Columbia River Project Water Use Plan

Arrow Reservoir Operations management Plan

Implementation Year 2

Reference: CLBMON-58

Kinbasket Reservoir: Monitoring of Impacts on Amphibians and Reptiles from Mica Units 5 and 6 in Kinbasket Reservoir

Study Period: 2013

Okanagan Nations Alliance, Westbank, BC
and
LGL Limited environmental research associates
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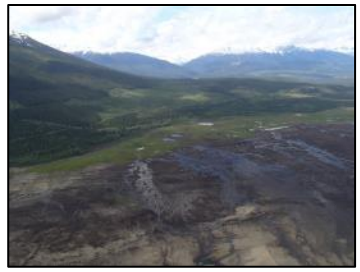


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From left to right: Columbia Spotted Frog (*Rana luteiventris*), Western Toad tadpoles (*Anaxyrus boreas*); Western Toad adult; Valemount Peatland © Virgil C. Hawkes, LGL Limited; and Long-toed Salamander (*Ambystoma macrodactylum*) © Krysia Tuttle, LGL Limited

EXECUTIVE SUMMARY

This year marked the second year of CLBMON-58, which is part of a larger 10-year amphibian and reptile life history and habitat use monitoring study in the drawdown zones (DDZs) of Kinbasket and Arrow Lakes Reservoirs. CLBMON-37, initiated in 2008, was designed to address the relative contribution and importance of the current reservoir operating regime (i.e., timing, duration and depth of inundation) on the life history (e.g., abundance, distribution and productivity) and habitat use of amphibians and reptiles occurring in the DDZs of each reservoir. CLBMON-58 specifically addresses the potential impacts of the installation of Units 5 and 6 at Mica Dam on amphibian and reptile populations in Kinbasket Reservoir. Ten management questions are investigated in this study, with the primary objective being to provide information on how amphibian and reptile communities at the landscape scale are affected by long-term variations in water levels and whether changes to the reservoir's operating regime may be required to maintain or enhance these communities or the habitats in which they occur.

Repeating the sampling of 2011 (and 2012), we documented the presence of three amphibian Western Toad (*Anaxyrus boreas*), Columbia Spotted Frog (*Rana luteiventris*), and Long-toed Salamander (*Ambystoma macrodactylum*) and one reptile species Common Garter Snake (*Thamnophis sirtalis*) in the drawdown zone of Kinbasket Reservoir. Western Toads and Columbia Spotted Frogs were the most commonly encountered species, usually in wetlands within clover-oxeye daisy, swamp-horsetail, Kellogg's sedge or willow-sedge habitats. Pond characteristics varied by species with Columbia Spotted Frogs using ponds situated at higher elevation and with a higher abundance and per cent cover of aquatic macrophytes compared to Western Toads. Western Toads breed in ponds as low as 734 m ASL in ponds that are typically devoid of vegetation or woody debris. In addition, there is little support that water physicochemical parameters measured (DO, conductivity, pH, temperature) affect the distribution or occurrence of either species, nor does development appear to be affected.

Most amphibian detections were distributed within an elevation band of 747 to 754 m ASL. The influence of reservoir operations on the availability of habitat in the DDZ was evident: as reservoir elevations increased throughout the season, the total amount of available habitat decreased. As such, the location of amphibians and reptiles in the DDZ was a function of seasonal habitat availability. Direct effects of reservoir operation on amphibians have not been observed, but the continued presence of Western Toad and Columbia Spotted Frogs of all life stages in the drawdown zone in consecutive years suggests that these species are not directly affected by reservoir operations. However, we do not know if the populations of Columbia Spotted Frogs and Western Toads are supressed relative to non-reservoir populations, and we won't know that unless suitable non-reservoir populations are studied.

Amphibian and Reptile monitoring will continue in 2014 (under CLBMON-37) and again in 2015 (under CLBMON-58) and additional methods are recommended to improve the likelihood of answering several management questions regarding how amphibians and reptiles use the drawdown zone to fulfill their life requisites. Obtaining these data is critical for assessing how a 0.6 m increase in reservoir elevations during the summer months might impact amphibians, reptiles, and their habitats. Most recommendations are carried forward from previous implementation years. The recommendations are listed here and discussed in more detail in the Recommendations Section.

Sampling

1. Continue with annual sampling (under CLBMON-37) to increase the time series of data;
2. Continue to start field surveys early in the year (late April);
3. Continue using pitfall trapping to determine site occupancy of inconspicuous species of amphibians that migrate to and from breeding ponds;
4. Include a telemetry study on Western Toads, Columbia Spotted Frog, and Common Garter Snakes for a minimum of one year. This will provide valuable information on the use of the drawdown zone by these species on a seasonal basis, including during winter, which will remove uncertainty as to whether the drawdown zone provides overwintering habitat. Radiotelemetry will help determine:
   - how snakes use the drawdown zone;
   - what time of year they are most likely to use the drawdown zone;
   - if amphibians comprise most of their diet (as suggested in Boyle 2012); and
   - where snakes are overwintering
   - where Columbia Spotted Frogs are overwintering
   - how adult toads use the drawdown zone (at what time of the year) and whether they are returning to the same breeding ponds each year.

Without this information, it will not be possible to determine the effects of normal or adjusted reservoir operations will be on amphibians and reptiles that use the drawdown zone of Kinbasket Reservoir.

Reservoir Operations

1. The inundation of elevations between ~735 and 754 m ASL should occur on or as close to the historical date calculated for the period 1978 to 2013 as possible.
2. Given that reservoir elevations are predicted to increase in the summer months as a result of the installation of units 5 and 6 at Mica Dam, achieving full pool in July is not recommended and maximum reservoir elevations should be targeted for the current average date of August 25. This will ensure that amphibians using the drawdown zone, particularly those in ponds >751 m ASL, will have enough time to develop prior to inundation

The status of CLBMON-58 after Year 2 (2013) with respect to the management questions and management hypotheses is summarized below.

Management Question (MQ)	**Able to Address MQ?**	**Scope**		**Sources of Uncertainty**
		Current supporting results	Suggested modifications to methods where applicable	
MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?	Yes	Data collected since 2008 have likely resulted in the documentation of all expected species in the drawdown zone	• Annual sampling • Increased frequency of sampling (i.e., annually)	• Natural annual population variation • Inconspicuous species • Bi-annual sampling • Variable reservoir operations
MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years?	Partially	4 years of site occupancy and detection rates data. Productivity estimated for some species	• Intensive productivity data collection for Western Toad and Columbia Spotted Frog • Annual sampling for select amphibians • Constrain study to Revelstoke Reach and Burton Creek • Add other sites as physical works are implemented	• Natural annual population variation • Unknown rate of immigration may confound productivity estimates • Inconspicuous species • Mortality difficult to assess • Bi-annual sampling • Variable reservoir operations
MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?	Partially	4 years of site occupancy data across multiple sites and seasons	• Telemetry studies on Western Toads to assess overwinter habitat use. This may only need to occur once to determine whether this species is using habitats in the drawdown zone to overwinter	• Natural annual population variation • Inconspicuous species • Lack of knowledge regarding the use of the drawdown zone in the winter • Variable reservoir operations

Management Question (MQ)	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
MQ4: Which habitats do amphibians and reptiles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?	Probably	3 years of macro and micro habitat data collection	• Reduce the number of monitoring sites • Focus on Western Toad and Columbia Spotted Frog • Telemetry study on Western Toads to assess habitat use • Re-evaluate existing habitat mapping and its relevance to amphibians and reptiles	• Habitat mapping is required at a scale relevant to amphibians and reptiles • Variable reservoir operations
MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?	Maybe	4 years of data collected on the occurrence and distribution of amphibians and reptiles in the drawdown zone	• None	• Natural annual population variation • Variable reservoir operations • Habitat mapping is required at a scale relevant to amphibians and reptiles
MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?	Possibly	N/A	• Restrict reservoir elevations for one year to elevations < 751 m ASL to determine whether doing so alters the use of the drawdown zone by amphibians and reptiles.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • Lack of experimentation to assess how varying the time of inundation correlates to the use of the drawdown zone by amphibians and reptiles
MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?	Not at this time	N/A	• Implement physical works	• Physical works have not been implemented. Until they are we cannot answer this question.

Management Question (MQ)	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?	Not at this time	N/A	• Ensure wetland-associated plants are included in the planting prescriptions associated with proposed and potential physical works.	• Revegetation of the drawdown zone has not been done in a replicated manner nor were the prescriptions designed to enhance amphibian and reptile habitat. Wetland-related plants would need to be planted to benefit amphibians and reptiles. work is not applicable to this study.
MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity, or productivity?	Not at this time	N/A	• Implement physical works	• Physical works have not been implemented. Until they are we cannot answer this question.
MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development?	Partially	Maximum reservoir elevations documented between 1978 and 2013 indicate that the average full pool date is August 25. At this time amphibians should be migrating out of the breeding ponds (Western Toads) or moving to overwintering sites in the drawdown zone of adjacent habitats (Columbia Spotted Frogs). This suggests that increasing reservoir elevations by 60 cm in the summer months should not directly impact amphibians. However, important habitats could be impacted.	• Use radiotelemetry to determine where Western Toads overwinter, whether Columbia Spotted Frogs overwinter in ponds in the drawdown zone, and to understand garter snake use of the drawdown zone in all seasons.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • It is not clear if surcharge can be used as proxy for increasing the reservoir by 60 cm in the summer months.

