7	64	14	30-Apr	23-May	20-Jun	10-Apr	18-Apr	17-Jun
216.5	7	57	21	16-Apr	20-May	12-Jun	10-Apr	24-Apr	26-Jun
216.0	7	43	14	14-Apr	13-May	28-May	10-Apr	23-Apr	16-Jul
215.5	7	36	14	16-Apr	10-May	27-May	10-Apr	27-Apr	28-Jul
215.0	7	29	21	14-Apr	07-May	24-May	10-Apr	30-Apr	01-Aug
214.5	7	14	14	08-May	15-May	23-May	10-Apr	15-May	07-Aug
214.0	7	14	14	04-May	13-May	22-May	10-Apr	21-May	27-Aug
213.5	7	14	7	23-Apr	07-May	21-May	10-Apr	20-Apr	11-May
213.0	7	7	0	21-May	21-May	21-May	11-Apr	11-Apr	11-Apr
212.5	7	7	0	20-May	20-May	20-May	11-Apr	11-Apr	11-Apr
212.0	7	7	0	20-May	20-May	20-May	11-Apr	11-Apr	11-Apr

1.4. Northwestern Salamander

1.4.1. Egg Period

Table 7. Amphibian effect metrics for Northwestern Salamander calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	93	7	0	01-Apr	01-Apr	01-Apr	11-Mar	11-Mar	12-Mar
219.5	79	14	7	31-Mar	05-May	09-Jun	11-Mar	12-Mar	23-Mar
219.0	79	14	7	29-Mar	29-Apr	31-May	11-Mar	14-Mar	19-Apr
218.5	50	43	7	13-Mar	06-May	08-Jun	11-Mar	18-Mar	14-Jun
218.0	36	36	21	15-May	28-May	12-Jun	11-Mar	14-Mar	07-Apr
217.5	14	43	36	09-May	26-May	09-Jun	11-Mar	24-Mar	16-May
217.0	7	43	29	05-May	22-May	05-Jun	11-Mar	20-Mar	28-Apr
216.5	7	43	29	16-Apr	16-May	01-Jun	11-Mar	27-Mar	13-May
216.0	7	36	21	02-Apr	03-May	28-May	11-Mar	17-Mar	16-Apr
215.5	7	29	21	02-Apr	04-May	27-May	11-Mar	20-Mar	20-Apr
215.0	7	29	21	17-Mar	20-Apr	24-May	11-Mar	24-Mar	25-Apr
214.5	7	14	14	17-Mar	19-Apr	23-May	11-Mar	24-Mar	30-Apr
214.0	7	7	14	11-Mar	16-Apr	22-May	12-Mar	04-Apr	04-May
213.5	7	7	14	21-May	21-May	21-May	12-Mar	10-Apr	11-May
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.4.2.Larval Period

Table 8. Amphibian effect metrics for Northwestern Salamander calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Northwestern Salamanders were not detected in the Upper Campbell Reservoir in the larval period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	29	71	0	04-Jan	28-Jun	10-Dec	02-Jan	28-Jan	01-Jan
219.5	21	71	7	02-Jan	28-Apr	18-Nov	02-Jan	29-Jan	01-Jan
219.0	0	79	14	10-Jan	18-May	01-Jan	02-Jan	06-Jan	07-Feb
218.5	0	64	29	04-Jan	31-May	01-Jan	02-Jan	11-Jan	02-Mar
218.0	0	50	43	05-Jan	13-Jun	01-Jan	02-Jan	26-Jan	20-Mar
217.5	0	29	64	09-May	05-Jul	01-Jan	02-Jan	14-Feb	16-May
217.0	0	29	64	05-May	02-Jul	01-Jan	02-Jan	11-Mar	12-Oct
216.5	0	7	86	16-May	08-Sep	01-Jan	02-Jan	20-Mar	15-Oct
216.0	0	7	71	06-May	03-Sep	01-Jan	02-Jan	12-Apr	31-Oct
215.5	0	0	64	01-Jan	01-Jan	01-Jan	14-Jan	10-Mar	28-Jul
215.0	0	0	57	01-Jan	01-Jan	01-Jan	30-Jan	26-Mar	01-Aug
214.5	0	0	50	01-Jan	01-Jan	01-Jan	13-Feb	01-May	17-Oct
214.0	0	0	43	01-Jan	01-Jan	01-Jan	01-Mar	24-May	21-Oct
213.5	0	0	29	01-Jan	01-Jan	01-Jan	06-Mar	27-May	23-Oct
213.0	0	0	14	01-Jan	01-Jan	01-Jan	27-Mar	11-Jul	26-Oct
212.5	0	0	7	01-Jan	01-Jan	01-Jan	31-Mar	31-Mar	31-Mar
212.0	0	0	7	01-Jan	01-Jan	01-Jan	04-Apr	04-Apr	04-Apr

1.5. Roughskin Newt

1.5.1. Egg Period

Table 9. Amphibian effect metrics for Roughskin Newt calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Roughskin Newts were not detected in the Upper Campbell Reservoir in the egg period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	79	21	0	01-Apr	14-Jun	26-Jul	02-Mar	02-Mar	03-Mar
219.5	43	57	0	08-Mar	08-Jun	24-Jul	02-Mar	02-Mar	03-Mar
219.0	29	71	0	06-Mar	08-Jun	17-Jul	02-Mar	02-Mar	03-Mar
218.5	29	50	21	13-Mar	25-May	24-Jun	02-Mar	11-Mar	14-Jun
218.0	21	36	43	15-May	04-Jun	18-Jun	02-Mar	14-Mar	22-Jun
217.5	7	43	43	09-May	26-May	09-Jun	02-Mar	19-Mar	16-May
217.0	7	43	36	05-May	22-May	05-Jun	02-Mar	25-Mar	17-Jun
216.5	7	36	43	16-Apr	14-May	01-Jun	02-Mar	30-Mar	26-Jun
216.0	7	29	36	14-Apr	11-May	28-May	02-Mar	26-Mar	16-Jul
215.5	7	29	29	02-Apr	04-May	27-May	02-Mar	01-Apr	28-Jul
215.0	7	29	21	17-Mar	20-Apr	24-May	02-Mar	19-Mar	25-Apr
214.5	7	21	14	03-Mar	03-Apr	23-May	02-Mar	16-Mar	30-Apr
214.0	7	14	14	11-Mar	16-Apr	22-May	02-Mar	25-Mar	04-May
213.5	7	0	21	NA	NA	NA	06-Mar	08-Apr	11-May
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.5.2.Larval Period

Table 10. Amphibian effect metrics for Roughskin Newt calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Roughskin Newts were not detected in the Upper Campbell Reservoir in the larval period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	71	29	0	01-Apr	27-Jun	05-Aug	29-Mar	29-Mar	30-Mar
219.5	43	57	0	31-Mar	14-Jun	24-Jul	29-Mar	29-Mar	30-Mar
219.0	29	57	14	29-Mar	18-Jun	17-Jul	29-Mar	01-Apr	19-Apr
218.5	29	50	21	21-May	12-Jun	11-Jul	29-Mar	06-Apr	14-Jun
218.0	21	57	21	15-May	07-Jun	04-Jul	29-Mar	08-Apr	22-Jun
217.5	14	57	29	09-May	30-May	25-Jun	29-Mar	18-Apr	29-Aug
217.0	7	57	21	04-Apr	17-May	05-Jun	29-Mar	08-Apr	17-Jun
216.5	7	50	29	16-Apr	16-May	01-Jun	29-Mar	15-Apr	26-Jun
216.0	7	50	14	02-Apr	07-May	28-May	29-Mar	12-Apr	16-Jul
215.5	7	43	14	02-Apr	03-May	27-May	29-Mar	16-Apr	28-Jul
215.0	7	21	29	31-Mar	02-May	24-May	29-Mar	21-Apr	01-Aug
214.5	7	14	14	08-May	15-May	23-May	29-Mar	09-May	07-Aug
214.0	7	7	21	22-May	22-May	22-May	30-Mar	15-May	27-Aug
213.5	7	7	14	21-May	21-May	21-May	30-Mar	16-Apr	11-May
213.0	7	7	0	21-May	21-May	21-May	30-Mar	30-Mar	30-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.6. Western Toad

1.6.1. Egg Period

Table 11. **Amphibian effect metrics for Western Toad calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.**

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	93	7	0	01-Apr	01-Apr	01-Apr	16-Mar	16-Mar	17-Mar
219.5	71	21	7	31-Mar	20-May	21-Jun	16-Mar	16-Mar	23-Mar
219.0	64	29	7	29-Mar	25-May	21-Jun	16-Mar	18-Mar	19-Apr
218.5	36	50	14	24-Mar	27-May	24-Jun	16-Mar	24-Mar	14-Jun
218.0	21	57	21	18-Mar	24-May	18-Jun	16-Mar	25-Mar	22-Jun
217.5	14	50	29	09-May	27-May	09-Jun	16-Mar	27-Mar	16-May
217.0	7	50	29	05-May	23-May	05-Jun	16-Mar	31-Mar	17-Jun
216.5	7	43	36	16-Apr	16-May	01-Jun	16-Mar	07-Apr	26-Jun
216.0	7	43	14	02-Apr	06-May	28-May	16-Mar	20-Mar	16-Apr
215.5	7	29	21	02-Apr	04-May	27-May	16-Mar	23-Mar	20-Apr
215.0	7	29	21	17-Mar	20-Apr	24-May	16-Mar	27-Mar	25-Apr
214.5	7	21	7	17-Mar	25-Apr	23-May	16-Mar	27-Mar	30-Apr
214.0	7	7	14	22-May	22-May	22-May	17-Mar	06-Apr	04-May
213.5	7	7	14	21-May	21-May	21-May	17-Mar	11-Apr	11-May
213.0	7	0	7	NA	NA	NA	27-Mar	27-Mar	27-Mar
212.5	7	0	7	NA	NA	NA	31-Mar	31-Mar	31-Mar
212.0	7	0	7	NA	NA	NA	04-Apr	04-Apr	04-Apr

1.6.2.Larval Period

Table 12. **Amphibian effect metrics for Western Toad calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Upper Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.**

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
220.0	79	21	0	16-Jul	26-Jul	05-Aug	08-Apr	08-Apr	09-Apr
219.5	43	50	7	26-Apr	25-Jun	24-Jul	08-Apr	08-Apr	10-Apr
219.0	29	57	14	31-May	29-Jun	17-Jul	08-Apr	09-Apr	19-Apr
218.5	29	57	14	21-May	15-Jun	12-Jul	08-Apr	14-Apr	14-Jun
218.0	21	64	14	15-May	06-Jun	04-Jul	08-Apr	16-Apr	22-Jun
217.5	14	57	29	09-May	30-May	25-Jun	08-Apr	23-Apr	29-Aug
217.0	7	57	21	05-May	26-May	20-Jun	08-Apr	16-Apr	17-Jun
216.5	7	50	29	16-Apr	16-May	01-Jun	08-Apr	21-Apr	26-Jun
216.0	7.1	42.9	14.3	14-Apr	13-May	28-May	08-Apr	21-Apr	16-Jul
215.5	7	36	14	16-Apr	10-May	27-May	08-Apr	25-Apr	28-Jul
215.0	7	36	14	09-Apr	01-May	24-May	08-Apr	27-Apr	01-Aug
214.5	7	14	14	08-May	15-May	23-May	08-Apr	14-May	07-Aug
214.0	7	14	14	04-May	13-May	22-May	08-Apr	20-May	27-Aug
213.5	7	14	7	23-Apr	07-May	21-May	09-Apr	25-Apr	11-May
213.0	7	7	0	21-May	21-May	21-May	09-Apr	09-Apr	09-Apr
212.5	7	7	0	20-May	20-May	20-May	09-Apr	09-Apr	09-Apr
212.0	7	7	0	20-May	20-May	20-May	09-Apr	09-Apr	09-Apr

2. LOWER CAMPBELL RESERVOIR

2.1. Long-toed Salamander

2.1.1. Egg Period

Table 13. Amphibian effect metrics for Long-toed Salamander calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Long-toed Salamanders were not detected in the Lower Campbell Reservoir in the egg period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	11-Mar	11-Mar	12-Mar
178.5	100	0	0	NA	NA	NA	11-Mar	11-Mar	12-Mar
178.0	86	7	7	12-Mar	28-Mar	13-Apr	11-Mar	11-Mar	17-Mar
177.5	43	14	29	11-Mar	13-Mar	15-Mar	11-Mar	13-Mar	21-Mar
177.0	14	14	29	12-Mar	14-Mar	16-Mar	11-Mar	20-Mar	05-Apr
176.5	7	0	21	NA	NA	NA	22-Mar	28-Mar	08-Apr
176.0	7	0	7	NA	NA	NA	05-Apr	05-Apr	05-Apr
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	0	NA	NA	NA	NA	NA	NA
174.5	7	0	0	NA	NA	NA	NA	NA	NA
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.1.2.Larval Period

Table 14. **Amphibian effect metrics for Long-toed Salamander calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Long-toed Salamanders were not detected in the Lower Campbell Reservoir in the larval period during field surveys in 2019 and 2020.**

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	02-Jan	02-Jan	02-Jan
178.5	100	0	0	NA	NA	NA	02-Jan	02-Jan	02-Jan
178.0	71	29	0	08-Feb	22-Mar	15-May	02-Jan	02-Jan	02-Jan
177.5	29	57	14	04-Jan	21-Jan	16-Feb	02-Jan	03-Jan	16-Jan
177.0	7	36	57	04-Jan	08-Jan	20-Jan	02-Jan	19-Feb	03-Jul
176.5	7	7	50	18-Jan	18-Jan	18-Jan	02-Jan	08-Apr	03-Jun
176.0	7	7	14	15-Jan	15-Jan	15-Jan	02-Jan	02-Apr	28-Jun
175.5	7	7	7	12-Jan	12-Jan	12-Jan	02-Jan	21-Feb	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.2. Northern Pacific Treefrog

2.2.1. Egg Period

Table 15. Amphibian effect metrics for Northern Pacific Treefrog calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	21-Mar	21-Mar	22-Mar
178.5	100	0	0	NA	NA	NA	21-Mar	21-Mar	22-Mar
178.0	86	14	0	13-Apr	29-Apr	15-May	21-Mar	21-Mar	22-Mar
177.5	36	36	29	22-Mar	12-Apr	17-May	21-Mar	03-Apr	01-Jun
177.0	7	14	79	22-Apr	12-May	02-Jun	22-Mar	29-Apr	03-Jul
176.5	7	7	50	30-May	30-May	30-May	24-Mar	02-May	03-Jun
176.0	7	0	14	NA	NA	NA	05-Apr	17-May	28-Jun
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.2.2.Larval Period

Table 16. Amphibian effect metrics for Northern Pacific Treefrog calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	25-Apr	25-Apr	26-Apr
178.5	100	0	0	NA	NA	NA	25-Apr	25-Apr	26-Apr
178.0	86	7	7	15-May	15-May	15-May	25-Apr	25-Apr	26-Apr
177.5	57	21	21	26-Apr	05-May	17-May	25-Apr	29-Apr	01-Jun
177.0	14	21	64	25-Apr	09-May	02-Jun	25-Apr	15-May	03-Jul
176.5	7	21	29	27-Apr	08-May	30-May	25-Apr	09-May	03-Jun
176.0	7	7	14	25-May	25-May	25-May	26-Apr	28-Jun	31-Aug
175.5	7	7	0	24-May	24-May	24-May	26-Apr	26-Apr	26-Apr
175.0	7	7	0	21-May	21-May	21-May	26-Apr	26-Apr	26-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.3. Northern Red-legged Frog

2.3.1. Egg Period

Table 17. Amphibian effect metrics for Northern Red-legged Frog calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	11-Mar	11-Mar	12-Mar
178.5	100	0	0	NA	NA	NA	11-Mar	11-Mar	12-Mar
178.0	79	14	7	12-Mar	13-Apr	15-May	11-Mar	11-Mar	17-Mar
177.5	36	21	36	11-Mar	29-Mar	17-May	11-Mar	16-Mar	27-Apr
177.0	7	21	43	12-Mar	27-Mar	22-Apr	11-Mar	27-Mar	23-Apr
176.5	7	0	36	NA	NA	NA	22-Mar	09-Apr	04-May
176.0	7	0	7	NA	NA	NA	05-Apr	05-Apr	05-Apr
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.3.2.Larval Period

Table 18. Amphibian effect metrics for Northern Red-legged Frog calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	10-Apr	10-Apr	11-Apr
178.5	100	0	0	NA	NA	NA	10-Apr	10-Apr	11-Apr
178.0	86	14	0	13-Apr	29-Apr	15-May	10-Apr	10-Apr	11-Apr
177.5	36	29	36	14-Apr	22-Apr	17-May	10-Apr	18-Apr	01-Jun
177.0	14	21	64	12-Apr	02-May	02-Jun	10-Apr	08-May	03-Jul
176.5	7	21	36	12-Apr	03-May	30-May	10-Apr	05-May	03-Jun
176.0	7	7	14	25-May	25-May	25-May	11-Apr	23-Jun	31-Aug
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.4. Northwestern Salamander

2.4.1. Egg Period

Table 19. Amphibian effect metrics for Northwestern Salamander calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	11-Mar	11-Mar	12-Mar
178.5	100	0	0	NA	NA	NA	11-Mar	11-Mar	12-Mar
178.0	79	14	7	12-Mar	13-Apr	15-May	11-Mar	11-Mar	17-Mar
177.5	36	21	43	11-Mar	29-Mar	17-May	11-Mar	22-Mar	01-Jun
177.0	7	21	57	12-Mar	27-Mar	22-Apr	11-Mar	08-Apr	08-Jun
176.5	7	0	57	NA	NA	NA	22-Mar	27-Apr	03-Jun
176.0	7	0	7	NA	NA	NA	05-Apr	05-Apr	05-Apr
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.4.2. Larval Period

Table 20. Amphibian effect metrics for Northwestern Salamander calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Northwestern Salamanders were not detected in the Lower Campbell Reservoir in the larval period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	02-Jan	28-Jan	01-Jan
178.5	100	0	0	NA	NA	NA	02-Jan	28-Jan	01-Jan
178.0	50	50	0	08-Feb	29-Jun	11-Dec	02-Jan	28-Jan	01-Jan
177.5	0	79	14	04-Jan	27-Apr	01-Jan	02-Jan	03-Jan	16-Jan
177.0	0	36	57	04-Jan	08-Mar	01-Jan	02-Jan	19-Feb	03-Jul
176.5	0	7	64	18-Jan	11-Jul	01-Jan	02-Jan	14-May	10-Oct
176.0	0	7	29	15-Jan	09-Jul	01-Jan	02-Jan	23-Jun	09-Dec
175.5	0	7	14	12-Jan	08-Jul	01-Jan	02-Jan	31-May	16-Dec
175.0	0	0	7	01-Jan	01-Jan	01-Jan	21-Apr	21-Apr	21-Apr
174.5	0	0	7	01-Jan	01-Jan	01-Jan	01-May	01-May	01-May
174.0	0	0	0	01-Jan	01-Jan	01-Jan	NA	NA	NA

2.5. Roughskin Newt

2.5.1. Egg Period

Table 21. Amphibian effect metrics for Roughskin Newt calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Roughskin Newts were not detected in the Lower Campbell Reservoir in the egg period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	02-Mar	02-Mar	03-Mar
178.5	100	0	0	NA	NA	NA	02-Mar	02-Mar	03-Mar
178.0	79	21	0	12-Mar	13-Apr	15-May	02-Mar	02-Mar	03-Mar
177.5	36	43	21	02-Mar	16-Mar	17-May	02-Mar	05-Mar	19-Mar
177.0	7	0	93	NA	NA	NA	04-Mar	21-Apr	03-Jul
176.5	7	0	57	NA	NA	NA	22-Mar	27-Apr	03-Jun
176.0	7	0	14	NA	NA	NA	05-Apr	17-May	28-Jun
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.5.2.Larval Period

Table 22. Amphibian effect metrics for Roughskin Newt calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Roughskin Newts were not detected in the Lower Campbell Reservoir in the larval period during field surveys in 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	29-Mar	29-Mar	30-Mar
178.5	100	0	0	NA	NA	NA	29-Mar	29-Mar	30-Mar
178.0	86	14	0	13-Apr	29-Apr	15-May	29-Mar	29-Mar	30-Mar
177.5	36	36	29	05-Apr	17-Apr	17-May	29-Mar	10-Apr	01-Jun
177.0	7	21	71	08-Apr	01-May	02-Jun	30-Mar	03-May	03-Jul
176.5	7	14	43	06-Apr	03-May	30-May	30-Mar	28-Apr	03-Jun
176.0	7	0	21	NA	NA	NA	05-Apr	21-Jun	31-Aug
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.6. Western Toad

2.6.1. Egg Period

Table 23. Amphibian effect metrics for Western Toad calculated for the egg period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	16-Mar	16-Mar	17-Mar
178.5	100	0	0	NA	NA	NA	16-Mar	16-Mar	17-Mar
178.0	86	14	0	13-Apr	29-Apr	15-May	16-Mar	16-Mar	17-Mar
177.5	36	14	50	28-Mar	22-Apr	17-May	16-Mar	31-Mar	01-Jun
177.0	7	14	64	16-Mar	23-Apr	02-Jun	17-Mar	16-Apr	08-Jun
176.5	7	0	57	NA	NA	NA	22-Mar	27-Apr	03-Jun
176.0	7	0	7	NA	NA	NA	05-Apr	05-Apr	05-Apr
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

2.6.2.Larval Period

Table 24. Amphibian effect metrics for Western Toad calculated for the larval period. Results are calculated for water elevation bands (0.5 m bins) for Lower Campbell Reservoir for the period 2006-2018. "NA" denotes that the event did not occur. Highlighted rows indicate the elevation bands where the age class was detected. Red = detection in 2019, blue = detection in 2020, and purple = detection in both 2019 and 2020.

Elevation Band Lower Boundary	% Years Not Inundated	% Years Exposed → Inundated	% Years Inundated → Exposed	Min. Date Inundated	Avg. Date Inundated	Max. Date Inundated	Min. Date Exposed	Avg. Date Exposed	Max. Date Exposed
179.0	100	0	0	NA	NA	NA	08-Apr	08-Apr	09-Apr
178.5	100	0	0	NA	NA	NA	08-Apr	08-Apr	09-Apr
178.0	86	14	0	13-Apr	29-Apr	15-May	08-Apr	08-Apr	09-Apr
177.5	36	21	43	14-Apr	25-Apr	17-May	08-Apr	17-Apr	01-Jun
177.0	14	21	64	12-Apr	02-May	02-Jun	08-Apr	08-May	03-Jul
176.5	7	14	43	29-Apr	14-May	30-May	09-Apr	04-May	03-Jun
176.0	7	7	14	25-May	25-May	25-May	09-Apr	22-Jun	31-Aug
175.5	7	0	7	NA	NA	NA	13-Apr	13-Apr	13-Apr
175.0	7	0	7	NA	NA	NA	21-Apr	21-Apr	21-Apr
174.5	7	0	7	NA	NA	NA	01-May	01-May	01-May
174.0	7	0	0	NA	NA	NA	NA	NA	NA

Appendix E. Summary of amphibian breeding survey results and selected habitat parameters for all Drawdown Zone Habitat and Reservoir Shoreline Habitat survey sites