Key Words: amphibian, reptile, life history, habitat use, reservoir elevation, drawdown zone, Kinbasket Reservoir, Mica

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TABLE OF CONTENTS

EXECUTIVE SUMMARY i
ACKNOWLEDGEMENTS iv
LIST OF TABLES viii
LIST OF FIGURES ix
LIST OF MAPS xi
LIST OF APPENDICES xii
1.0 INTRODUCTION 1
1.1 Study Species 2
2.0 STUDY OBJECTIVES 3
2.1 Study Design 3
2.2 Management Questions and Hypotheses 4
3.0 STUDY AREA 6
3.1 Physiography 6
3.2 Climatology 6
3.3 Kinbasket Reservoir 6
3.3.1 Study Locations 8
4.0 METHODS 8
4.1 Field Schedule 8
4.2 Data Collection 9
4.2.1 General Survey Data 9
4.2.2 Species Morphometric Data 9
4.2.3 Pond-breeding Amphibian Data 10
4.2.4 Habitat Data 11
4.3 Data Analysis 12
4.3.1 Species Richness 12
4.3.2 Amphibian Observations 13
4.3.3 Amphibian Morphotmetric Data 13
4.3.4 Site Occupancy – Western Toad and Columbia Spotted Frog 14
4.3.5 Habitat Availability 14
4.3.6 Habitat Associations 15
5.0 RESULTS 15
5.1 Environmental Data 15
5.2 Water Physicochemical Data 16
5.3 Amphibian and Reptile Occurrence and Distribution 19
5.3.1 Landscape Units 19

5.3.2 Elevation 19
5.3.3 Pond and Wetland Habitat in the Drawdown Zone 22
5.3.4 Vegetation Community Associations 23
5.4 H1: Annual and seasonal variation in water levels in Kinbasket Reservoir (due to reservoir operations), the implementation of soft operational constraints, and the effects of Units 5 and 6 in Mica Dam on Kinbasket Reservoir, do not directly or indirectly impact reptile and amphibian populations 26
5.4.1 Soft Operational Constraints 26
5.4.2 Effects of Mica 5/6 26
5.5 $H1_A$: Reservoir operations do not result in a decreased abundance of amphibians or reptiles in the drawdown zone. 29
5.6 $H1_B$: Reservoir operations do not increase the stage specific (e.g. larval, juvenile, or adult) mortality rates of amphibians or reptiles in the drawdown zone. 31
5.7 $H1_C$: Reservoir operations do not result in decreased site occupancy of amphibians or reptiles in the drawdown zone. 33
5.7.1 Proportion of Mapped Sites 33
5.7.2 34
5.7.3 Site Occupancy Modelling 34
5.8 $H1_D$: Reservoir operations do not result in decreased productivity of amphibians or reptiles in the drawdown zone. 36
5.9 $H1_E$: Reservoir operations do not reduce the availability and quality of breeding habitat, foraging habitat and overwintering habitat for amphibians or reptiles in the drawdown zone. 37
5.9.1 Breeding Habitat 38
5.9.2 Foraging Habitat 42
5.9.3 Overwintering Habitat 43
5.10 $H2_A$: Revegetation and physical works do not increase species diversity or seasonal (spring/summer/fall) abundance of amphibians or reptiles in the drawdown zone. 43
5.10.1 Revegetation 43
5.10.2 Physical Works 43
5.11 $H2_B$: Revegetation and physical works do not increase amphibian or reptile productivity in the drawdown zone. 44
5.11.1 Revegetation 44
5.11.2 Physical Works 44
5.12 $H2_C$: Revegetation does not increase the amount or improve habitat for amphibians and reptiles in the drawdown zone. 44
6.0 DISCUSSION 45
6.1 MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur? 46

6.2 MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years? ... 46
6.2.1 Amphibian Abundance, Diversity and Productivity ... 46
6.2.2 Reptile Abundance, Diversity and Productivity ... 47
6.3 MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone? ... 48
6.4 MQ4: Which habitats do reptiles and amphibians use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)? ... 48
6.5 MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes? ... 49
6.6 MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles? ... 51
6.7 MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations? ... 51
6.8 MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles? ... 52
6.9 MQ9: Do physical works projects implemented during the course of this monitoring program increase the abundance of amphibians and reptiles abundance, diversity, or productivity? ... 52
6.10 MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development? ... 52
6.11 Management Questions - Summary ... 58
7.0 RECOMMENDATIONS ... 60
8.0 Additional Reporting Requirements ... 61
8.1 Data Deliverables ... 61
8.1.1 Data Provided to BC Hydro ... 61
8.1.2 Data Provided to the Ministry of Environment ... 61
8.2 SARA-listed Species ... 61
9.0 REFERENCES ... 62
10.0 APPENDICES ... 68

LIST OF TABLES

Table 1-1: Provincial and federal status of species of amphibians and reptiles that occur in the Columbia Basin. 3

Table 2-1: Monitoring years for CLBMON-37 and CLBMON-58 in Kinbasket Reservoir. The current year is indicated in bold 3

Table 2-2: Hypotheses addressed by each theme for CLBMON-58. 5

Table 5-1: Summary of water physicochemistry data collected at ponds with and without amphibians in the drawdown zone of Kinbasket Reservoir, 2011, 2012, and 2013...17

Table 5-2: Site occupancy (shaded cells) of amphibians and reptiles observed in the drawdown zone of Kinbasket Reservoir between 2011 and 2013. 19

Table 5-3: Observed life history activity of amphibian and reptile species in the drawdown zone of Kinbasket Reservoir from 2011 to 2013. 31

Table 5-4: Size ranges and linear regression coefficients for Western Toad and Columba Spotted Frog males and females. 33

Table 5-5: Proportion of sites occupied at each survey site for each species of amphibian and reptile known to use habitats in the drawdown zone of Kinbasket Reservoir between 2011 and 2013. 34

Table 5-6: Ranking of models for detectability (ρ) and occupancy (Ψ) for Columbia Spotted Frog and Western Toad in the drawdown zone of Kinbasket Reservoir, southeastern BC. 34

Table 5-7: Proportion of time between April and September (n = 183 days) that Kinbasket Reservoir exceeded a given range of elevations. 43

Table 6-1: Observed life history activity of amphibian and reptile species in the drawdown zone of Kinbasket Reservoir 48

Table 6-2: Examples of potential effects on amphibians resulting from Kinbasket Reservoir elevations exceeding the normal maximum operating elevation by 0.6 m...56

Table 6-3: Relationships between management questions (MQs), methods and results, Sources of Uncertainty, and the future of project CLBMON-58.....58

LIST OF FIGURES

Figure 3-1: Location of Kinbasket Reservoir in British Columbia, and locations sampled for CLBMON-58 in 2013..7

Figure 3-2: Kinbasket Reservoir hydrograph for the period 2008 through 2013. 8

Figure 5-1: Daily precipitation (mm, left) and temperature (°C, right) for April through September, 2011, 2012, and 2013 as measured at Mica Dam. 16

Figure 5-2: Temperature profiles obtained from three Hobo Onset tidbit temperature data loggers deployed in different ponds in the drawdown zone of Kinbasket Reservoir in 2011 and 2012...17

Figure 5-3: Daily variation in dissolved oxygen (DO; mg/L) and water temperature (°C) relative to reservoir elevation (m ASL) for three locations in the drawdown zone of Kinbasket Reservoir..18

Figure 5-4: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in and adjacent to the drawdown zone of Kinbasket Reservoir in 2011, 2012, and 2013...20

Figure 5-5: Elevation distribution of adult Western Toad (ANBO) and Columbia Spotted Frog (RALU) males and females (left panel) and egg masses (right panel) documented in and adjacent to the drawdown zone regions of Kinbasket Reservoir in 2011, 2012, and 2013. 21

Figure 5-6: Elevation (m ASL) at which egg masses and adults of Western Toad (top) and Columbia Spotted Frog (bottom) were detected across reaches, 2011, 2012, and 2013...22

Figure 5-7: Elevation distribution of vegetation communities in which amphibian habitat occurs (A), size-frequency distribution of ponds within those habitats (B), elevation distribution of Columbia Spotted Frog (A-RALU) and Western Toad (A-ANBO) adults and egg masses, and elevation distribution of ponds (by area) in the drawdown zone of Kinbasket Reservoir. Amphibian data from 2011 to 2013 pooled. 23

Figure 5-8: Distribution of Western Toads (left) and Columbia Spotted Frogs (right) by vegetation community class and year in the drawdown zone of Kinbasket Reservoir (for adults and egg masses only). 24

Figure 5-9: Regression tree describing the habitats occupied by Western Toads in the drawdown zone of Kinbasket Reservoir..25

Figure 5-10: Regression tree describing the habitats occupied by Columbia Spotted Frogs in the drawdown zone of Kinbasket Reservoir. 26

Figure 5-11: Maximum reservoir elevations (metres above sea level, m ASL) achieved in Kinbasket Reservoir, 1976 to 2013..................................27

Figure 5-12: Risk matrix portraying risk of increasing reservoir elevations to pond-breeding amphibians and their habitats at various elevations in the drawdown zone of Kinbasket Reservoir, depending on time of year.....28

Figure 5-13: Variation in detection rates for Western Toad (top) and Columbia Spotted Frog (bottom panel) relative to reservoir elevation and time of year...30

Figure 5-14: Photo of unfertilized Western Toad eggs (A; white orbs) surrounded by recently hatched Western Toad tadpoles (from another egg string) and fertilized Western Toad eggs (B) 31

Figure 5-15: Stranded Western Toad egg string at Bear Island, June 2013. 32

Figure 5-16: Relationship between snout-urostyle length (mm) and body mass (g) for adult male and female Western Toads captured in the drawdown zone of Kinbasket Reservoir 2011, 2012, and 2013..32

Figure 5-17: Estimated occupancy (± SE) of Western Toad and Columbia Spotted Frog in the drawdown zone of Kinbasket Reservoir 2011, 2012, and 2013..35

Figure 5-18: Estimated detectability (± 95% Confidence Limits) for Western Toad and Columbia Spotted Frog in the drawdown zone of Kinbasket Reservoir 2011, 2012, and 2013 36

Figure 5-19: Annual Change in habitat availability (bars) relative to month and average reservoir elevation (line) for year 2008 to 2013 in Kinbasket Reservoir...38

Figure 5-20: Elevation distribution of ponds (top panel) delineated in and adjacent to the drawdown zone at Bear Island (BEAR), the Bush Arm Causeway (CSWY), Bush Arm at km 79 (KM79), Ptarmigan Creek (PTAR) and the Valemount Peatland (VAPL) and the proportion of ponds occurring at elevations ranging from 733 to 756 m ASL (bottom panel). 39