LIST OF TABLES

Table 1. Total number of individuals, by species and developmental stage, recorded at survey sites with amphibian detections in the Upper Campbell Reservoir in 2019 and 2020 (dashes indicate no detections). All sites are in Drawdown Zone Habitats except for JHT-PBA52S which is within Reservoir Shoreline Habitat. Numbers are added across surveys within years; for survey-specific information, see Table 3.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Year	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA01	311770	5523044	219.1	2019	-	-	-	-	-	-	-	-	-	-	-	100	-	3	-	-	-	-	-	-	50,000	300	-	2,000	14
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20,000	-	-	-	-
JHT-PBA02	311826	5522950	216.6	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	50	-	50	-
JHT-PBA03	311758	5522882	217	2019	-	-	-	-	-	-	-	-	-	-	-	50	-	2	-	-	-	-	-	-	-	20,000	20	20,201	-
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20,300	27,550	100	-	-
JHT-PBA04	310789	5523998	219.1	2019	-	-	-	-	-	-	-	-	-	-	800	50,500	-	2,000	1	-	-	-	-	1	-	-	-	-	-
				2020	-	-	-	-	-	-	-	-	-	-	2,465	3,540	200	50	4	-	-	-	-	-	-	-	-	-	-
JHT-PBA05	310832	5523911	219.65	2020	-	-	-	-	-	-	-	-	-	-	-	1,200	100	50	-	-	-	-	-	-	-	-	-	-	-
JHT-PBA06	310940	5523765	217.55	2019	-	-	-	-	-	-	-	-	-	-	-	90	-	-	2	-	-	-	-	-	-	-	-	-	-
JHT-PBA09	317128	5500332	214.85	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	19,859	66,001	20,000	10,000	9
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	10,800,305	400	3,300	1
JHT-PBA10	316938	5499801	220.8	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	140,000	-	-	-	-
JHT-PBA11	317026	5499915	218.3	2019	-	-	-	-	-	-	-	-	-	-	-	1	-	11	2	-	-	-	-	-	32,500	1,350,500	1,500	1,001	42
				2020	-	-	-	-	-	-	-	-	-	-	500	40	-	2	3	-	-	-	-	1	10,000	500,000	-	84	1
JHT-PBA13	317222	5499837	216.7	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	450	-	50	-
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-
JHT-PBA14	315214	5493285	219	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-
JHT-PBA15	315315	5493727	217.3	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
JHT-PBA17	310540	5527762	219.5	2019	-	-	-	-	-	192	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
				2020	-	-	-	-	-	150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
JHT-PBA18	311041	5523661	216.8	2019	-	-	-	-	-	-	-	-	-	-	45	3	-	6	-	-	-	-	-	-	-	101	-	-	-

Table 1. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Year	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA19	310445	5527857	216.3	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20,000	10,000	20,000	-
				2020	-	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-	-	-	-	400,000	31,070	-	306	14
JHT-PBA21	310309	5527955	218.2	2019	-	-	-	-	-	-	-	-	-	-	-	1,500	-	-	-	-	-	-	-	-	-	5,000	1,000	5,000	-
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	5,510	-	2	32
JHT-PBA33	315424	5493744	217.3	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
JHT-PBA36	315491	5493653	217.6	2019	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,500	-	-	-
				2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5,000	-	-	-	-
JHT-PBA50	303100	5528495	219.8	2019	-	-	-	1	2	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	-
JHT-PBA51	302972	5528466	220	2019	-	-	-	-	3	51	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-
JHT-PBA52S	316862	5501134	n/a	2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70	-	-	-
JHT-PBA57	315001	5539615	216.58	2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4,010	-	-	-
JHT-PBA58	314966	5539590	217.2	2020	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	9,500	-	50	-
JHT-PBA59	315058	5539475	217.5	2020	-	-	-	-	-	-	-	-	-	-	-	200	-	-	1	-	-	-	-	-	-	400	-	1,000	-

[1] Pond surface elevations were estimated in the field as the elevation of the pond surface if the pond was at its maximum depth (n/a indicates the site is a reservoir shoreline site and not a pond). The elevation of JHT-PBA71 was not estimated in the field so the elevation in this table is from the spatial pond layer provided by BC Hydro.

[2] E = egg; L = larvae; M = metamorph; J = juvenile, A = adult.

Table 2. Total number of individuals, by species and developmental stage, recorded at survey sites with amphibian detections in the Lower Campbell Reservoir in 2019 and 2020 (dashes indicate no detections). All sites are in Drawdown Zone Habitats except for JHT-PBA46S which is within Reservoir Shoreline Habitat. Numbers are added across surveys within years; for survey-specific information, see Table 4.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Year	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA08	315029	5541820	177.3	2019	-	-	-	-	-	125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	1	-
				2020	-	-	-	-	-	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	70,020	1,002	-	-	6
JHT-PBA16	315125	5541653	178.1	2019	-	-	-	-	-	-	-	-	-	-	-	500	-	-	-	-	-	-	-	-	-	-	-	-	-
JHT-PBA20	315405	5544286	177	2019	640	3	-	-	2	1,347	-	-	-	-	130	-	-	-	2	-	-	-	-	-	-	-	-	-	1
				2020	330	-	-	-	-	505	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
JHT-PBA22	316767	5545104	178.5	2019	100	-	-	-	-	210	-	-	-	-	25	-	-	-	1	-	-	-	-	-	-	-	-	-	-
				2020	-	-	-	-	-	35	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
JHT-PBA46S	324852	5539912	n/a	2019	-	-	-	-	-	35	-	-	-	-	1,040	-	-	-	2	-	-	-	-	-	-	-	-	-	-
				2020	270	-	-	-	-	875	-	-	-	-	50	-	-	-	1	-	-	-	-	-	-	50	-	1	-
JHT-PBA70	315657	5544206	177.5	2020	-	-	-	-	-	465	-	-	-	-	4,680	-	-	-	2	-	-	-	-	-	-	-	-	-	-
JHT-PBA71	315666	5544122	176.94	2020	-	-	-	-	-	-	-	-	-	-	20	-	-	-	-	-	-	-	-	-	-	-	-	-	-

[1] Pond surface elevations were estimated in the field as the elevation of the pond surface if the pond was at its maximum depth (n/a indicates the site is a reservoir shoreline site and not a pond). The elevation of JHT-PBA71 was not estimated in the field so the elevation in this table is from the spatial pond layer provided by BC Hydro.

[2] E = egg; L = larvae; M = metamorph; J = juvenile, A = adult.

Table 3. Number of individuals, by species, developmental stage, and survey date, recorded by survey site in the Upper Campbell Reservoir in 2019 and 2020. All sites are in Drawdown Zone Habitats except those for which labels end in an "S" (which are in Reservoir Shoreline Habitats). Blanks indicate the species was not detected; zeros indicate life stages were not detected when the species was detected during a survey.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA01	311770	5523044	219.1	13-Mar-2019																									
				25-Apr-2019																									
				11-Jun-2019																					50,000	0	0	0	14
				04-Jul-2019											0	100	0	0	0						0	300	0	0	0
				09-Aug-2019											0	0	0	3	0						0	0	0	2,000	0
				01-Apr-2020																									
				23-Apr-2020																					20,000	0	0	0	0
				11-Jun-2020																									
				15-Jul-2020																									
JHT-PBA02	311826	5522950	216.6	13-Mar-2019																									
				11-Jun-2019																									
				04-Jul-2019																					0	50	0	0	0
				09-Aug-2019											0	0	0	1	0						0	0	0	50	0
				01-Apr-2020																									
				23-Apr-2020																									
				11-Jun-2020																									
				15-Jul-2020																									

Table 3. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA03	311758	5522882	217	13-Mar-2019																									
				25-Apr-2019																									
				11-Jun-2019																					0	20,000	0	0	0
				04-Jul-2019											0	50	0	0	0						0	0	20	20,001	0
				09-Aug-2019											0	0	0	2	0						0	0	0	200	0
				01-Apr-2020																									
				23-Apr-2020																					20,300	10,000	0	0	0
				11-Jun-2020																					0	12,000	0	0	0
				15-Jul-2020																					0	5,550	100	0	0
				13-Aug-2020																									
JHT-PBA04	310789	5523998	219.1	13-Mar-2019																									
				03-Apr-2019											0	0	0	0	1										
				11-Jun-2019											750	500	0	0	0										
				04-Jul-2019											50	30,000	0	0	0	0	0	0	0	1					
				09-Aug-2019											0	20,000	0	2,000	0										
				17-Mar-2020																									
				23-Apr-2020											80	0	0	0	1										
				14-May-2020											2,300	40	0	0	1										
				11-Jun-2020											85	2,000	0	0	2										
				15-Jul-2020											0	1,000	0	0	0										
				13-Aug-2020											0	500	200	50	0										
JHT-PBA05	310832	5523911	219.65	17-Mar-2020																									
				11-Jun-2020											0	500	0	0	0										
				15-Jul-2020											0	500	0	0	0										
				13-Aug-2020											0	200	100	50	0										

Table 3. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA06	310940	5523765	217.55	13-Mar-2019																									
				24-Apr-2019																									
				11-Jun-2019											0	0	0	0	1										
				04-Jul-2019											0	90	0	0	1										
				17-Mar-2020																									
				23-Apr-2020																									
				14-May-2020																									
JHT-PBA07	314929	5539922	215.9	13-Mar-2019																									
JHT-PBA09	317128	5500332	214.85	28-Mar-2019																									
				24-Apr-2019																					19,859	0	0	0	9
				14-May-2019																					0	1,001	0	0	0
				11-Jun-2019																					0	25,000	0	0	0
				04-Jul-2019																					0	40,000	20,000	0	0
				09-Aug-2019																					0	0	0	10,000	0
				17-Mar-2020																									
				01-Apr-2020																									
				22-Apr-2020																									
				14-May-2020																					0	10,800,000	0	0	0
				15-Jul-2020																					0	305	400	3,300	1
JHT-PBA10	316938	5499801	220.8	28-Mar-2019																					0	0	0	0	15
				17-Mar-2020																									
				01-Apr-2020																									
				22-Apr-2020											0	0	0	0	2						140,000	0	0	0	0

Table 3. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA11	317026	5499915	218.3	28-Mar-2019											0	0	0	0	1						1,300	0	0	0	21
				03-Apr-2019																					20,500	0	0	0	21
				24-Apr-2019											0	0	0	0	1						10,700	1,250,000	0	0	0
				14-May-2019																					0	100,000	0	0	0
				11-Jun-2019																					0	500	1,500	0	0
				04-Jul-2019											0	1	0	10	0						0	0	0	1,000	0
				09-Aug-2019											0	0	0	1	0						0	0	0	1	0
				17-Mar-2020																									
				01-Apr-2020																									
				22-Apr-2020											0	0	0	0	3						10,000	100,000	0	0	0
				14-May-2020											500	40	0	0	0	0	0	0	0	1	0	400,000	0	0	0
				15-Jul-2020											0	0	0	2	0						0	0	0	84	1
JHT-PBA13	317222	5499837	216.7	03-Apr-2019																									
				24-Apr-2019																									
				14-May-2019																					0	100	0	0	0
				11-Jun-2019																					0	300	0	0	0
				04-Jul-2019																					0	50	0	0	0
				09-Aug-2019											0	0	0	0	1						0	0	0	50	0
				01-Apr-2020																									
				22-Apr-2020																									
				15-Jul-2020																					0	2	0	0	0
JHT-PBA14	315214	5493285	219	03-Apr-2019											0	0	0	0	1										
				14-May-2019																					0	1	0	0	0
				22-Apr-2020																									
JHT-PBA15	315315	5493727	217.3	03-Apr-2019											0	0	0	0	1										
				14-May-2019																									
				22-Apr-2020																									

Table 3. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA17	310540	5527762	219.5	02-Apr-2019						142	0	0	0	4											0	0	0	0	1
				15-May-2019						50	0	0	0	0															
				04-Jul-2019																									
				09-Apr-2020						60	0	0	0	0											0	0	0	0	1
				11-Jun-2020						90	0	0	0	0															
				13-Aug-2020																									
JHT-PBA18	311041	5523661	216.8	11-Jun-2019											30	0	0	0	0						0	100	0	0	0
				04-Jul-2019											15	3	0	0	0						0	1	0	0	0
				09-Aug-2019											0	0	0	6	0										
				01-Apr-2020																									
				23-Apr-2020																									
				14-May-2020																									
JHT-PBA19	310445	5527857	216.3	04-Jul-2019																					0	20,000	10,000	20,000	0
				09-Apr-2020																					0	0	0	0	14
				21-Apr-2020																					400,000	20,000	0	0	0
				11-Jun-2020																					0	11,070	0	0	0
				13-Aug-2020											0	22	0	0	0						0	0	0	306	0
JHT-PBA21	310309	5527955	218.2	02-Apr-2019																									
				04-Jul-2019											0	1,500	0	0	0						0	5,000	1,000	5,000	0
				09-Apr-2020																0	0	0	0	1	0	0	0	0	32
				21-Apr-2020											0	0	0	0	1										
				11-Jun-2020																					0	5,510	0	1	0
				13-Aug-2020																					0	0	0	1	0
JHT-PBA29	310556	5527889	220.4	02-Apr-2019																									
JHT-PBA33	315424	5493744	217.3	03-Apr-2019																									
				14-May-2019											0	0	0	0	1										
				22-Apr-2020																									

Table 3. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA36	315491	5493653	217.6	03-Apr-2019																									
				14-May-2019																					0	1,000	0	0	0
				11-Jun-2019																					0	500	0	0	0
				22-Apr-2020																					5,000	0	0	0	0
JHT-PBA37	316031	5509678	220.5	24-Apr-2019																									
JHT-PBA38	311322	5523937	216.6	23-Apr-2020																									
JHT-PBA40S	317380	5503866	n/a	24-Apr-2019																									
JHT-PBA41S	311394	5523828	n/a	24-Apr-2019																									
JHT-PBA42S	311987	5523317	n/a	24-Apr-2019																									
JHT-PBA44S	311910	5523246	n/a	24-Apr-2019																									
JHT-PBA45S	311907	5522532	n/a	25-Apr-2019																									
				23-Apr-2020																									
JHT-PBA50	303100	5528495	219.8	15-May-2019	0	0	0	1	2						0	0	0	0	1	0	0	0	0	1					
JHT-PBA51	302972	5528466	220	15-May-2019	0	0	0	0	3	51	0	0	0	0											0	1	0	0	0
JHT-PBA52S	316862	5501134	n/a	14-May-2020																					0	70	0	0	0
JHT-PBA57	315001	5539615	216.58	30-Mar-2020																									
				11-Jun-2020																					0	4,010	0	0	0
				13-Aug-2020																									
JHT-PBA58	314966	5539590	217.2	30-Mar-2020																									
				14-May-2020																					0	3,500	0	0	0
				11-Jun-2020																					0	6,000	0	0	0
				13-Aug-2020																					0	0	0	50	0
JHT-PBA59	315058	5539475	217.5	30-Mar-2020																									
				14-May-2020											0	0	0	0	1						0	200	0	0	0
				11-Jun-2020											0	200	0	0	0						0	200	0	0	0
				13-Aug-2020																					0	0	0	1,000	0

Table 3. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA79	311085	5523616	216.64	01-Apr-2020																									
				23-Apr-2020																									
				14-May-2020																									
JHT-PBA80S	315071	5539547	n/a	30-Mar-2020																									
				14-May-2020																									
JHT-PBA81S	311388	5523421	n/a	01-Apr-2020																									
JHT-PBA82S	310211	5527925	n/a	21-Apr-2020																									

[1] Pond surface elevations were estimated in the field as the elevation of the pond surface if the pond was at its maximum depth (n/a indicates the site is a reservoir shoreline site and not a pond). The elevation of JHT-PBA71 was not estimated in the field so the elevation in this table is from the spatial pond layer provided by BC Hydro.

[2] E = egg; L = larvae; M = metamorph; J = juvenile, A = adult.

Table 4. Number of individuals, by species, developmental stage, and survey date, recorded by survey site in the Lower Campbell Reservoir in 2019 and 2020. All sites are in Drawdown Zone Habitats except those for which labels end in an "S" (which are in Reservoir Shoreline Habitats). Blanks indicate the species was not detected; zeros indicate life stages were not detected when the species was detected during a survey.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA08	315029	5541820	177.3	13-Mar-2019																									
				02-Apr-2019																									
				23-Apr-2019						100	0	0	0	0															
				15-May-2019						25	0	0	0	0											0	1,000	0	1	0
				11-Jun-2019																									
				04-Jul-2019																									
				09-Apr-2020						30	0	0	0	0											0	0	0	0	6
				23-Apr-2020						45	0	0	0	0											70,020	0	0	0	0
				11-Jun-2020																					0	1,002	0	0	0
				13-Aug-2020																									
JHT-PBA16	315125	5541653	178.1	13-Mar-2019																									
				14-May-2019											0	500	0	0	0										
				09-Apr-2020																									
JHT-PBA20	315405	5544286	177	02-Apr-2019	160	0	0	0	2	87	0	0	0	0											0	0	0	0	1
				23-Apr-2019	480	0	0	0	0	1,260	0	0	0	0	40	0	0	0	2										
				15-May-2019	0	2	0	0	0						90	0	0	0	0										
				11-Jun-2019	0	1	0	0	0																				
				09-Aug-2019																									
				30-Mar-2020	230	0	0	0	0	180	0	0	0	0	0	0	0	0	1										
				21-Apr-2020	100	0	0	0	0	80	0	0	0	0															
				08-May-2020	0	0	0	0	0	245	0	0	0	0															
				15-Jul-2020																									

Table 4. Continued.

Site	UTM Coordinates (Zone 10U)		Pond Surface Elevation (m)[1]	Date	Number of Individuals Recorded by Species and Developmental Stage[2]																								
					Northern Red-legged Frog					Northwestern Salamander					Northern Pacific Treefrog					Roughskin Newt					Western Toad				
	Easting	Northing			E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A	E	L	M	J	A
JHT-PBA22	316767	5545104	178.5	23-Apr-2019	100	0	0	0	0	210	0	0	0	0	25	0	0	0	1										
				30-Mar-2020						35	0	0	0	0	0	0	0	0	1										
JHT-PBA23	316704	5544858	174.5	23-Apr-2019																									
				30-Mar-2020																									
JHT-PBA25	316762	5543239	177.3	25-Apr-2019																									
JHT-PBA30	329591	5542172	175.2	28-Mar-2019																									
JHT-PBA31	329543	5542166	175.2	28-Mar-2019																									
JHT-PBA46S	324852	5539912	n/a	25-Apr-2019						35	0	0	0	0	1,040	0	0	0	2										
				08-May-2020	270	0	0	0	0	875	0	0	0	0	50	0	0	0	1						0	50	0	1	0
JHT-PBA47S	316999	5543204	n/a	25-Apr-2019																									
JHT-PBA48S	315124	5541869	n/a	09-Apr-2020																									
JHT-PBA49S	316849	5501051	n/a	02-Apr-2019																									
				14-May-2019																									
				30-Mar-2020																									
				08-May-2020																									
JHT-PBA70	315657	5544206	177.5	08-May-2020						465	0	0	0	0	4,680	0	0	0	2										
JHT-PBA71	315666	5544122	176.94	08-May-2020											20	0	0	0	0										

[1] Pond surface elevations were estimated in the field as the elevation of the pond surface if the pond was at its maximum depth (n/a indicates the site is a reservoir shoreline site and not a pond). The elevation of JHT-PBA71 was not estimated in the field so the elevation in this table is from the spatial pond layer provided by BC Hydro.

[2] E = egg; L = larvae; M = metamorph; J = juvenile, A = adult.

Table 5. Summary of amphibian breeding survey results and selected habitat parameters in the Lower Campbell Reservoir.

Site	Habitat Type[1]	Permanence[2]	Site Type[3]	# Surveys 2019	# Surveys 2020	Pond Surface Area (m^2)	Pond Bottom Elevation (m)	Shoreline Slope (%)	Avg. Depth (m) 2019	Avg. Depth (m) 2020	Fish Presence	Northern Red-legged Frog				Northwestern Salamander				Northern Pacific Treefrog				Rough-skinned Newt				Western Toad			
												2019		2020		2019		2020		2019		2020		2019		2020		2019		2020	
												B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult	B[3] Breeding	A[4] Adult
Lower Campbell Reservoir																															
JHT-PBA08	DZH	Perm	Comp.	6	4	1,500	175.8	20	0.5	0.4	Yes	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	1,001	-	11	6
JHT-PBA16	DZH	Perm	Rapid	2	1	97	177.8	8	0.3	0.1	No	-	-	-	-	-	-	-	-	500	-	-	-	-	-	-	-	-	-	-	-
JHT-PBA20	DZH	Perm	Comp.	4	4	7,864	175.3	5	0.3	0.8	Yes	11	2	4	-	39	-	8	-	3	2	-	1	-	-	-	-	-	1	-	-
JHT-PBA22	DZH	Perm	Comp.	1	1	18,589	176.5	3	0.7	0.5	Yes	1	-	-	-	5	-	1	-	1	1	-	1	-	-	-	-	-	-	-	-
JHT-PBA23	DZH	Ephm	Rapid	1	1	4,018	169.0	8	1.0	0.8	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JHT-PBA25	DZH	Ephm	Rapid	2	0	17,980	175.8	20	0.9	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA30	DZH	Perm	Rapid	1	0	2,158	170.2	25	3.0	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA31	DZH	Perm	Rapid	1	0	2,080	170.2	30	0.5	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA46S	RSH	n/a	Rapid	1	1	n/a	n/a	4.5	0.1	1.3	Yes	-	-	4	-	1	-	18	-	43	2	2	1	-	-	-	-	-	-	51	-
JHT-PBA47S	RSH	n/a	Rapid	1	0	n/a	n/a	25	0.5	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA48S	RSH	n/a	Rapid	0	1	n/a	n/a	n/c	n/a	0.4	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA49S	RSH	n/a	Rapid	2	2	n/a	n/a	5.5	0.4	1.1	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JHT-PBA70	DZH	Ephm	Rapid	0	1	495	177.5	n/c	n/a	0.8	No	n/a	n/a	-	-	n/a	n/a	12	-	n/a	n/a	105	2	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA71	DZH	Ephm	Rapid	0	1	301	n/c	n/c	n/a	1.3	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	1	-	n/a	n/a	-	-	n/a	n/a	-	-

[1] DZH = Drawdown Zone Habitat, RSH = Reservoir shoreline Habitat (RSH)

[2] Perm = Permanent pond, Ephm = Ephemeral pond

[3] B = Breeding occurrences - approximate number of observations of breeding age classes. The 'Breeding' age class includes eggs, tadpoles and larvae (and Western Toad juveniles and metamorphs); "-" = zero detections; "n/a" = no surveys conducted

[4] A = The 'Adult' age class includes juveniles and metamorphs for all species except for Western Toad; "-" = zero detections; "n/a" = no surveys conducted

Table 6. Summary of amphibian breeding survey results and selected habitat parameters in the Upper Campbell Reservoir.