Figure 5-21: Relationship between breeding habitat availability (pond area) and reservoir elevations for the period April 1 through September 30, 2011 to 2013..40

Figure 5-22: Plot of ponds (*N*=65) according to observed species richness and abundance of amphibians and reptiles (adults and egg masses)..........41

Figure 5-23: The relationship between reservoir elevation and foraging habitat availability in the drawdown zone of Kinbasket Reservoir for the period April 1 to September 30 2008 to 2013. 42

Figure 6-1: Historical reservoir elevations measured in July and August 1978 to 2013. 60 cm was added to historical elevations to simulate reservoir elevations with the addition of units 5 and 6 at Mica Dam.....................55

Figure 6-2: Accumulation of wood debris at the Bush Arm Causeway (above) and in pond 12 in Valemount Peatland (below) over a 5-year period (2007 to 2012, left to right). 57

LIST OF MAPS

Map 9-1: Species documented in the Valemount Peatland, Kinbasket Reservoir. Species codes can be found in Table 1-1....69

Map 9-2: Species documented at Ptarmigan Creek, Kinbasket Reservoir. Species codes can be found in Table 1-1....70

Map 9-3: Species documented at Sprague Bay, Kinbasket Reservoir. Species codes can be found in Table 1-1....71

Map 9-4: Species documented at Bush Arm (Causeway), Kinbasket Reservoir. Species codes can be found in Table 1-1....72

Map 9-5: Species documented at Bear Island in Bush Arm, Kinbasket Reservoir. Species codes can be found in Table 1-1....73

Map 9-6: Species documented at km 79 marshes Bush Arm, Kinbasket Reservoir. Species codes can be found in Table 1-1....74

LIST OF APPENDICES

Appendix 9-1: Survey locations and amphibian and reptile captures made in the drawdown zone of Kinbasket Reservoir, 2011, 2012, and 2013. 68

1.0 INTRODUCTION

Dams regulate the flow regime in most of the world's large river systems, and the flooding resulting from dam construction and water storage creates a complex disturbance that can modify entire ecosystems (Nilsson and Berggren 2004; Eskew et al. 2012). These impacts are not restricted to the direct flooding and loss of riparian and wetland habitats upstream of dams, but also extend downstream of dams through disturbance of annual flooding regimes needed to maintain the health of floodplain environments (MacKenzie and Shaw 2000; Nilsson and Berggren 2004; Eskew et al. 2012; Kupferberg et al. 2011). To date, most studies of the effects of impoundment have focused primarily on the instream and riparian effects on fish and wildlife downstream of dams (e.g., Burt and Munde 1986; Hayes and Jennings 1986; Kupferberg 1996; Ligon et al. 1995; Lind et al. 1996; Wright and Guimond 2003; Nilsson et al. 2005; García et al. 2011). The need to understand the operational aspects of reservoir effects upstream of dams on wildlife and their habitat remains high (Brandão and Araújo 2008; Eskew et al. 2012), and that is the focus of this study.

Most major rivers in British Columbia have been dammed, and such hydroelectric developments have had numerous negative impacts on wetland ecosystems throughout the province (Hawkes 2005). This is particularly true for the Columbia River in southeastern B.C., which has been extensively altered by dams built for flood control and hydroelectric power production in both Canada and the United States. There are 14 dams on the Columbia River, three of which are in B.C. (Mica, Revelstoke, and Hugh Keenleyside); the remainder are in the U.S. Kinbasket Reservoir was created when the Columbia River was impounded by Mica Dam in 1973. Mica Dam was built under the Columbia River Treaty to provide water storage for power generation and flood control. The creation of Kinbasket Reservoir flooded ~42,650 ha resulting in the loss or alteration of eight broad habitat types (lakes: 2,343 ha; rivers: 4,897 ha; streams: 192 ha; shallow ponds: 555 ha; gravel bars: 236 ha; wetlands: 5,863 ha; floodplain [riparian]: 15, 527 ha; and upland forest: 13, 036 ha) (Utzig and Schmidt 2011).

During the Columbia River Water Use Planning process (WUP), concerns were expressed about potential impacts of the operations of the Kinbasket and Arrow Lakes Reservoirs on wildlife and vegetation, including amphibians and reptiles. However, a lack of information on the abundance, distribution, life history and habitat use of these animals made it difficult to assess the impact of current operations and operating alternatives on them. In 2008, BC Hydro initiated a long-term monitoring program (CLBMON-37) to assess the life history and habitat use of amphibian and reptile populations in the Arrow Lakes and Kinbasket Reservoirs of the Columbia Basin. Monitoring populations of amphibians and reptiles in the drawdown zone will provide the necessary information to address management questions related to (1) their life history and habitat use, (2) the effects of reservoir operations on those populations, and (3) the potential to mitigate those impacts by using physical works (as per CLBMON-37).

In addition to the uncertainties raised during the Columbia River WUP process, concerns were raised about the potential impacts of the installation of Units 5 and 6 at Mica Dam on amphibian and reptile populations in Kinbasket Reservoir. Mica Dam was originally designed to hold six generating units; however only four were installed at the time of construction in 1973. The installation of the 5^{th} and 6^{th} units commenced in 2011 with a planned operational date of 2014 (unit 5) and 2015 (unit 6). To optimize reservoir storage for power generation associated with the new units, it was predicted that reservoir levels would increase by 0.6 m during the summer months. It was suggested that this could affect larvae survival of amphibian populations that use wetland habitats in the upper elevations of the reservoir. As a result, the Mica 5/6 Core Committee recommended that additional monitoring (CLBMON-58) be conducted to augment the existing Columbia Water Licence Requirements (WLR) study (CLBMON-37) on amphibian and reptiles to assess whether the incremental increase in summer water levels affect amphibian or reptile populations using habitats in the drawdown zone of Kinbasket Reservoir.

This report summarizes the findings of Year 2 (2013) monitoring surveys for BC Hydro's Monitoring Program CLBMON-58: *Monitoring the Impacts of Mica Units 5 and 6 on Amphibians and Reptiles in Kinbasket Reservoir*. Data collected in 2011 and 2012 (CLBMON-37) are used to assess whether any trends are apparent in the data.

1.1 Study Species

Monitoring associated with CLBMON-58 is intended to address the impacts of the installation of units 5 and 6 at Mica Dam on amphibian populations using habitats in and adjacent to the drawdown zone of Kinbasket Reservoir. Because amphibians occupy both aquatic and terrestrial habitats during different parts of their life cycle, their response is likely to be very different from other taxa (e.g., fish, mammals, and birds). Amphibians have long been considered as model organisms to study the effects of human-induced habitat change on ecosystems (Hopkins 2007), and several characteristics of their life history make them particularly well-suited to studies of ecological processes as well as anthropogenic changes to the natural world. Specifically, their trophic importance, environmental sensitivity, research tractability, and impending extinction (of some species) make them ideal study organisms. Furthermore, amphibians have relatively low vagilities (i.e., movements or dispersion), which may amplify the effects of habitat change; some populations experience increased mortality risk associated with migration to and from breeding ponds, combined with an increasing proportion of lowered habitat suitability across the landscape; many species have narrow habitat tolerances, which exacerbates the effects of habitat loss; and almost all species exhibit a vulnerability to pathogens, increased UV-B exposure, and environmental pollution (Lutz and Kloas 1999; Houlahan et al. 2000; Cushman 2006).

Of the 16 species of amphibians and reptiles that occur in the Columbia Basin, three species of amphibians and two species of reptiles occur along the impounded waters of the Columbia River in Kinbasket Reservoir (Table 1-1). A fourth species of amphibian, Wood Frog (*Lithobates sylvatica*) has not been documented from the drawdown zone or adjacent upland habitats of Kinbasket Reservoir and it is not likely to occur in the study area (see Hawkes and Tuttle 2009, 2010a, 2013). One species of amphibian is considered to be at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC): the Western Toad (*Anaxyrus boreas*) is currently (November 2012) listed as Special Concern.

Table 1-1: Provincial and federal status of species of amphibians and reptiles that occur in the Columbia Basin. Species names in bold are known to occur in the drawdown zone of Kinbasket Reservoir

Group and Species	Species Code	Status†	
		CDC	COSEWIC*
Amphibian			
Columbia Spotted Frog (*Rana luteiventris*)	**RALU**	Y	
Wood Frog (*Lithobates sylvatica*)	LISY	Y	
Western Toad (*Anaxyrus boreas*)	**ANBO**	B	SC
Long-toed Salamander (*Ambystoma macrodactylum*)	**AMMA**	Y	
Reptile			
Western Terrestrial Garter Snake (*Thamnophis elegans*)	**THEL**	Y	
Common Garter Snake (*Thamnophis sirtalis*)	**THSI**	Y	

†Status: CDC = British Columbia Conservation Data Centre: B = blue-listed; Y = yellow-listed; *COSEWIC = Committee on the Status of Endangered Wildlife in Canada/SARA Schedule: SC = Special Concern

2.0 STUDY OBJECTIVES

2.1 Study Design

In 2008, BC Hydro initiated a long-term monitoring program (CLBMON-37) to assess the life history and habitat use of amphibian and reptile populations in the Arrow Lakes and Kinbasket Reservoirs of the Columbia Basin. Monitoring populations of amphibians and reptiles in the drawdown zone will provide the necessary information to address management questions related to (1) their life history and habitat use, (2) the effects of reservoir operations on those populations, and (3) the potential to mitigate those impacts by using physical works (as per CLBMON-37). Monitoring efforts specific to Kinbasket Reservoir (as per CLBMON-58) will enable an assessment of the impacts of Mica Units 5 and 6 on amphibians using habitats in the drawdown zone of Kinbasket Reservoir. Table 2-1 summarizes the annual implementation schedule for CLMBON-37 and CLBMON-58 in Kinbasket Reservoir only.

Table 2-1: Monitoring years for CLBMON-37 and CLBMON-58 in Kinbasket Reservoir. The current year is indicated in bold

Year	CLBMON-58	CLBMON-37	Reference
2008		Year 1	Hawkes and Tuttle 2009
2009		Year 2	Hawkes and Tuttle 2010a
2010		Year 3	Hawkes et al. 2011
2011	Year 1		Hawkes and Tuttle 2012
2012		Year 4	Hawkes and Tuttle 2013a, b
2013	**Year 2**		**Annual report**
2014		Year 5	Annual report
2015	Year 3		Annual report
2016		Year 6	Annual report
2017	Year 4		Annual report
2018	Year 5	Year 7	Final comprehensive report

2.2 Management Questions and Hypotheses

Nine management questions (MQs) were developed in 2008 to determine the impacts of reservoir operations on amphibians and reptiles that use habitats in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs (as per CLBMON-37). In 2011, a tenth management question asked how the installation of Mica Units 5 and 6 will affect amphibian populations in the drawdown zone of Kinbasket Reservoir. The ten MQs are grouped into four broad themes:

CLBMON-37/58 – Theme 1: Life History and Habitat Use

MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?

MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years?

MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?

MQ4: Which habitats do amphibians and reptiles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

CLBMON-37/58 – Theme 2: Reservoir Operations and Habitat Change

MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?

MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?

CLBMON-37/58 – Theme 3: Physical Works

MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?

MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?

MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity, or productivity?

CLBMON-58 – Theme 4: Effects of Mica Units 5 and 6

MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development?

Hypotheses were developed to address the four themes of management questions. Hypothesis H_1 was modified to include the effect of Units 5 and 6 on amphibians that use habitats in the drawdown zone of Kinbasket Reservoir:

H_1 Annual and seasonal variation in water levels in Kinbasket Reservoir (due to reservoir operations), the implementation of soft operational constraints, and the effects of Units 5 and 6 in Mica Dam on Kinbasket Reservoir, do not directly or indirectly impact reptile and amphibian populations.

H_{1A} Reservoir operations do not result in a decreased abundance of amphibians or reptiles in the drawdown zone.

H_{1B} Reservoir operations do not increase the stage specific (e.g., larval, juvenile, or adult) mortality rates of amphibians or reptiles in the drawdown zone.

H_{1C} Reservoir operations do not result in decreased site occupancy of amphibians or reptiles in the drawdown zone.

H_{1D} Reservoir operations do not result in decreased productivity of amphibians or reptiles in the drawdown zone.

H_{1E} Reservoir operations do not reduce the availability and quality of breeding habitat, foraging habitat and over-wintering habitat for amphibians or reptiles in the drawdown zone.

H_2 The physical works projects and revegetation efforts do not increase the utilization of habitats by amphibians or reptiles in the drawdown zone.

H_{2A} Revegetation and physical works do not increase species diversity or seasonal (spring/summer/fall) abundance of amphibians or reptiles in the drawdown zone.

H_{2B} Revegetation and physical works do not increase amphibian or reptile productivity in the drawdown zone.

H_{2C} Revegetation does not increase the amount or improve habitat for amphibians and reptiles in the drawdown zone.

These questions and hypotheses will be tested directly by this monitoring program, which is aimed at determining the habitat use/associations and distribution of amphibians and reptiles in the drawdown of Kinbasket Reservoir relative to reservoir operational regimes, including changing water levels (Table 2-2). The monitoring program is also designed to address whether or not the proposed physical works and/or revegetation programs will enhance habitat suitability for amphibians and reptiles in the drawdown zone.

Table 2-2: Hypotheses addressed by each theme for CLBMON-58. A √ indicates a relationship between the theme and hypothesis

Theme	Hypotheses									
	H_1	H_{1A}	H_{1B}	H_{1C}	H_{1D}	H_{1E}	H_2	H_{2A}	H_{2B}	H_{2C}
Life History and Habitat Use	√	√	√	√	√	√				
Reservoir Operations and Habitat Change	√	√	√	√	√	√				
Physical Works							√	√	√	√
Effects of Mica Units 5 and 6	√	√	√	√	√	√				

3.0 STUDY AREA

3.1 Physiography

The Columbia Basin in southeastern British Columbia is bordered by the Rocky, Selkirk, Columbia, and Monashee Mountains. The headwaters of the Columbia River begin at Columbia Lake in the Rocky Mountain Trench, and the river flows northwest along the trench for about 250 km before it empties into Kinbasket Reservoir behind Mica Dam (BC Hydro 2007). From Mica Dam, the river continues southward for about 130 km to Revelstoke Dam. The river then flows almost immediately into Arrow Lakes Reservoir behind Hugh Keenleyside Dam. The entire drainage area upstream of Hugh Keenleyside Dam is approximately 36,500 km^2.

The Columbia Basin is characterized by steep valley side slopes and short tributary streams that flow into Columbia River from all directions. The Columbia River valley floor elevation extends from approximately 800 m near Columbia Lake to 420 m near Castlegar. Approximately 40 per cent of the drainage area within the Columbia Basin is above 2,000 m elevation. Permanent snowfields and glaciers predominate in the northern high mountain areas above 2,500 m elevation. About 10 per cent of the Columbia River drainage area above Mica Dam exceeds this elevation.

3.2 Climatology

Precipitation in the basin is produced by the flow of moist, low-pressure weather systems that move eastward through the region from the Pacific Ocean. More than two-thirds of the precipitation in the basin falls as winter snow. Snow packs often accumulate above 2,000 m elevation through the month of May and continue to contribute runoff long after the snow pack has melted at lower elevations. Summer snowmelt is reinforced by rain from frontal storm systems and local convective storms. Runoff begins to increase in April or May and usually peaks in June to early July, when approximately 45 per cent of the runoff occurs. The mean annual local inflow for the Mica, Revelstoke and Hugh Keenleyside projects is 577 m^3/s, 236 m^3/s and 355 m^3/s, respectively.

Air temperatures across the basin tend to be more uniform than is precipitation. With allowances for temperature lapse rates, station temperature records from the valley can be used to estimate temperatures at higher elevations. The summer climate is usually warm and dry, with the average daily maximum temperature for June and July ranging from 20 to 32°C.

3.3 Kinbasket Reservoir

Located in southeastern B.C., Kinbasket Reservoir is surrounded by the Rocky and Monashee Mountain ranges, and is approximately 216 km long. The Mica hydroelectric dam, located 135 km north of Revelstoke, B.C., spans the Columbia River and impounds Kinbasket Reservoir. The Mica powerhouse, completed in 1973, has a generating capacity of 1,805 MW, and Kinbasket Reservoir has a licensed storage volume of 12 million acre feet (MAF; BC Hydro 2007). The normal operating range of the reservoir is between 707.41 m and 754.38 m elevation, but can be operated to 754.68 m ASL with approval from the Comptroller of Water Rights. The biogeoclimatic (BEC) zones that occur in the lower elevations of Kinbasket Reservoir are the Interior Cedar-Hemlock (ICH) zone and the Sub-Boreal Spruce (SBS) zone (Figure 3-1).

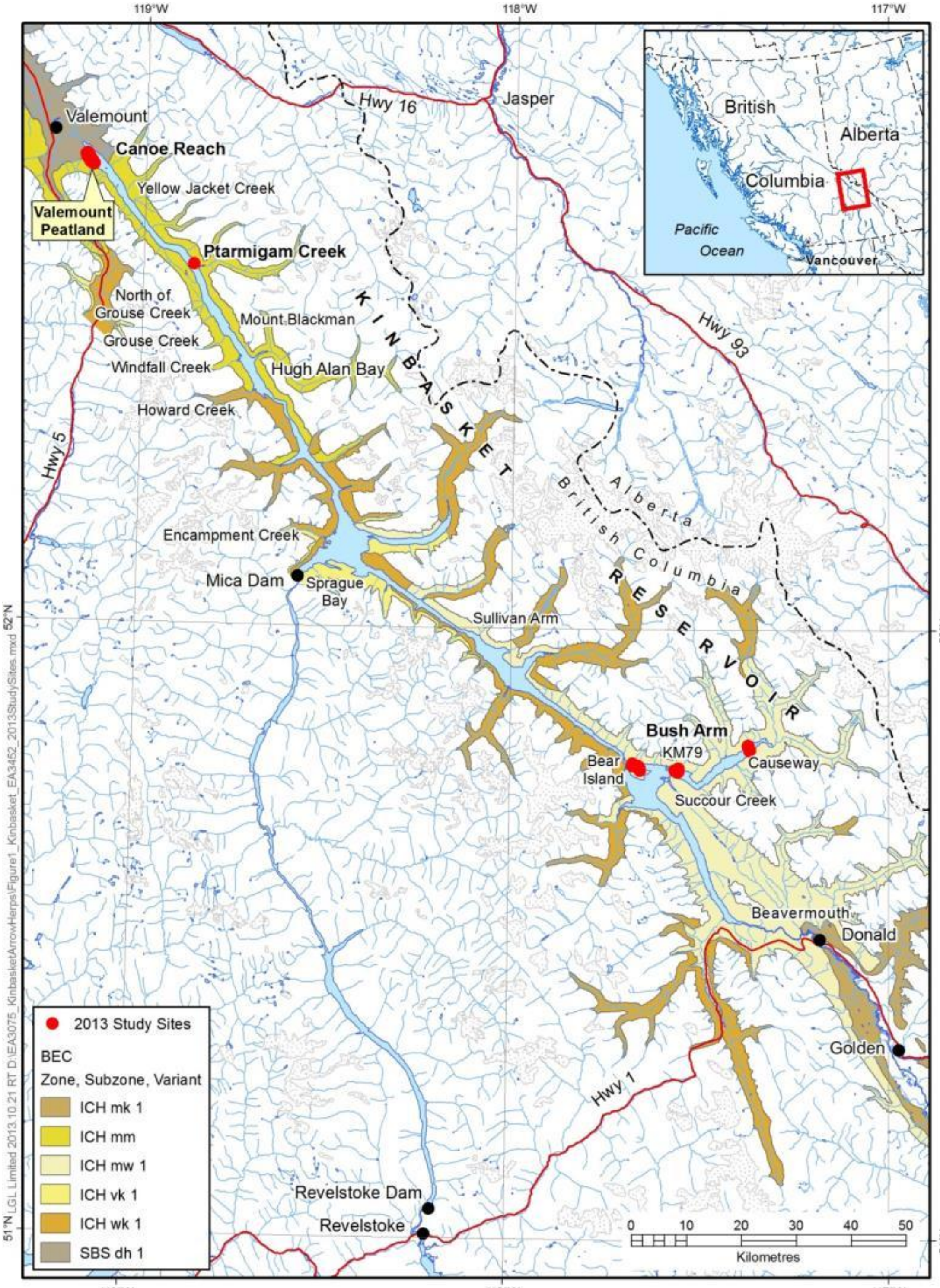

Figure 3-1: Location of Kinbasket Reservoir in British Columbia and locations sampled for CLBMON-58 in 2013. Naming follows Hawkes et al. (2007)

Kinbasket Reservoir fills in the spring and is typically full by the mid- to late-summer (Figure 3-2). Although there is some year to year variation, the general pattern is consistent. In 2012 and 2013 Kinbasket was filled beyond the normal operating maximum (i.e., > 754.38 m ASL) for the first time since 1997.