Site	Habitat Type[1]	Permanence[2]	Site Type[3]	# Surveys 2019	# Surveys 2020	Pond Surface Area (m²)	Pond Bottom Elevation (m)	Shoreline Slope (%)	Avg. Depth (m) 2019	Avg. Depth (m) 2020	Fish Presence	Northern Red-legged Frog				Northwestern Salamander				Northern Pacific Treefrog				Rough-skinned Newt				Western Toad			
												2019		2020		2019		2020		2019		2020		2019		2020		2019		2020	
												B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]	B[3]	A[4]
												Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult	Breeding	Adult
Upper Campbell Reservoir																															
JHT-PBA01	DZH	Ephm	Comp.	5	4	1,655	216.4	12	0.2	0.4	Yes	-	-	-	-	-	-	-	-	100	-	-	-	-	-	-	-	5	14	3	-
JHT-PBA02	DZH	Ephm	Comp.	3	4	1,135	215.4	40	0.4	0.5	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	50	-	-	-
JHT-PBA03	DZH	Ephm	Comp.	4	5	7,149	216.0	30	0.2	0.4	Yes	-	-	-	-	-	-	-	-	50	-	-	-	-	-	-	-	20,000	-	10,072	-
JHT-PBA04	DZH	Ephm	Comp.	5	6	950	215.1	30	0.3	0.5	Yes	-	-	-	-	-	-	-	-	550	1	558	204	-	1	-	-	-	-	-	-
JHT-PBA05	DZH	n/c	Comp.	0	4	160	217.0	n/c	n/a	0.4	No	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	700	150	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA06	DZH	Perm	Rapid	4	3	1,043	215.6	30	0.5	0.4	Yes	-	-	-	-	-	-	-	-	90	2	-	-	-	-	-	-	-	-	-	-
JHT-PBA07	DZH	Ephm	Rapid	1	0	1,924	209.0	40	0.5	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA09	DZH	Perm	Comp.	6	5	102,300	215.7	3	3.5	0.2	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11,020	9	10,800,000	1
JHT-PBA10	DZH	Perm	Rapid	1	2	13,025	218.0	3	0.2	0.5	Yes	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	15	16	-
JHT-PBA11	DZH	Perm	Comp.	6	4	2,874	217.8	5	0.3	0.3	Yes	-	-	-	-	-	-	-	-	1	2	42	3	-	-	-	1	13	42	100,006	1
JHT-PBA13	DZH	Perm	Comp.	5	2	633	216.2	5	0.2	0.3	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	100	-	2	-
JHT-PBA14	DZH	Perm	Rapid	2	1	6,840	217.4	6	0.6	0.4	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	-	-
JHT-PBA15	DZH	Perm	Rapid	2	1	1,041	216.5	3	0.5	0.4	Yes	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
JHT-PBA17	DZH	Perm	Comp.	3	3	784	218.1	3	0.8	0.4	Yes	-	-	-	-	6	4	5	-	-	-	-	-	-	-	-	-	-	1	-	1
JHT-PBA18	DZH	Perm	Comp.	2	4	1,977	216.1	3	0.2	0.3	Yes	-	-	-	-	-	-	-	-	4	-	-	-	-	-	-	-	100	-	-	-
JHT-PBA19	DZH	Ephm	Comp.	1	4	1,150	218.5	22	0.2	0.4	Yes	-	-	-	-	-	-	-	-	-	-	22	-	-	-	-	-	50,000	-	20,328	14
JHT-PBA21	DZH	Ephm	Comp.	2	4	1,816	214.4	22	0.1	0.4	Yes	-	-	-	-	-	-	-	-	1,500	-	-	1	-	-	-	1	11,000	-	2	32
JHT-PBA29	DZH	Ephm	Rapid	1	0	719	220.0	3	0.1	n/a	No	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA33	DZH	Perm	Rapid	2	1	216	217.0	4	0.1	0.2	No	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-
JHT-PBA36	DZH	Perm	Rapid	3	1	185	216.6	3	0.3	0.3	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1,000	-	2	-
JHT-PBA37	DZH	Perm	Rapid	1	0	989	219.0	35	0.5	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA38	DZH	Ephm	Rapid	0	1	212	215.5	n/c	n/a	0.4	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA40S	RSH	n/a	Rapid	1	0	n/a	n/a	25	0.3	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA41S	RSH	n/a	Rapid	1	0	n/a	n/a	6	0.3	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA42S	RSH	n/a	Rapid	1	0	n/a	n/a	10	0.4	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA44S	RSH	n/a	Rapid	1	0	n/a	n/a	20	0.4	n/a	Yes	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a
JHT-PBA45S	RSH	n/a	Rapid	1	1	n/a	n/a	4	0.3	0.2	Yes	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
JHT-PBA50	DZH	Perm	Rapid	1	0	785	219.1	3	15.0	n/a	No	-	2	n/a	n/a	-	-	n/a	n/a	-	1	n/a	n/a	-	1	n/a	n/a	-	-	n/a	n/a
JHT-PBA51	DZH	Perm	Rapid	1	0	819	219.1	3	0.4	n/a	No	-	3	n/a	n/a	2	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	1	-	n/a	n/a
JHT-PBA52S	RSH	n/a	Rapid	0	1	n/a	n/a	n/c	n/a	0.1	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	70	-
JHT-PBA57	DZH	Ephm	Rapid	0	3	1,227	n/c	10	n/a	0.4	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	4,010	-
JHT-PBA58	DZH	Ephm	Rapid	0	3	716	215.9	12	n/a	0.4	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	3,550	-
JHT-PBA59	DZH	Ephm	Rapid	0	4	655	n/c	12	n/a	0.4	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	200	1	n/a	n/a	-	-	n/a	n/a	1,200	-
JHT-PBA79	DZH	Ephm	Rapid	0	3	642	216.2	6	n/a	0.2	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA80S	RSH	n/a	Rapid	0	2	n/a	n/a	7	n/a	0.5	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA81S	RSH	n/a	Rapid	0	1	n/a	n/a	4	n/a	0.2	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-
JHT-PBA82S	RSH	n/a	Rapid	0	1	n/a	n/a	22	n/a	0.5	Yes	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-	n/a	n/a	-	-

[1] DZH = Drawdown Zone Habitat, RSH = Reservoir shoreline Habitat (RSH)

[2] Perm = Permanent pond, Ephm = Ephemeral pond

[3] B = Breeding occurrences - approximate number of observations of breeding age classes. The 'Breeding' age class includes eggs, tadpoles and larvae (and Western Toad juveniles and metamorphs); "-" = zero detections; "n/a" = no surveys conducted

[4] A = The 'Adult' age class includes juveniles and metamorphs for all species except for Western Toad; "-" = zero detections; "n/a" = no surveys conducted

Appendix F. Broad Scale (Site Level) Habitat Characteristics of Survey Sites

LIST OF TABLES

Table 1. Summary of broad scale (site level) habitat characteristics collected at each visit in the Lower Campbell Reservoir.

Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Date	Time	Water Temp. (°C)	Avg. Depth (m)	Max Depth (m)	Fish Exposure	Reservoir Elevation (m)[3]
Yes	JHT-PBA08	WETO, NWSA	2019	2019-03-13	15:46:00	7	0.40	0.70	Yes	177.0
				2019-04-02	13:49:32	19	0.40	0.70	Yes	175.8
				2019-04-23	09:41:25	13	0.50	0.80	Yes	176.0
				2019-05-15	13:44:12	24				176.0
				2019-06-11	16:28:31	33	0.30	1.00	Yes	176.1
				2019-07-04		25	1.00	0.90	Yes	176.3
			2020	2020-04-09	13:53:46	14	0.35	1.20	Yes	177.1
				2020-04-23	15:50:23	15	0.50	2.00	Yes	177.5
				2020-06-11	16:10:53	22	0.50	1.00	Yes	177.0
				2020-08-13	13:54:29	22	0.40	0.70	Yes	177.0
	JHT-PBA16	NPTF	2019	2019-03-13		2		0.35	No	177.0
				2019-05-14		23	0.25	0.40	No	176.0
			2020	2020-04-09	15:03:29	16	0.10	0.30	No	177.1
	JHT-PBA20	NRLF, NWSA, NPTF	2019	2019-04-02	14:59:29	15	0.50	0.70	Yes	175.8
				2019-04-23	11:15:04	17	0.40	0.50	Yes	176.0
				2019-04-23		17	0.20	0.60	Yes	176.0
				2019-05-15	15:09:00	23	0.15	0.40	Yes	176.0
				2019-06-11	17:06:51	26	0.30	0.50	Yes	176.1
				2019-08-09	17:55:32	26	0.10	0.40	Yes	176.5
			2020	2020-03-30	10:29:23	9	0.35	1.00	Yes	177.1
				2020-04-21	09:50:53	16	0.50	1.20	Yes	177.5
				2020-05-08	10:51:28	17	1.20	2.20	Yes	177.5
				2020-07-15	15:54:56	21	1.00	1.70	Yes	177.0
	JHT-PBA22	NWSA, NPTF, NRLF	2019	2019-04-23	15:25:20	16	0.70	1.50	No	176.0
			2020	2020-03-30	13:50:59	11	0.45	1.00	Yes	177.1
	JHT-PBA46S	NPTF, WETO, NRLF, NWSA	2019	2019-04-25	15:44:43	20	0.10	0.50	Yes	176.0
			2020	2020-05-08		16	1.30	2.50	Yes	177.5
	JHT-PBA70	NPTF, NWSA	2020	2020-05-08	13:19:23	11	0.80	1.80	No	177.5
	JHT-PBA71	NPTF		2020-05-08	14:59:22	18	1.30	2.50	Yes	178.0
No	JHT-PBA23		2019	2019-04-23	17:12:35	16	1.00	5.00	Yes	176.0
			2020	2020-03-30	15:06:33	9	0.80	2.00	Yes	177.1
	JHT-PBA25		2019	2019-04-25	13:31:54	13	1.00	3.50	Yes	176.0
				2019-04-25	14:28:06	9	0.80	0.80	Yes	176.0
	JHT-PBA30		2019	2019-03-28	17:12:38	7	3.00	5.00	Yes	175.8
	JHT-PBA31		2019	2019-03-28	17:19:14	7	0.50	5.00	Yes	175.8
	JHT-PBA47S		2019	2019-04-25		13	0.50	1.40	Yes	176.0
	JHT-PBA48S		2020	2020-04-09	14:50:33	6	0.40	0.80	Yes	177.1
	JHT-PBA49S		2019	2019-04-02		8	0.40	0.60	Yes	175.8
				2019-05-14	13:04:26	15	0.40		Yes	176.0
			2020	2020-03-30	12:44:43	8	0.60	1.50	Yes	177.1
				2020-05-08	12:21:50	16	1.50	2.00	Yes	177.5

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] Corresponding reservoir elevation (Upper or Lower Campbell Reservoir depending on site) at the time of survey.

Table 2. Summary of broad scale (site level) habitat characteristics collected at each visit in the Upper Campbell Reservoir.

Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Date	Time	Water Temp. (°C)	Avg. Depth (m)	Max Depth (m)	Fish Exposure	Reservoir Elevation (m)[3]
Yes	JHT-PBA01	WETO, NPTF	2019	2019-03-13	10:51:33	5	0.25	0.40	Yes	214.6
				2019-04-25	10:20:59	12	0.12	0.10	No	214.4
				2019-06-11	15:20:45	30	0.15	0.25	No	216.4
				2019-07-04	14:46:46	25	0.20	0.30	No	216.6
				2019-08-09	15:32:48	24				216.8
			2020	2020-04-01	14:16:44	10	0.35	1.00	Yes	216.7
				2020-04-23	11:51:33	16	0.20	0.65	Yes	216.2
				2020-06-11	10:44:30	18	0.65	2.00	Yes	217.6
				2020-07-15	13:28:11	22	0.50	1.50	Yes	218.3
	JHT-PBA02	WETO	2019	2019-03-13	11:36:30	9	0.40	0.75	Yes	214.6
				2019-06-11	15:41:51	24				216.4
				2019-07-04	14:37:10	25	0.40	0.70	No	216.6
				2019-08-09	15:53:48	24				216.8
			2020	2020-04-01	14:14:44	9	0.60	1.20	Yes	216.7
				2020-04-23	11:37:12	14	0.30	0.35	Yes	216.2
				2020-06-11	10:31:57	15	0.75	1.70	Yes	217.6
				2020-07-15	13:19:17	18	0.45	1.50	Yes	218.3
	JHT-PBA03	WETO, NPTF	2019	2019-03-13	12:20:40	8	0.40	0.60	Yes	214.6
				2019-04-25	10:39:07		0.06	0.10	No	214.4
				2019-06-11	14:46:02	26	0.20	0.60	No	216.3
				2019-07-04	13:44:05	24				216.6
				2019-08-09	15:17:11	26	0.10	0.30	No	216.8
			2020	2020-04-01	13:43:06	9	0.20	1.00	Yes	216.7
				2020-04-23	13:44:31	14	0.30	1.00	Yes	216.2
				2020-06-11	09:44:57	16	0.50	1.00	Yes	217.6
				2020-07-15	12:44:53	21	0.40	0.70	Yes	218.3
				2020-08-13	09:11:40	19	0.50	1.50	Yes	218.0
	JHT-PBA04	NPTF	2019	2019-03-13	13:22:14	5	0.30	0.40	Yes	214.6
				2019-04-03	15:41:16		0.00	0.00	No	214.0
				2019-06-11	13:25:02	24				216.3
				2019-07-04	15:25:20	23	0.50	1.50	No	216.6
				2019-08-09	16:48:27	0	0.20	2.00	No	216.8
			2020	2020-03-17	16:46:44	9	0.40	2.00	No	217.7
				2020-04-23	14:09:43	15	0.45	1.20	Yes	216.2
				2020-05-14	15:21:33	16	0.50	1.50	Yes	217.1
				2020-06-11	11:25:17	16	0.80	1.00	No	217.6
				2020-07-15	14:23:31	23	0.40	1.00	No	218.3
				2020-08-13	10:35:43	18	0.50	1.00	No	218.0
	JHT-PBA05	NPTF	2020	2020-03-17	16:36:50	13	0.20	0.35	No	217.7
				2020-06-11	11:50:42	17	0.30	0.50	No	217.6
				2020-07-15	14:03:44	22	0.60	1.00	No	218.3
				2020-08-13	10:12:40	19	0.35	0.60	No	218.0

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] Corresponding reservoir elevation (Upper or Lower Campbell Reservoir depending on site) at the time of survey.