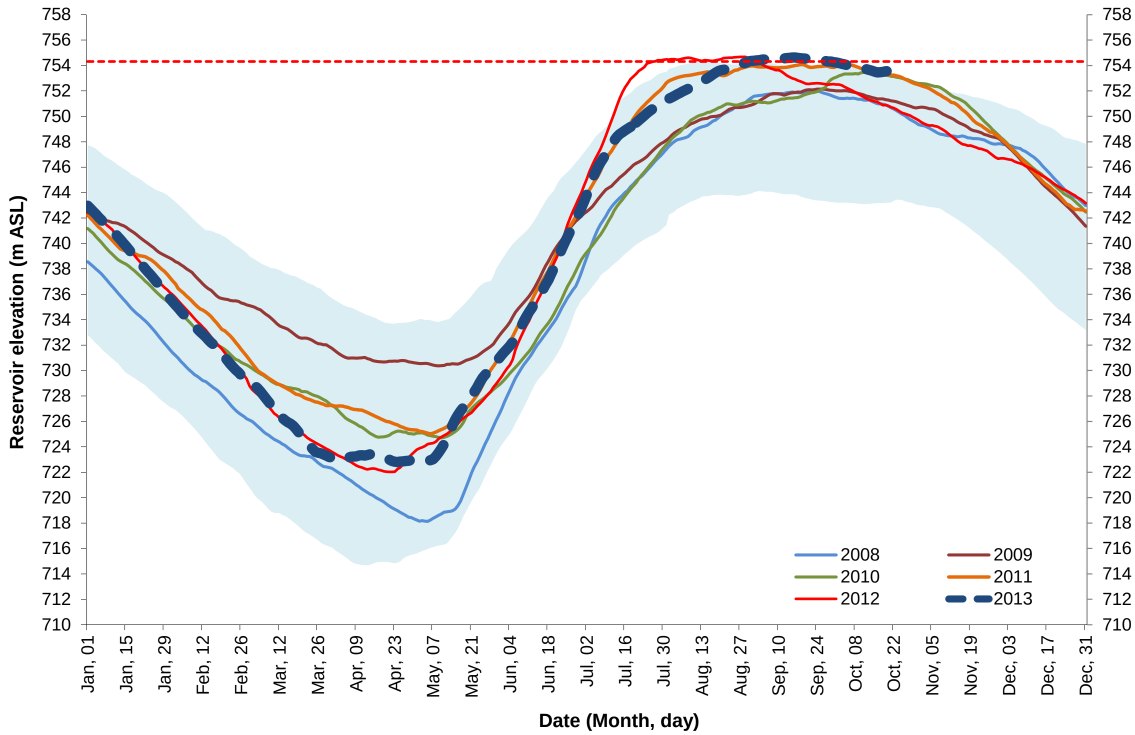

Figure 3-2: **Kinbasket Reservoir hydrograph for the period 2008 through 2013. The shaded area represents the 10th and 90th percentile for the period 1976 to 2013; the dashed red line is the normal operating maximum**

3.3.1 Study Locations

Specific habitats in the drawdown zone of Kinbasket Reservoir are sampled under CLBMON-58. These areas were selected because of the presence of wetlands and ponds in the drawdown zone and the use of those sites by amphibians for breeding. Sites studied include habitats at the east end of Bush Arm (i.e., the Bush Arm Causeway), areas on the north side of Bush Arm including habitats at ~79.5 km along Bush FSR ("KM 79") and KM 88 (i.e., the mouth of Bush Arm), and sites in Canoe Reach in the Valemount Peatland and at Ptarmigan Creek (Figure 3-1; see Appendix 10-1 for maps of each study site).

4.0 METHODS

4.1 Field Schedule

In 2013, field sampling was conducted between May and August to coincide with the active period of amphibians and reptiles. Field sampling occurred between May 5 and 15, May 28 and June 3, June 16 to 23, and August 6 to 9. Additional surveys were conducted in July and coincided with field work for CLBMON-

61(Kinbasket wetland assessment: July 9 to 17) and CLBMON-9 (Kinbasket revegetation effectiveness monitoring: July 15 to 23). The 2013 field sampling schedule followed a similar timeline as that implemented in 2011 (and in 2008, 2009, 2010, and 2012) to facilitate data comparison between years. Predicted reservoir levels obtained from BC Hydro were incorporated into field scheduling to determine how much of the DDZ would be available for sampling.

4.2 Data Collection

4.2.1 General Survey Data

A variety of techniques (egg mass surveys [EMS], larval surveys [LVS] and visual encounter surveys [VES]) were used to survey amphibians and reptiles in the DDZ of Kinbasket Reservoir in 2011-2013. Of these methods, VES surveys were the most appropriate method to sample amphibians of all life stages, mainly because of the conspicuous nature of pond-breeding amphibians, particularly during the breeding season. Total survey time per person was recorded to calculate catch per unit effort time (i.e., detection rate) for each survey site, field session and species.

Surveys for egg masses, tadpoles and larvae were conducted in the spring at various wetland sites, but are considered to be a subset survey type of VES and are reported with those results.

Pitfall traps were also established at the Bush Arm Causeway to document the presence of amphibians moving in and out of the DDZ in early spring. Five linear pitfall arrays consisting of five traps each (i.e., 30 cm deep cans) were installed in five locations near the Bush Arm Causeway. Traps were connected by 5 m of drift fence and monitored daily for a period of three or four nights. Morphometric data were collected for all trapped amphibians.

All previously mapped ponds and wetlands were surveyed in the Valemount Peatland, at Ptarmigan Creek, and throughout Bush Arm (Bear Island, Causeway, and KM 79). The total area surveyed at each geographic location varied relative to the total area of wetland and pond habitat. Ponds were numbered at each site and were monitored during the active season (late April through September) to determine amphibian occupancy and use (provided access to the wetlands or ponds was not hindered by inundation from the reservoir or other access issues).

All amphibian (and reptile) observations and captures, including incidental observations, were georeferenced to associate each observation with a given wetland or pond, elevation, and vegetation community (as defined in Hawkes et al. 2007). During field surveys, we also recorded all observations of other animals and their signs (e.g., tracks, scat, hair, nest).

4.2.2 Species Morphometric Data

The Resources Inventory Standards Committee (RISC) protocols for sampling and handling of amphibians and reptiles (RISC 1998a, b) were followed. All captured animals were weighed and measured, most were photographed, and UTM coordinates were obtained for each observation. The sex of an animal was determined where possible. The marking scheme used in previous years was continued in 2013 (e.g., photo identification for adult amphibians and subcaudal scute clipping in snakes).

Amphibian Morphometric Data—Snout-urostyle length (SUL) was measured using Vernier calipers to the nearest 0.1 mm. Mass (to the nearest 0.1 g) was obtained using Pesola spring scales. The sex of each animal was determined (where possible) based on longer tail and enlarged vent in male salamanders and presence of nuptial pads on forelimbs of male frog and toad species during the breeding season. Larval amphibians were staged according to the Gosner (1960) or Harrison (1969) indexing standards.

Reptile Morphometric Data—Snout-vent length (SVL [mm]), tail length (TL [mm]) were measured using foldable metric rulers (2 m) and mass (to the nearest 0.1 g) was obtained with a Pesola spring scale. Sex in snakes was determined by probing for hemipenes (i.e., the probe was inserted farther in males due to the presence of the spaces in which the hemipenes occupy).

For a detailed description of the methods used to sample amphibians and reptiles in 2013, refer to the CLBMON-37 Year 1 report (Hawkes and Tuttle 2009) and revised monitoring program sampling protocols (Hawkes and Tuttle 2012).

4.2.3 Pond-breeding Amphibian Data

Assessing the potential impacts of increasing Kinbasket Reservoir elevations by as much as 0.6 m required a combination of modelling and site-specific studies of pond-breeding amphibian habitat locations in the drawdown zone of Kinbasket Reservoir. To address the management question associated with CLMBON-58 and to collect data appropriate for testing the associated hypotheses, the following methods were used:

1. Identifying the locations of pond-breeding amphibian habitat in the drawdown zone of Kinbasket Reservoir

When reservoir levels were low (May), all ponds in the drawdown zone at each monitoring location were visited to determine if they were being used by amphibians for breeding. Ponds were classified as used or unused ponds (as defined by the presence of egg masses or tadpoles).

2. Mapping the location of pond-breeding amphibian habitat in a GIS and determining the elevation at which that habitat occurs

All ponds in the drawdown zone of Kinbasket Reservoir (monitoring locations) were previously mapped between 2008 and 2011 using a handheld GPS receiver (Garmin GPSMap 60cSx). These GPS tracks were mapped using ArcMap 10 to determine the location, total area and elevation of each pond within the drawdown zone. Ponds were visited to determine (1) availability (presence or absence in a given field session prior to inundation), (2) amphibian (or reptile) occupancy, and (3) breeding activity. The delineation of each pond was updated in 2013 to the 2012 orthorectified imagery of the drawdown zone of Kinbasket Reservoir.

3. Determining use of those habitats by pond-breeding amphibians for breeding

Ponds at each monitoring location were visited at least three times each year to document species' presence, relative abundance (based on catch per unit effort [CPUE]), breeding occurrence and productivity, and seasonal use of pond areas as reservoir elevations change the availability of habitat.

Egg mass surveys, larval surveys and visual encounter surveys were used to document amphibian habitat use. Breeding activity was documented for each species by estimating counts of egg masses, larval aggregations, and breeding adults (e.g., numbers of pairs in amplexus and adult males and females).

4. Studying the development of pond-breeding amphibians from egg deposition through to metamorphosis at various elevations

One of the critical life history stages for amphibians that use drawdown zone ponds is the larval stage because tadpoles/larvae are unable to move out of ponds until metamorphosis is complete. To evaluate how amphibian species are affected by reservoir operations, we monitored breeding occurrences, larval development (e.g., Gosner staging) and timing of metamorphosis (where possible) in Canoe Reach and Bush Arm.

5. Modelling the risk impacts of increasing the elevation of Kinbasket Reservoir by 0.6 m on ponds that occur in the drawdown zone

To model the effects of increasing the elevation of Kinbasket Reservoir by 0.6 m on pond-breeding amphibian habitat in the drawdown zone, we:

a. added 0.6 m to reservoir elevation reported during the time of year when ponds would be used by pond-breeding amphibians (April through August)

b. used the results of the site- and elevation-specific studies to determine the time of year when ponds at various elevations were inundated. We assumed that the effects on pond-breeding amphibians and their habitats vary by time of year and life stage (egg mass, tadpole, larvae, juvenile and adult).

c. used the output of the above to develop a risk matrix that portrays the risk of increasing reservoir elevations to pond-breeding amphibians and their habitats depending on the time of year. The risk matrix was developed by creating a plot of the reservoir hydrograph and overlaying the distribution of amphibian eggs, larvae and metamorphs by elevation and time of year. This provided a visual indication of the relationship between reservoir elevation, time of year (month) and life stage associated with pond-breeding amphibians. The risk matrix includes actual reservoir elevations and the predicted maximum increase in elevation (0.6 m) resulting from the installation of Mica 5/6.

4.2.4 Habitat Data

Habitat data were collected in a standardized manner at all locations where amphibians were observed as well as at locations where they were not. Habitat data collected included characteristics at both the macro and micro scales. The vegetation community types (from CLBMON-10) in which species were observed was determined by relating the species observation location to the vegetation polygon on a GIS map. For a detailed description of the methods used to sample habitat (micro and macro) in 2011, refer to the CLBMON-37 Year 1 report (Hawkes and Tuttle 2009) and revised monitoring program sampling protocols (Hawkes and Tuttle 2010b).

Water chemistry data (dissolved oxygen in mg/L, conductivity in µs, temperature in °C, and pH) were collected at all pond and reservoir sampling locations at each study site. A YSI 85 multi-function metre was used to measure dissolved oxygen, conductivity, and temperature. An Oakten waterproof pH Tester 30 was used to obtain pH data. Nine conductivity (Onset U24-001) and five dissolved oxygen (PME MiniDOT) dataloggers were installed in select wetlands to collect continuous data. The dataloggers were installed between 30 cm and 50 cm below the water's surface in depths of 65 to 80 cm. The units were affixed to rebar (125 cm in length) using a pipe clamp and the rebar was fitted with an orange plastic safety cap for easy relocation. The dataloggers were factory programmed to record data every 5 minutes and data were downloaded using the manufacture's software (Onset Hoboware and PME miniDOT software). Data collected from the dataloggers spanned 31 to 129 days. The dataloggers were deployed from June to October in 2012 and May to November in 2013.

In 2011, HOBO temperature data loggers were installed at several locations in Bush Arm and Canoe Reach to track water temperature changes in those ponds as a result of reservoir inundation. Data loggers were attached to a pin-flag or flagging tape and were weighted down with a brick, and the site was georeferenced and photographed. Data loggers were programmed to record hourly temperatures over a 3-year period. Data are downloaded in the spring and fall of each year.

Temporal habitat availability (i.e., the time of year when habitats are available and how long they are available) is likely to have a greater effect on amphibian and reptile populations than spatial habitat availability (i.e., the size of the habitat that may be used). This is particularly true for pond-breeding amphibians. This is based on an assessment of the distribution of amphibians and reptiles observed since 2008 and on our understanding of where important amphibian and reptile habitats occur in the drawdown zone of Kinbasket Reservoir. Temporal habitat availability was assessed by evaluating the range of elevations that amphibians and reptiles would likely be using in the DDZ of Kinbasket Reservoir. The temporal assessment was based on the duration of the active season (i.e., the number of days between April 1 and September 30) during which the drawdown zone was available to amphibians and reptiles. This was accomplished by correlating reservoir elevation (in 1 m increments) to the number of days between April 1 and September 30 (n = 183) that each 1 m elevation band was exposed and therefore available for use.

4.3 Data Analysis

4.3.1 Species Richness

Statistical analyses were performed using R (V3.0.2) and Microsoft Excel 2010 (© 1985–2011). Comparisons of species richness (i.e., the number of species per study site and vegetation community) relative to vegetation communities and landscape units were made by standardizing capture data by correcting for total time surveyed per area (number of observations per hour). For all analyses measures of relative are used. Summary boxplot graphs were produced to describe the dispersion of richness, diversity and evenness per transect according to landscape units, vegetation communities and elevation (Massart et al. 2005). In boxplot graphs, the boxes represent between 25 per cent and 75 per cent of the ranked data. The horizontal line inside the box is the median. The length of the boxes is their interquartile range (Sokal and Rohlf 1995). A small box indicates that most data are found around the median (small dispersion of the data). The opposite is true for a long box: the data are dispersed and not concentrated around the median. Whiskers are drawn from the top of the box to the largest observation within 1.5 interquartile range of the top, and from the bottom of the box to the smallest observation within 1.5 interquartile range of the bottom of the box. Boxplots display the differences between groups of data without making any assumptions about their underlying statistical distributions, and show their dispersion and skewness. Analysis of variance (ANOVA) was used to test for differences in detection rates across survey locations and between years. The critical level of alpha was set to 0.1.

4.3.2 Amphibian Observations

To assess whether observations of amphibians varied significantly with elevation, we created contingency tables and performed Chi-square analyses. Contingency tables provided the frequency of observations of each species at each elevation band for four sampling locations (Bear Island, KM 79, Ptarmigan Creek and Valemount Peatland). Locations and elevations that had too few or no observations were eliminated or merged to reduce the number of zeros.

Chi-square analyses were performed (on data from each location) to test the null hypothesis (H_0) of independence between the two descriptors (i.e., the frequency of observations of amphibians is not affected by elevation, and thus amphibians are distributed randomly in the drawdown zone of Kinbasket Reservoir). The Pearson Chi-square statistic (X^2_P) (Pearson 1900) was calculated in R with the with function chisq.test of the stats package in R language software (version 2.15.0). To test the significance of the relationship between amphibian occurrence and elevation, P-values were estimated by 10,000 Monte-Carlo simulations (Hope 1968).

Further, to determine which cells of the contingency table contained significantly different values, Freeman-Tukey deviates were computed (Legendre and Legendre 1998). A Bonferroni correction was applied to control for the effect of several simultaneous tests of significance, hence α was divided by the total number of cells to which the post hoc tests were performed (Legendre and Legendre 1998). The computation of the Freeman-Tukey deviates and criteria was performed in MS Excel (see Hawkes and Tuttle 2012 for details).

4.3.3 Amphibian Morphometric Data

Analysis of covariance (ANCOVA) was used to investigate the relationship between mass and snout-urostyle length of Western Toad sex and year (as per Shine 1979 and Duellman and Trueb 1986). Length-weight relationships have been useful in estimating biomass for a variety of organisms (see summary in Deichmann et al. 2008) and such data could be used to document changes in community biomass and serve as a baseline for changes in individual taxa over time. These data may also be used to infer the health of a population relative to environmental stressors, or in this case, changing reservoir elevations.

4.3.4 Site Occupancy – Western Toad and Columbia Spotted Frog

Monitoring amphibians can lead to biased population estimates and inaccurate interpretations of habitat relationships when imperfect detections of the species are not considered (Bailey et al. 2004; Mackenzie et al. 2006). Site occupancy modelling and probabilistic sampling are methods that help overcome this deficiency (Hansen et al. 2012). Site occupancy was assessed in three ways: (1) the presence of any life stage of a species at a survey site; (2) the naïve occupancy rate (MacKenzie et al. 2006), or the proportion of mapped sites (ponds and wetlands nested within each survey site) that a species was detected at least once in the three years of study (i.e., 2011 through 2013); and (3) the modelled occupancy and detectability of Western Toad and Columbia Spotted Frog for the mapped sites and each year of survey (2011, 2012, and 2013).

Models were constructed in the program PRESENCE (Hines 2006) using species presence data, which was based on the detection of any life stage of Western Toad or Columbia Spotted Frog at mapped sites. All life stages were pooled to determine occupancy because (1) we assumed that if adults were in the ponds of the drawdown zone they could use those sites for breeding; (2) if egg masses were observed, breeding had occurred; and (3) if tadpoles were observed, breeding had occurred. Occupancy modelling was not used to estimate occupancy and detection probabilities for specific life stages because we did not always observe adult toads at potential breeding sites and we could not always determine exactly when individuals hatched, making it more difficult to meet the occupancy closure assumption (MacKenzie et al., 2002).

A multi-season model was used to estimate seasonal (spring and summer) occupancy for ponds in the drawdown zone. Occupancy models assume that detectability is either constant or that any variation is modelled by covariates. For detection probability, we assumed between year variation; within years, we used a constant probability of detection. Because reservoir elevations change over the year, elevation was included as a covariate.

We based our model rankings on ΔAIC and Akaike weights (Burnham and Anderson 2002) for each model. For each species, the model with the lowest ΔAIC and AIC was considered the best and the covariates it contained (if any) were included in all subsequent analyses to account for variation in detectability.