Table 2. Continued.

Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Date	Time	Water Temp. (°C)	Avg. Depth (m)	Max Depth (m)	Fish Exposure	Reservoir Elevation (m)[3]
Yes	JHT-PBA06	NPTF	2019	2019-03-13		6	0.50	1.30	Yes	214.6
				2019-04-24	15:40:38	16	0.50	0.10	No	214.3
				2019-06-11	14:08:04	24				216.3
				2019-07-04	12:50:17	23	0.40	1.00	No	216.6
			2020	2020-03-17	17:02:21	8	0.30	1.60	Yes	217.7
				2020-04-23	13:56:20	13	0.40	0.60	Yes	216.2
				2020-05-14	15:04:58	15	0.40	1.00	Yes	217.1
	JHT-PBA09	WETO	2019	2019-03-28	11:13:47	9	0.50	1.50	Yes	214.0
				2019-04-24	10:38:51		20.00	2.00	Yes	214.3
				2019-05-14	10:22:39	16	0.10	1.30	Yes	215.1
				2019-06-11	10:17:11	23	0.10	1.90	Yes	216.4
				2019-07-04	10:20:15	24				216.6
				2019-08-09	11:15:39	21	0.05	1.10	No	216.8
			2020	2020-03-17	13:57:12	9	0.20	0.40	Yes	217.7
				2020-04-01	10:29:45	8	0.15	0.25	Yes	216.7
				2020-04-22	10:43:31	16	0.15	0.50	Yes	216.2
				2020-05-14	11:59:55	20	0.10	0.15	Yes	217.1
				2020-07-15	09:16:37	18	0.40	1.50	Yes	218.3
	JHT-PBA10	WETO	2019	2019-03-28	12:35:24	10	0.20	2.80	Yes	214.0
			2020	2020-03-17	15:23:39	8	0.50	2.80	Yes	217.7
				2020-04-01	11:29:22	10	0.60	1.50	Yes	216.7
				2020-04-22	12:34:49	15	0.25	1.60	Yes	216.2
	JHT-PBA11	WETO, NPTF	2019	2019-03-28	14:30:23	11	0.40	0.50	Yes	214.0
				2019-04-03	11:08:40	12	0.40	0.70	Yes	214.0
				2019-04-24	12:19:13	18	0.50	0.50	Yes	214.3
				2019-05-14	11:35:02	16	0.30	0.50	Yes	215.1
				2019-06-11	11:17:26	24				216.4
				2019-07-04	11:15:20	24				216.6
				2019-08-09	12:15:34	24				216.8
			2020	2020-03-17	14:30:51	9	0.20	0.50	Yes	217.7
				2020-04-01	11:03:33	9	0.30	0.50	Yes	216.7
				2020-04-22	11:39:52	15	0.30	0.50	Yes	216.2
				2020-05-14	10:57:29	20	0.25	0.50	Yes	217.1
				2020-07-15	10:51:05	23	0.30	1.50	Yes	218.3
	JHT-PBA13	WETO	2019	2019-04-03	10:54:40	9	0.30	0.50	Yes	214.0
				2019-04-24	12:11:25	13	0.30	0.50	Yes	214.3
				2019-05-14	11:17:03	15	0.15	0.45	Yes	215.2
				2019-06-11	11:04:25	21	0.14	0.30	Yes	216.4
				2019-07-04	11:02:24	22	0.10	0.30	Yes	216.6
				2019-08-09	11:56:15	21	0.20	0.30	Yes	216.8
			2020	2020-04-01	12:13:22	7	0.20	0.35	Yes	216.7
				2020-04-22	13:11:47	14	0.25	0.35	Yes	216.2
				2020-07-15	10:31:40	19	0.50	1.50	Yes	218.3

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] Corresponding reservoir elevation (Upper or Lower Campbell Reservoir depending on site) at the time of survey.

Table 2. Continued.

Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Date	Time	Water Temp. (°C)	Avg. Depth (m)	Max Depth (m)	Fish Exposure	Reservoir Elevation (m)[3]
Yes	JHT-PBA14	WETO	2019	2019-04-03	13:18:35	9	0.80	0.90	No	214.0
				2019-05-14	14:04:54	12	0.40	1.70	Yes	215.1
			2020	2020-04-22	15:00:59	12	0.40	1.00	Yes	216.2
	JHT-PBA17	NWSA	2019	2019-04-02	11:11:01	12	0.70	0.70	Yes	213.9
				2019-05-15	12:19:11	19	0.60	1.00	Yes	215.1
				2019-07-04		23	1.00	1.00	Yes	216.6
			2020	2020-04-09	12:10:56	11	0.50	1.00	Yes	216.2
				2020-06-11	13:20:26	20	0.45	0.75	Yes	217.6
				2020-08-13	17:41:53	18	0.35	0.75	Yes	218.0
	JHT-PBA18	NPTF, WETO	2019	2019-06-11	14:45:02	24				216.4
				2019-07-04	12:40:51	23	0.20	0.50	No	216.6
				2019-08-09	14:46:04	22	0.10	0.80	No	216.8
			2020	2020-04-01	15:43:47	8	0.15	0.35	Yes	216.7
				2020-04-23	13:31:40	19	0.13	0.25	Yes	216.2
				2020-04-23	13:53:57	18	0.45	1.50	Yes	216.2
				2020-05-14	14:48:23	18	0.40	1.20	Yes	217.1
	JHT-PBA19	WETO, NPTF	2019	2019-07-04		23	0.15	1.50	No	216.6
			2020	2020-04-09	10:15:00	11	0.35	1.00	Yes	216.2
				2020-04-21	13:46:07	17	0.30	0.90	Yes	216.2
				2020-06-11	12:26:16	20	0.50	0.75	Yes	217.6
				2020-08-13	12:32:10	22	0.50	1.00	Yes	218.0
	JHT-PBA21	WETO, NPTF	2019	2019-04-02	10:30:50		0.00	0.00	No	213.9
			2019	2019-07-04		23	0.25	1.00	No	216.6
			2020	2020-04-09	10:35:31	11	0.40	1.00	No	216.2
				2020-04-21	14:41:09	18	0.40	1.20	Yes	216.2
				2020-06-11	12:51:39	20	0.45	1.20	Yes	217.6
				2020-08-13	12:14:31	21	0.45	1.00	Yes	218.0
	JHT-PBA36	WETO	2019	2019-04-03	14:42:54	15	0.40	1.00	No	214.0
				2019-05-14	15:25:31	19	0.15	0.30	Yes	215.1
				2019-06-11	12:18:21	24				216.4
			2020	2020-04-22	13:53:34	15	0.25	0.45	No	216.2
	JHT-PBA51	WETO, NWSA	2019	2019-05-15	10:41:34	13	0.40	0.60	No	215.1
	JHT-PBA52S	WETO	2020	2020-05-14	13:08:43	17	0.10	0.40	Yes	217.1
	JHT-PBA57	WETO	2020	2020-03-30	16:47:01	12	0.20	0.40	Yes	216.8
				2020-06-11	15:01:04	16	0.45	1.30	Yes	217.6
				2020-08-13	15:28:32	21	0.40	1.30	Yes	218.0
	JHT-PBA58	WETO	2020	2020-03-30	16:36:13	11	0.40	0.75	Yes	216.8
				2020-05-14	17:15:01	19	0.20	1.00	Yes	217.1
				2020-06-11	15:18:50	17	0.45	1.40	Yes	217.6
				2020-08-13	15:36:25	22	0.50	1.00	Yes	218.0

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] Corresponding reservoir elevation (Upper or Lower Campbell Reservoir depending on site) at the time of survey.

Table 2. Continued.

Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Date	Time	Water Temp. (°C)	Avg. Depth (m)	Max Depth (m)	Fish Exposure	Reservoir Elevation (m)[3]
Yes	JHT-PBA59	WETO, NPTF	2020	2020-03-30	16:22:35	11	0.35	0.80	No	216.8
				2020-05-14	16:52:36	24				217.1
				2020-06-11	14:36:19	19	0.40	0.80	Yes	217.6
				2020-08-13	15:09:53	22	0.40	0.80	Yes	218.0
No	JHT-PBA07		2019	2019-03-13	14:55:41	6	0.50	1.00	Yes	214.6
	JHT-PBA15		2019	2019-04-03	14:07:33	9	0.50	0.80	No	214.0
				2019-05-14	14:56:49	12	0.40	0.70	Yes	215.1
			2020	2020-04-22	14:42:11	11	0.35	1.32	Yes	216.2
	JHT-PBA29		2019	2019-04-02	13:01:23	15	0.05	0.40	No	213.9
	JHT-PBA33		2019	2019-04-03	14:28:30		0.08	0.30	No	214.0
				2019-05-14	15:08:59	12	0.20	0.40	No	215.1
			2020	2020-04-22	14:23:37	11	0.15	0.25	No	216.2
	JHT-PBA37		2019	2019-04-24	14:48:47	5	0.50	1.50	Yes	214.3
	JHT-PBA38		2020	2020-04-23	14:59:21	16	0.35	2.00	Yes	216.2
	JHT-PBA40S		2019	2019-04-24	14:09:02	10	0.30	1.00	Yes	214.3
	JHT-PBA41S		2019	2019-04-24	15:59:59	8	0.30	0.70	Yes	215.0
	JHT-PBA42S		2019	2019-04-24	16:32:18		0.40	0.80	Yes	214.3
	JHT-PBA44S		2019	2019-04-24	16:41:43	14	0.40	0.70	Yes	214.3
	JHT-PBA45S		2019	2019-04-25	11:12:52	12	0.30	0.60	Yes	214.4
			2020	2020-04-23	12:24:39	18	0.20	0.12	Yes	216.2
	JHT-PBA50		2019	2019-05-15	10:05:19	8	15.00	0.30	No	215.2
	JHT-PBA79		2020	2020-04-01	15:28:58	15	0.15	0.44	Yes	216.7
				2020-04-23	13:15:33	19	0.10	0.15	Yes	216.2
				2020-05-14	14:34:08	18	0.30	0.70	Yes	217.1
	JHT-PBA80S		2020	2020-03-30	16:59:18	8	0.60	1.00	Yes	216.8
				2020-05-14	17:30:03	18	0.40	0.70	Yes	217.1
	JHT-PBA81S		2020	2020-04-01	14:55:59	8	0.20	0.40	Yes	216.7
	JHT-PBA82S		2020	2020-04-21	15:02:52	13	0.50	1.00	Yes	216.2

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[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] Corresponding reservoir elevation (Upper or Lower Campbell Reservoir depending on site) at the time of survey.

Table 3. Summary of broad scale (site level) habitat characteristics collected annually.