4.3.5 Habitat Availability

Habitat availability was assessed through graphical presentation of total area available relative to use (breeding, foraging, and overwintering). Pearson's correlation coefficients were used to describe the associations between total available habitat, reservoir elevation and time of year (month) and linear regression was used to assess the relationships between reservoir elevation and the amount of foraging habitat available to amphibians and reptiles.

To identify ponds with respect to their potential as breeding or diversity hotspots, a scatterplot of observed species richness by number of detections of amphibians and reptiles (adults and egg masses) was plotted for each pond (n=65). Ponds were characterized as follows: "hotspots" that supported high species richness and high abundances (≥ 0.5*maximum), "warmspots" that supported moderate levels of species richness (≥ 0.5*maximum) at moderate abundances (≥ 0.1*maximum), and "coldspots" that supported low species richness

(< 0.5*maximum) and low abundances (< 0.1*maximum) of breeding amphibians and reptiles. The plot delineations were subjective, but were chosen for ease of interpretation of the scatterplot and standardized for replicability.

4.3.6 Habitat Associations

Habitat associations were assessed for Western Toads and Columbia Spotted Frogs through graphical presentation of the distribution of adults and egg masses of each species by vegetation community. To account for annual differences in sampling effort, presence data were used and standardized by species totals within each year. Further, we described the distribution of Western Toad and Columbia Spotted Frog occurrence in habitats of the drawdown zone of Kinbasket Reservoir through regression trees (De'ath 2002) using the MVPART package (version 1.6-1) in R (De'ath 2013). Species presence (1) and non-detection (0) was used as a response variable to biologically relevant environmental variables, such as: vegetation community, water temperature, pond substrate, pond area, elevation, reach, site, distance to shore, location (drawdown zone or upland), year, and season. Selection of trees was made by specifying the cross-validation to within one standard error of the overall best tree. Variables that did not improve the variance explained were removed one-at-a-time, such that the final model achieved minimum cross-validation and relative error.

5.0 RESULTS

Our ability to observe possible effects of reservoir activity depends upon the availability of robust occurrence data, which for this study relates to Western Toad and Columbia Spotted Frog. As such, the majority of the results presented in this report focus on amphibians, and specifically Western Toad and Columbia Spotted Frog.

5.1 Environmental Data

Weather conditions are known to affect the surface activity of amphibians. Thus, weather data were obtained from Environment Canada's Mica Dam weather station (11U: UTM_E: 391261 UTM_N: 5766272; 579.10 m ASL) to evaluate the influence of weather conditions on species detectability and measures of relative abundance. Daily temperature varied by month from April to September ($F = 266.8$; $p < 0.001$) and between years ($F = 4.2$; $p = 0.04$), which is to be expected. Similarly, total rainfall varied to some degree on a monthly basis ($F = 2.02$; $p = 0.07$), but not between years ($F = 0.01$; $p = 0.93$; Figure 5-1). The level of variation in precipitation and temperature was not sufficient to affect surface activities of amphibians, and thus, is not likely to have influenced detectability measures (Olson 1999; Hawkes and Gregory 2012). Further, temperatures were within the range of conditions considered suitable for amphibian sampling (Olson 1999; Hawkes and Gregory 2012).

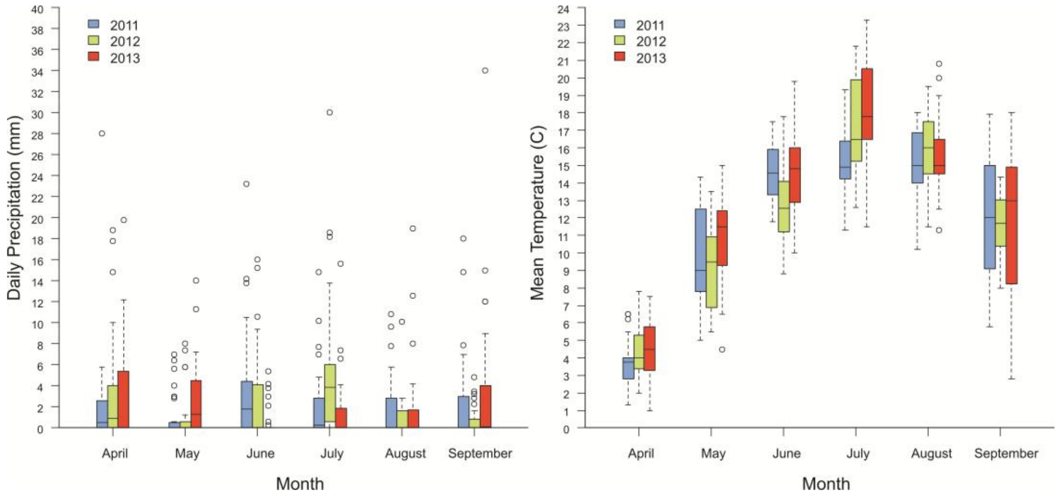

Figure 5-1: Daily precipitation (mm, left) and temperature (°C, right) for April through September, 2011, 2012, and 2013 as measured at Mica Dam. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html)

5.2 Water Physicochemical Data

Point data [pH, Conductivity (µS/cm), and Temperature (°C)] are summarized for ponds (Table 5-1). Data obtained from ponds in the drawdown zone (KM 79: 750.6 m ASL; KM 88 – Bear Island: 748.4 m ASL; Valemount Peatland–1: 753.5 m ASL) indicate that water temperature profiles are relatively stable between June and September (Figure 5-2), suggesting that inundation resulting from reservoir filling is not likely to influence tadpole development.

The influence of reservoir elevations on dissolved oxygen was assessed (Figure 5-3). In general, water physical chemistry is believed to play a minor role in affecting the species richness of amphibians in certain areas (e.g., Hecnar and M'Closkey 1996) and our data suggest that most values are characteristic of sites with relatively neutral pH, low conductivity, and warm spring and summer temperatures. These conditions are not likely to influence amphibian populations in the drawdown zone of Kinbasket Reservoir.

Table 5-1: Summary of water physicochemistry data collected at ponds with and without amphibians in the drawdown zone of Kinbasket Reservoir, 2011, 2012, and 2013

WITHOUT		pH				Conductivity (µS/cm)				Temperature (°C)			
Year	*N*	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD
2011	210	6.3	8.7	7	0.5	0	274	82.8	49.9	4.5	25.4	17	4.3
2012	1	7.5	7.5	7.5	--	88	88	88	--	20.9	20.9	20.9	--
2013	86	7.4	9	8	0.3	5.5	501	160.2	112.5	7.6	28.5	18.9	4.4
WITH													
Year	*N*	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD	Min	Max	$\bar{x}$	SD
2011	1533	5.1	10.5	7.1	0.5	0	378	77.4	43.7	4.8	29.6	18.8	4.1
2012	133	5.9	9.5	7.8	0.7	2	367	166.4	114.4	11.8	33.1	18.3	5.1
2013	232	6.7	8.8	8	0.4	30.2	637	210.7	157.4	12.8	29.3	20.7	4.5

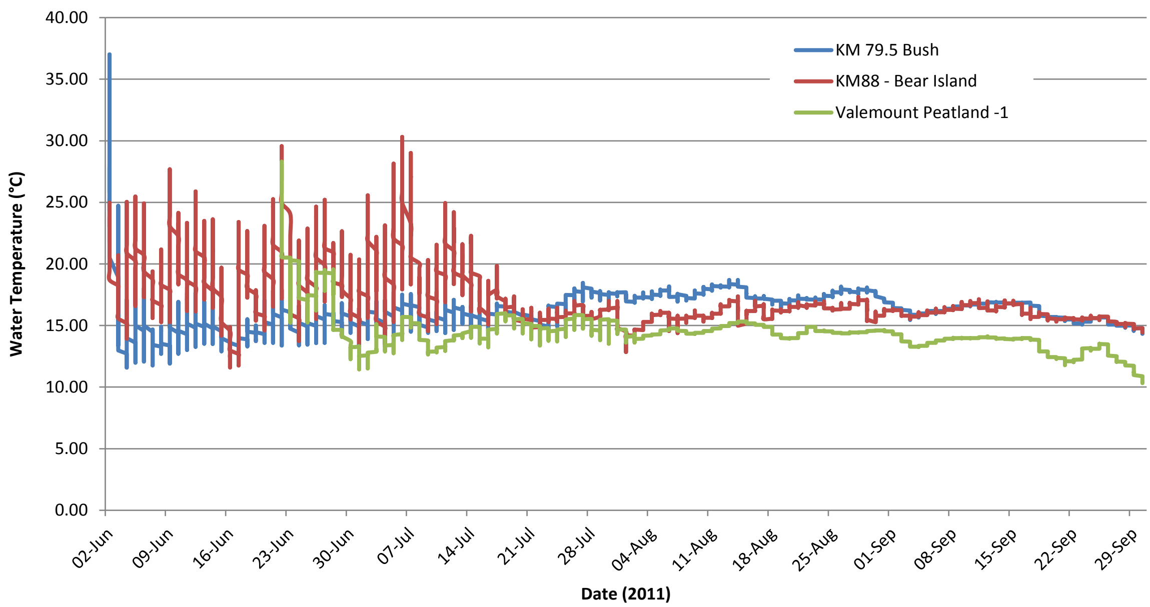

Figure 5-2: Temperature profiles obtained from three Hobo Onset tidbit temperature data loggers deployed in different ponds in the drawdown zone of Kinbasket Reservoir in 2011 and 2012 (data from June to September 2011 shown)

Data from 2013 clearly show the influence of reservoir inundation on temperature and dissolved oxygen levels (Figure 5-3). In all cases DO and temperature decreased following inundation and for two of the three locations (Bush Arm Causeway and Pond 12 in Valemount Peatland), the ponds became hypoxic (i.e., DO < 2.0 mg/L). At the causeway this occurs prior to inundation and in Canoe Reach this occurs following inundation, although there is a downward trend prior to inundation. These conditions are measured at the depth of the DO meter, which was installed 30 cm below the surface of the water.