Water-body	Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Wave Action	Habitat	Substrate[3,4] R	OM	B	MS	DW	Berm Height (m)	Average Shoreline Slope (%)	Shade (%)[5]	Fish Exposure	Avg. Depth[6] (m)	Avg. Max depth[7] (m)	Distance to Forest Cover (m)	Beaver Evidence	Water Source
LCR	Yes	JHT-PBA08	WETO, NWSA	2019	Low	Shallow Pool	SD	SD		D		1.5	20.0	0, <50%	Yes	0.5	0.9	10 - 40	No	Flood,Precipitation,Sub-Irrigation
				2020		Shallow Pool						0.2	0.0	0, <50%	Yes	0.4	1.2			
		JHT-PBA16	NPTF	2019	None	Shallow Pool			D			0.4	8.0	<50%	No	0.3	0.4	10 - 40	No	Flood,Precipitation,Stream
				2020		Shallow Pool						0.0	0.0	0	No	0.1	0.3			
		JHT-PBA20	NRLF, NWSA, NPTF	2019	Low	Shallow Pool, Small Lake		SD		D	SD	1.8	5.0	0, <50%	Yes	0.3	0.5	0 - 10	Yes	Flood,Precipitation,Seep
				2020		Shallow Pool, Small Lake						-0.4	0.0	0, <50%	Yes	0.8	1.5		Yes	
		JHT-PBA22	NWSA, NPTF, NRLF	2019	Low	Small Lake		D		SD		0.4	3.0	0	No	0.7	1.5	10 - 40	Yes	Flood,Precipitation,Seep
				2020		Small Lake						0.0	0.0	0	Yes	0.5	1.0		Yes	
		JHT-PBA46S	NPTF, WETO, NRLF, NWSA	2019	Low	Large Bay		T		D	T	0.0	2.0	0	Yes	0.1	0.5	10 - 40	No	Flood,Precipitation,Seep,Stream
				2020	Low	Large Bay	D	T		SD	T	-	7.0	<50%	Yes	1.3	2.5	0 - 10	No	Flood
		JHT-PBA70	NPTF, NWSA	2020	None	Shallow Pool		SD		D	T	0.9	0.0	100%	No	0.8	1.8	0 - 10	No	Precipitation,Sub-Irrigation
		JHT-PBA71	NPTF	2020	High	Small Bay		T		D	T	-1.0	0.0	<50%	Yes	1.3	2.5	0 - 10	No	Flood
	No	JHT-PBA23		2019	Low	Small Lake	D	T		T		5.0	8.0	<50%	Yes	1.0	5.0	10 - 40	No	Flood,Precipitation,Seep
				2020		Small Bay						0.0	0.0	<50%	Yes	0.8	2.0			
		JHT-PBA25		2019	None, Medium	Shallow Pool, Large Bay	D	T		D	SD, T	2.4	20.0	>50%, <50%	Yes	0.9	2.2	0 - 40	No	Flood,Precipitation
		JHT-PBA30		2019	Low	Small Lake	D					5.0	25.0	>50%	Yes	3.0	5.0	0 - 10	No	Flood,Precipitation,Seep
		JHT-PBA31		2019	Low	Small Lake	D	T		T	SD	5.0	30.0	>50%	Yes	0.5	5.0	0 - 10	No	Flood,Precipitation
		JHT-PBA47S		2019	Medium	Large Bay	D				T	0.0	25.0	<50%	Yes	0.5	1.4	10 - 40	No	Flood,Precipitation,Sub-Irrigation
		JHT-PBA48S		2020		Large Bay						0.0	0.0	<50%	Yes	0.4	0.8			
		JHT-PBA49S		2019	Low, Medium	Large Bay	D	T		D		0.0	5.5	0	Yes	0.4	0.6	0 - 80	No	Flood,Precipitation, Flood,Precipitation,Sub-Irrigation
				2020		Large Bay						-	0.0	<50%	Yes	1.1	1.8		Yes	
UCR	Yes	JHT-PBA01	WETO, NPTF	2019	None	Shallow Pool	T	T		D	T	2.9	12.0	0	Yes	0.2	0.3	0 - 10	No	Flood,Precipitation,Seep, Precipitation,Sub-Irrigation
				2020		Shallow Pool						1.8	0.0	0, <50%	Yes	0.4	1.3			
		JHT-PBA02	WETO	2019	Low, None	Shallow Pool	T	T		D		1.0	40.0	0	Yes	0.4	0.7	0 - 10	No	Flood,Precipitation
				2020		Shallow Pool						-0.5	0.0	0, <50%	Yes	0.5	1.2			
		JHT-PBA03	WETO, NPTF	2019	None	Small Lake, Shallow Pool		T		D	T	0.5	30.0	0	Yes	0.2	0.4	10 - 40	No	Flood,Precipitation,Seep
				2020		Small Lake, Shallow Pool						-0.5	0.0	0, <50%	Yes	0.4	1.0			
		JHT-PBA04	NPTF	2019	None	Shallow Pool	T	T		D		3.0	30.0	<50%, 0	Yes	0.3	1.1	0 - 10	No	Flood,Precipitation,Seep
				2020		Shallow Pool						1.6	0.0	<50%, 0, 100%	Yes	0.5	1.3		No	
		JHT-PBA05	NPTF	2020		Shallow Pool						2.2	0.0	<50%, 0, >50%	No	0.4	0.6		No	
		JHT-PBA06	NPTF	2019	None	Shallow Pool				D		0.9	30.0	<50%, 100%	Yes	0.5	0.8	10 - 40	No	Seep, Flood,Precipitation
				2020		Shallow Pool						0.7	0.0	<50%, 0	Yes	0.4	1.1		No	
		JHT-PBA09	WETO	2019	None	Small Lake, Shallow Pool				D	T	1.7	3.0	0	Yes	3.5	1.5		No	Precipitation,Sub-Irrigation
				2020		Small Lake						-0.9	0.0	<50%, 100%, 0	Yes	0.2	0.6			
		JHT-PBA10	WETO	2019	Low	Shallow Pool		SD		D	T	2.8	3.0	<50%	Yes	0.2	2.8	0 - 10	Yes	Other,Precipitation,Seep
				2020		Shallow Pool, Small Lake						2.3	0.0	<50%, 0	Yes	0.5	2.0		Yes	
		JHT-PBA11	WETO, NPTF	2019	Low	Shallow Pool		SD		D	T	0.4	5.0	0, <50%	Yes	0.3	0.5	0 - 10	Yes	Flood,Precipitation,Stream,Sub-Irrigation
				2020		Shallow Pool						0.7	0.0	0, <50%	Yes	0.3	0.7		Yes	

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] R = Rock, OM = Organic Matter, B = Bedrock, MS = Mineral Soil, DW = Decaying Wood.

[4] D = Dominant, SD = Subdominant, T = Trace.

[5] Shade was estimated at each site visit and varied depending on extent of leaf out (i.e., less shade early in the spring, more shade as shrubs and trees grew leaves and vegetation filled in through the late spring and summer).

[6] Average pond depth was estimated during each site visit and then an average value was calculated for each year.

[7] Maximum pond depth was estimated during each site visit and and then an average value was calculated for each year.

Table 3. Continued.

Water-body	Breeding Life Stage[1] Detected	Site	Species Breeding[2]	Year	Wave Action	Habitat	Substrate[3,4] R	OM	B	MS	DW	Berm Height (m)	Average Shoreline Slope (%)	Shade (%)[5]	Fish Exposure	Avg. Depth[6] (m)	Avg. Max depth[7] (m)	Distance to Forest Cover (m)	Beaver Evidence	Water Source
UCR	Yes	JHT-PBA13	WETO	2019	Low	Shallow Pool		T		D	T	0.5	5.0	0, <50%	Yes	0.2	0.4	0 - 10	Yes	Flood,Precipitation,Stream
				2020		Shallow Pool						-0.5	0.0	0, <50%	Yes	0.3	0.7			
		JHT-PBA14	WETO	2019	Low	Shallow Pool		SD		D	SD	0.0	6.0	0, <50%	Yes	0.6	1.3	10 - 40		Precipitation,Seep,Stream
				2020		Shallow Pool		T		D		2.8	0.0	<50%	Yes	0.4	1.0	10 - 40	Yes	Flood,Precipitation,Sub-Irrigation
		JHT-PBA17	NWSA	2019	None	Shallow Pool, Small Lake		D		T	T	1.4	3.0	0	Yes	0.8	0.9	10 - 40	Yes	Flood,Precipitation,Seep,Stream,Sub-Irrigation
				2020		Small Lake						1.3	0.0	0	Yes	0.4	0.8			
		JHT-PBA18	NPTF, WETO	2019	High	Shallow Pool		T		T		0.8	3.0	0	No	0.2	0.6	10 - 40	No	Flood,Precipitation,Seep
				2020		Shallow Pool						0.0	0.0	<50%, 0	Yes	0.3	0.8			
		JHT-PBA19	WETO, NPTF	2019	None	Shallow Pool						3.1	22.0	0	No	0.2	1.5	0 - 10	No	Flood,Precipitation,Sub-Irrigation
				2020	None	Shallow Pool	T			D		1.5	0.0	<50%, 0	Yes	0.4	0.9	10 - 40	No	Precipitation,Sub-Irrigation
		JHT-PBA21	WETO, NPTF	2019	None	Shallow Pool		T		D		2.7	22.0	0, <50%	No	0.1	0.5	0 - 10	No	Flood,Precipitation,Seep,Sub-Irrigation
				2020		Shallow Pool						1.2	0.0	<50%, 0, >50%	Yes	0.4	1.1			
		JHT-PBA36	WETO	2019	Low	Shallow Pool		T		D	T	0.1	3.0	0	Yes	0.3	0.7	80 - 200	Yes	Flood,Precipitation,Sub-Irrigation
				2020	None	Shallow Pool		T		D		0.4	0.0	<50%	No	0.3	0.5	0 - 10	No	Sub-Irrigation
		JHT-PBA51	WETO, NWSA	2019	Low	Shallow Pool		D		D	T	0.0	3.0	<50%	No	0.4	0.6	0 - 10	No	Flood,Precipitation,Sub-Irrigation
		JHT-PBA52S	WETO	2020	Low	Large Bay	SD	D		T		0.0	0.0	0	Yes	0.1	0.4	> 200	No	Flood
		JHT-PBA57	WETO	2020	None	Shallow Pool	T			D		-0.5	10.0	0, <50%	Yes	0.4	1.0	0 - 10	No	Precipitation,Sub-Irrigation
		JHT-PBA58	WETO	2020	None	Shallow Pool	T			D		-0.4	12.0	<50%, 0	Yes	0.4	1.0	0 - 10	No	Flood,Precipitation,Sub-Irrigation
		JHT-PBA59	WETO, NPTF	2020	None	Shallow Pool	T			D		0.3	12.0	0, <50%	Yes	0.4	0.8	0 - 10	No	Precipitation,Sub-Irrigation
	No	JHT-PBA07		2019	Low	Shallow Pool	D			T		6.0	40.0	<50%	Yes	0.5	1.0	10 - 40	No	Flood,Precipitation
		JHT-PBA15		2019	Low	Shallow Pool		SD		D	SD	0.0	3.0	0, <50%	Yes	0.5	0.8	40 - 80	No	Flood,Precipitation,Sub-Irrigation
				2020		Shallow Pool		T		D		1.2	0.0	<50%	Yes	0.4	1.3		No	Flood,Precipitation,Sub-Irrigation
		JHT-PBA29		2019	None	Other		SD		D	SD	0.0	3.0	<50%	No	0.1	0.4	0 - 10		Flood,Precipitation,Stream
		JHT-PBA33		2019	Low	Shallow Pool		SD		D	T	0.0	4.0	0	No	0.1	0.4	10 - 40		Flood,Precipitation,Sub-Irrigation
				2020	None	Shallow Pool				D		1.2	-	<50%	No	0.2	0.3	10 - 40	Yes	Flood,Precipitation,Sub-Irrigation
		JHT-PBA37		2019	Low	Shallow Pool		SD		D	SD	1.5	35.0	>50%	Yes	0.5	1.5	0 - 10	Yes	Flood,Precipitation,Stream
		JHT-PBA38		2020	None	Shallow Pool	D			T		0.4	0.0	<50%	Yes	0.4	2.0	10 - 40	No	Flood,Precipitation,Sub-Irrigation
		JHT-PBA40S		2019	High	Small Bay	D				T	0.0	25.0	0	Yes	0.3	1.0	10 - 40	No	Flood,Precipitation
		JHT-PBA41S		2019	Medium	Large Bay	T			D	T	0.0	6.0	0	Yes	0.3	0.7	40 - 80	No	Flood,Precipitation
		JHT-PBA42S		2019	High	Small Bay	D				T	0.0	10.0	0	Yes	0.4	0.8	10 - 40	No	Flood,Precipitation,Sub-Irrigation
		JHT-PBA44S		2019	High	Small Bay	D					0.0	20.0	0	Yes	0.4	0.7	10 - 40	Yes	Flood,Precipitation,Sub-Irrigation
		JHT-PBA45S		2019	Medium	Large Bay	D	T		T	T	0.0	4.0	0	Yes	0.3	0.6	10 - 40	No	Flood,Precipitation,Stream,Sub-Irrigation
				2020	Medium	Large Bay	T			D	T	0.0	0.0	<50%	Yes	0.2	0.1	40-80	No	Flood,Sub-Irrigation
		JHT-PBA50		2019	None	Shallow Pool		D		D	T	0.7	3.0	<50%	No	15.0	0.3	0 - 10	No	Flood,Precipitation,Stream,Sub-Irrigation
		JHT-PBA79		2020	None	Shallow Pool	T			D		-0.1	6.0	<50%, 0	Yes	0.2	0.4	10 - 40	No	Precipitation,Sub-Irrigation
		JHT-PBA80S		2020	Low	Large Bay				D	T	0.0	7.0	<50%	Yes	0.5	0.9	10 - 40	No	
		JHT-PBA81S		2020	Low	Large Bay	T			D		0.0	4.0	0	Yes	0.2	0.4	80 - 200	No	Flood,Precipitation
		JHT-PBA82S		2020	Medium	Large Bay	D					0.0	22.0	0	Yes	0.5	1.0	10 - 40	No	

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Roughskin Newt.

[3] R = Rock, OM = Organic Matter, B = Bedrock, MS = Mineral Soil, DW = Decaying Wood.

[4] D = Dominant, SD = Subdominant, T = Trace.

[5] Shade was estimated at each site visit and varied depending on extent of leaf out (i.e., less shade early in the spring, more shade as shrubs and trees grew leaves and vegetation filled in through the late spring and summer).

[6] Average pond depth was estimated during each site visit and then an average value was calculated for each year.

[7] Maximum pond depth was estimated during each site visit and and then an average value was calculated for each year.

Table 4. Summary of broad scale (site level) vegetation habitat characteristics collected annually.

Water-body	Breeding Life Stage[1]	Site	Species Breeding[2]	Year	Submerged Vegetation: Vegetation Cover (%)[3] Small Herb	Graminoid	Shrub	Tree	CWD Cover (%)[3]	Organic Substrate[4]	Emergent Vegetation: Vegetation Cover (%)[3] Small Herb	Graminoid	Shrub	Tree	CWD Cover (%)[3]	Organic Substrate[4]	Shoreline Terrestrial Vegetation: Vegetation Community (TEM)[5]	Vegetation Cover (%)[3] Small Herb	Graminoid	Shrub	Tree	CWD Cover (%)[3]	Organic Substrate[4]
LCR	Yes	JHT-PBA08	WETO, NWSA	2019	3	0	0	0	1	low	3	0	0	0	1	low	-	2	2	2	2	1	low
		JHT-PBA16	NPTF	2019	0	0	0	0	0	none	0	0	0	0	0	none	-	2	1	2	4	1	low
		JHT-PBA20	NRLF, NWSA, NPTF	2019	2	0	0	0	1	low	2	0	0	0	1	low	HL	1	2	2	4	1	low
		JHT-PBA22	NWSA, NPTF, NRLF	2019	2	0	0	0	1	high	2	0	0	0	1	high	HL	1	2	3	2	1	high
		JHT-PBA46S	NPTF, WETO, NRLF, NWSA	2019	3	0	0	0	1	none	3	0	0	0	1	none	SL	3	2	2	3	1	low
				2020	1	1	0	0	1	none	1	1	0	0	1	none	SL	1	2	3	3	2	low
		JHT-PBA70	NPTF, NWSA	2020	2	0	0	0	2	low	2	0	0	0	2	low	-	1	1	3	3	2	low
		JHT-PBA71	NPTF	2020	1	2	1	0	2	none	1	2	1	0	2	none	WS	1	2	4	2	2	low
	No	JHT-PBA23		2019	3	0	0	0	2	none	3	0	0	0	2	none	WS	3	2	2	4	1	low
		JHT-PBA25		2019	-	-	-	-	-	low	-	-	-	-	-	low	HS	-	-	-	-	-	low
		JHT-PBA30		2019	1	0	0	0	2	none	1	0	0	0	2	none	-	1	1	1	4	1	low
		JHT-PBA31		2019	4	0	0	0	2	none	4	0	0	0	2	none	-	1	2	1	4	1	none
		JHT-PBA47S		2019	0	0	0	0	1	none	0	0	0	0	1	none	-	1	2	2	3	1	low
		JHT-PBA49S		2019	1	0	0	0	0.5	none	1	0	0	0	0.5	none	MF	1	2	3	1.5	1	low
UCR	Yes	JHT-PBA01	WETO, NPTF	2019	1	0	0	0	0	none	1	0	0	0	0	none	SL	1	2	2	4	1	none
		JHT-PBA02	WETO	2019	3	0	0	0	0	none	3	0	0	0	0	none	-	2	3	2	3	2	none
		JHT-PBA03	WETO, NPTF	2019	4	0	0	0	0	low	4	0	0	0	0	low	-	1	2	2	2	1	none
		JHT-PBA04	NPTF	2019	2	0	0	0	1	low	2	0	0	0	1	low	HS	1	2	2	4	1	low
		JHT-PBA06	NPTF	2019	0	0	0	0	0	none	0	0	0	0	0	none	MF	2	2	2	4	1	(blank)
		JHT-PBA09	WETO	2019	0	0	0	0	1	none	0	0	0	0	1	none	MF	2	2	1	3	1	low
		JHT-PBA10	WETO	2019	2	0	0	0	1	low	2	0	0	0	1	low	WS	1	2	2	4	1	low
		JHT-PBA11	WETO, NPTF	2019	4	0	0	0	1	low	4	0	0	0	1	low	SL	1	3	1	2	1	low
		JHT-PBA13	WETO	2019	2	0	0	0	1	low	2	0	0	0	1	low	SL	2	2	2	4	1	low
		JHT-PBA14	WETO	2019	2	0	0	0	2	low	2	0	0	0	2	low	WS	1	3	4	2	1	low
				2020	0	0	0	0	1	none	0	0	0	0	1	none	WS	0	0	0	0	1	none

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Rough-skinned Newt.

[3] Cover category: 0 = 0%, 1 = 1-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = >75%.

[4] None = no organics, low = 0-5 cm organics, medium = 5-50 cm organics, high = >50 cm organics.

[5] CW = Black Cottonwood - Willow, HL = Hardhack - Labrador Tea, HS = Hairgrass - Water Sedge, MF = Lake Mudflat (unvegetated), SL = Spearwort Lakeflat, WS = Sitka Willow - Water Sedge.

Table 4. Continued.

Water-body	Breeding Life Stage[1]	Site	Species Breeding[2]	Year	Submerged Vegetation						Emergent Vegetation						Shoreline Terrestrial Vegetation						
					Vegetation Cover (%)[3]				CWD	Organic	Vegetation Cover (%)[3]				CWD	Organic	Vegetation	Vegetation Cover (%)[3]				CWD	Organic
					Small Herb	Graminoid	Shrub	Tree	Cover (%)[3]	Substrate[4]	Small Herb	Graminoid	Shrub	Tree	Cover (%)[3]	Substrate[4]	Community (TEM)[5]	Small Herb	Graminoid	Shrub	Tree	Cover (%)[3]	Substrate[4]
		JHT-PBA17	NWSA	2019	2	0	0	0	1	high	2	0	0	0	1	high	HS	1	3	4	1	1	high
				2020	-	-	-	-	-	n/a	-	-	-	-	-	n/a	HS	-	-	-	-	-	n/a
		JHT-PBA18	NPTF, WETO	2019	2	0	0	0	0	none	2	0	0	0	0	none	MF	1	1	2	2	1	low
				2020	-	-	-	-	-	n/a	-	-	-	-	-	n/a	MF	-	-	-	-	-	n/a
		JHT-PBA19	WETO, NPTF	2019	2	1	0	0	0	none	2	1	0	0	0	none	SL	1	3	2	1	1	none
				2020	4	0	0	0	0	none	4	0	0	0	0	none	SL	2	1	1	0	1	none
		JHT-PBA21	WETO, NPTF	2019	1	3	0	0	0	none	1	3	0	0	0	none	SL	1	2	3	1	1	none
				2020	-	-	-	-	-	n/a	-	-	-	-	-	n/a	SL	-	-	-	-	-	n/a
		JHT-PBA36	WETO	2019	2	0	0	0	1	none	2	0	0	0	1	none	HS	1	2	3	1	1	low
				2020	2	0	0	0	1	low	2	0	0	0	1	low	HS	2	4	2	0	1	low
		JHT-PBA51	WETO, NWSA	2019	2	2	0	0	1	low	2	2	0	0	1	low	CW	1	2	3	3	1	low
		JHT-PBA52S	WETO	2020	3	0	0	0	1	none	3	0	0	0	1	none	MF	4	3	1	0	1	none
		JHT-PBA57	WETO	2020	3	0	0	0	1	none	3	0	0	0	1	none	SL	2	2	2	0	1	none
		JHT-PBA58	WETO	2020	2	0	0	0	0	none	2	0	0	0	0	none	SL	2	2	3	0	1	none
		JHT-PBA59	WETO, NPTF	2020	2	1	0	0	0	none	2	1	0	0	0	none	SL	1	2	3	0	1	none
	No	JHT-PBA07		2019	0	0	0	0	2	none	0	0	0	0	2	none	SL	1	1	2	2	1	none
		JHT-PBA15		2019	2	0	0	0	2	low	2	0	0	0	2	low	HS	2	3	3	2	1	low
				2020	3	0	0	0	0	none	3	0	0	0	0	none	HS	1	4	2	0	0	none
		JHT-PBA29		2019	1	1	0	0	1	low	1	1	0	0	1	low	WS	1	2	4	3	1	low
		JHT-PBA33		2019	1	1	0	0	1	none	1	1	0	0	1	none	HS	2	4	3	2	1	low
				2020	3	1	0	0	1	none	3	1	0	0	1	none	HS	1	4	2	0	1	none
		JHT-PBA37		2019	1	1	0	0	0	none	1	1	0	0	0	none	-	1	2	2	3	0	low
		JHT-PBA38		2020	1	1	0	0	0	none	1	1	0	0	0	none	-	1	1	2	2	2	low
		JHT-PBA40S		2019	0	0	0	0	1	none	0	0	0	0	1	none	-	1	2	2	2	1	low
		JHT-PBA41S		2019	1	0	0	0	2	none	1	0	0	0	2	none	-	2	1	2	1	1	low
		JHT-PBA42S		2019	1	0	0	0	2	none	1	0	0	0	2	none	-	1	2	2	3	1	low
		JHT-PBA44S		2019	0	0	0	0	1	none	0	0	0	0	1	none	-	1	1	1	2	1	low
		JHT-PBA45S		2019	1	0	0	0	0	none	1	0	0	0	0	none	-	2	3	2	2	1	low
				2020	1	1	0	0	0	none	1	1	0	0	0	none	-	1	3	3	3	0	(blank)
		JHT-PBA50		2019	2	2	0	0	1	low	2	2	0	0	1	low	CW	2	2	4	1	1	low
		JHT-PBA79		2020	1	0	0	0	0	none	1	0	0	0	0	none	SL	2	1	2	0	1	none
		JHT-PBA80S		2020	3	1	0	0	1	none	3	1	0	0	1	none	MF	2	2	2	0	1	none
		JHT-PBA81S		2020	2	0	0	0	1	none	2	0	0	0	1	none	SL	2	1	0	0	1	none
		JHT-PBA82S		2020	0	0	0	0	1	none	0	0	0	0	1	none	-	1	1	1	0	1	none

[1] The 'Breeding' life stage includes eggs, tadpoles and larvae of all species, in addition to Western Toad juveniles and metamorphs.

[2] WETO = Western Toad, NPTF = Northern Pacific Treefrog, NRLF = Northern Red-legged Frog, NWSA = Northwestern Salamander, RSNE = Rough-skinned Newt.

[3] Cover category: 0 = 0%, 1 = 1-5%, 2 = 5-25%, 3 = 25-50%, 4 = 50-75%, 5 = >75%.

[4] None = no organics, low = 0-5 cm organics, medium = 5-50 cm organics, high = >50 cm organics.

[5] CW = Black Cottonwood - Willow, HL = Hardhack - Labrador Tea, HS = Hairgrass - Water Sedge, MF = Lake Mudflat (unvegetated), SL = Spearwort Lakeflat, WS = Sitka Willow - Water Sedge.