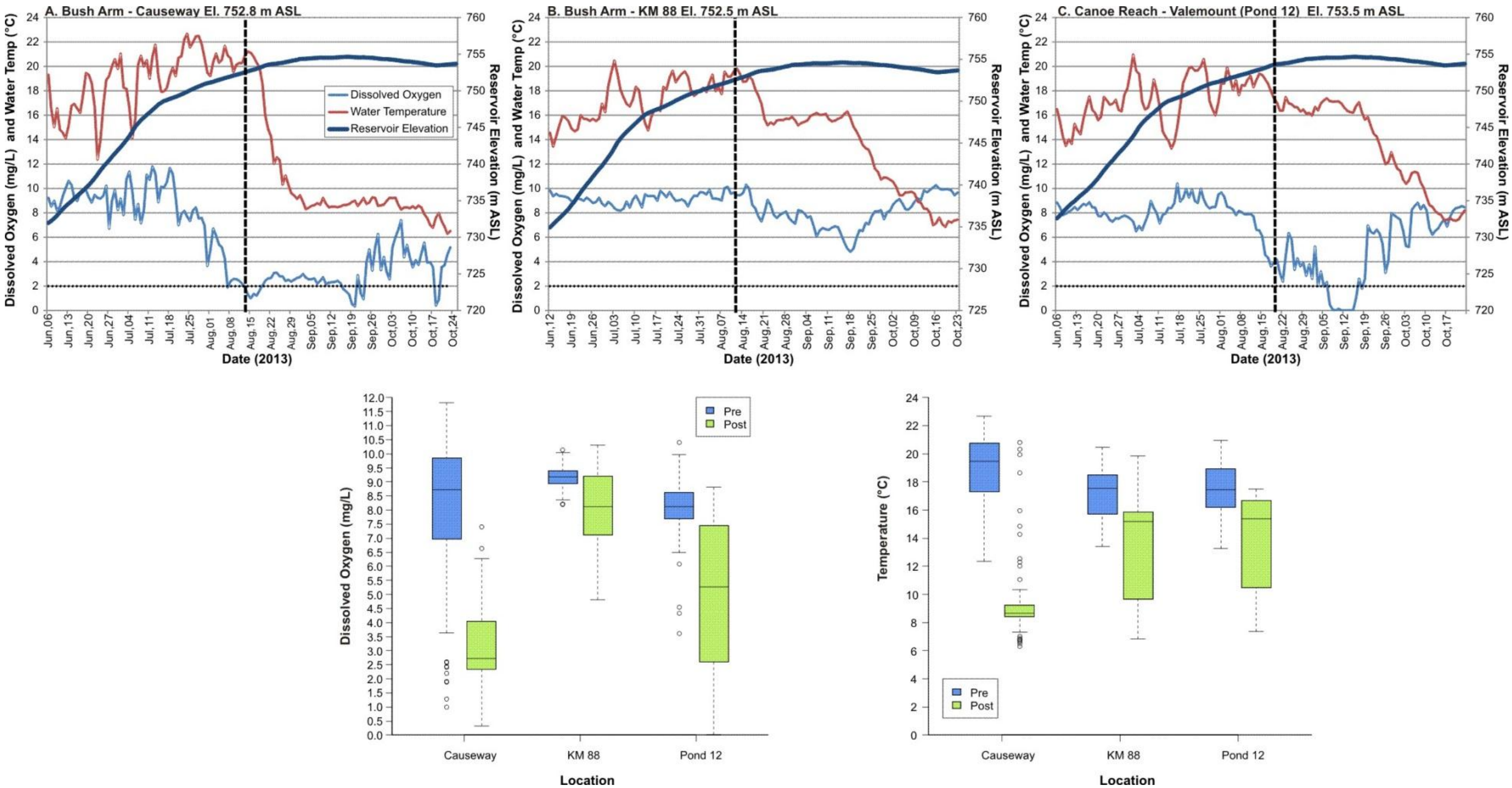

Figure 5-3: Daily variation in dissolved oxygen (DO; mg/L) and water temperature (°C) relative to reservoir elevation (m ASL) for three locations in the drawdown zone of Kinbasket Reservoir. The dashed vertical line represents the date of inundation. The dashed horizontal line represents the point at which the water column is hypoxic. Data loggers set at a depth of 30 cm below the surface when first installed. Box plots depict differences in DO and water temperature before and after inundation

Based on the data presented above, environmental conditions do not appear to influence our ability to detect amphibians in the drawdown zone and water physicochemical parameters are not likely to negatively impact the development of amphibians using ponds in the drawdown zone of Kinbasket Reservoir.

5.3 Amphibian and Reptile Occurrence and Distribution

5.3.1 Landscape Units

At the landscape level, four species of amphibians and one reptile were observed in the DDZ of Kinbasket Reservoir in 2012 and 2013 compared to five in 2011 (Table 5-2). Three sites supported all three species of amphibians in 2013: Ptarmigan Creek, Valemount Peatland, and Bush Arm Causeway. Western Toads and Columbia Spotted Frogs occupied most of the sites surveyed in all years and accounted for most of the observations. One species (*Thamnophis elegans*, R-THEL) was only documented in 2011; Common Garter Snakes were detected in all three years. Mapped occurrences of all species for the years 2011, 2012, and 2013 are included in Appendix 10-1.

Table 5-2: Site occupancy (shaded cells) of amphibians and reptiles observed in the drawdown zone of Kinbasket Reservoir between 2011 and 2013. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake.

	AMMA			ANBO			RALU			THEL			THSI			Species		
Survey Site	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
KIN Bush Arm Bear Island																4	3	2
KIN Bush Arm Causeway																5	4	4
KIN Bush Arm km 79																3	2	3
KIN Bush Arm km 79 perched wetland																2	1	2
KIN Sprague Bay																0	2	0
KIN Sprague Bay Perched Wetland																3	0	0
KIN Ptarmigan Creek																3	2	4
KIN Valemount Peatland																4	4	4
Total Survey Sites Occupied	**2**	**2**	**3**	**7**	**6**	**6**	**7**	**7**	**6**	**2**	**0**	**0**	**6**	**3**	**4**			

5.3.2 Elevation

Amphibians and reptiles were found across a wide range of elevations in Kinbasket Reservoir in 2011, 2012, and 2013 (Figure 5-4). Western Toad (A-ANBO) occurred across the widest range of elevations in all years followed by Columbia Spotted Frog (A-RALU) and Common Garter Snake (R-THSI). Long-toed Salamanders (A-AMMA) were typically associated with habitats situated between 752 and 754 m ASL. When they were detected, Western Terrestrial Garter Snake (R-THEL) occupied a similar range of elevations as Common Garter Snake.

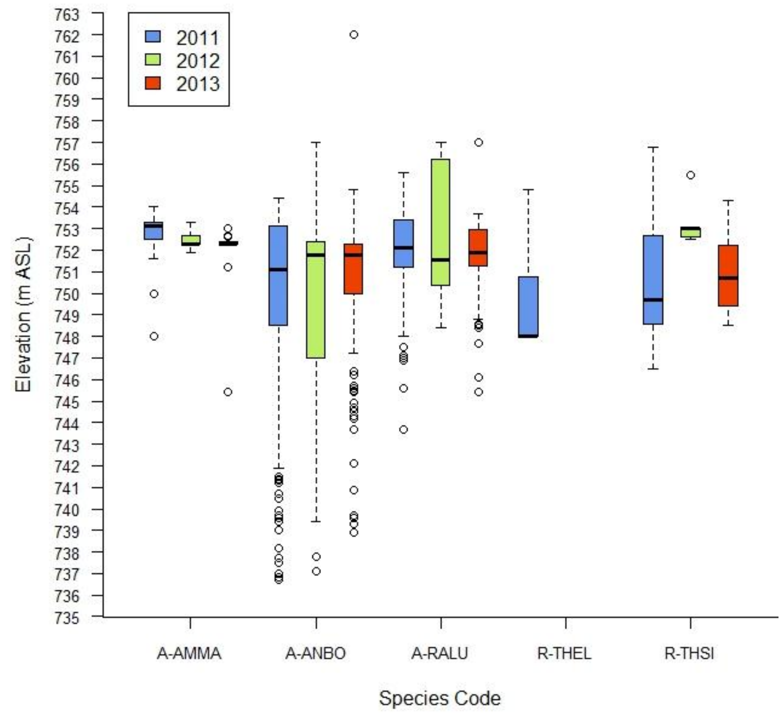

Figure 5-4: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in and adjacent to the drawdown zone of Kinbasket Reservoir in 2011, 2012, and 2013. A- = Amphibian; R- =Reptile. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake

Western Toads and Columbia Spotted Frogs were distributed across an elevation range of 737 to 754 m ASL. The largest aggregations of both species were observed between ~747 and 754 m ASL, which is related to the distribution of wetlands in the drawdown zone (see Section 5.9). Salamanders occupied only the highest elevation ponds (752 to 753 m ASL), which may be related to the proximity of these ponds to upland forest where this species typically lives. The distribution of snakes in Kinbasket Reservoir overlapped that of amphibians in most cases: Common and Western Terrestrial Garter Snakes were typically found between 747 and 753 m ASL. Differences between the species could be due to habitat availability (e.g., habitats at higher elevations were available for longer periods than those at lower elevations), or proximity of higher elevation habitats to forests (e.g., closer to hibernation sites), or animals could have preferentially selected habitats based on specific features (e.g., ponds that do not get inundated until later in the season, availability of foraging or basking sites). The current data set does not provide the information necessary to determine habitat associations at this scale.

Adult Western Toad and Columbia Spotted Frog observations were made at similar elevations in 2011, 2012, and 2013 and males and females occurred over the same range (Figure 5-5). The distribution of Western Toad and Columbia Spotted Frog egg masses was also similar each year, ranging in elevation from ~739.5 m ASL to ~755 m ASL (Figure 5-5). The lack of difference in elevation distribution of Western Toad and Columbia Spotted Frog suggests that these species are using the same sites in the drawdown zone on an annual basis.

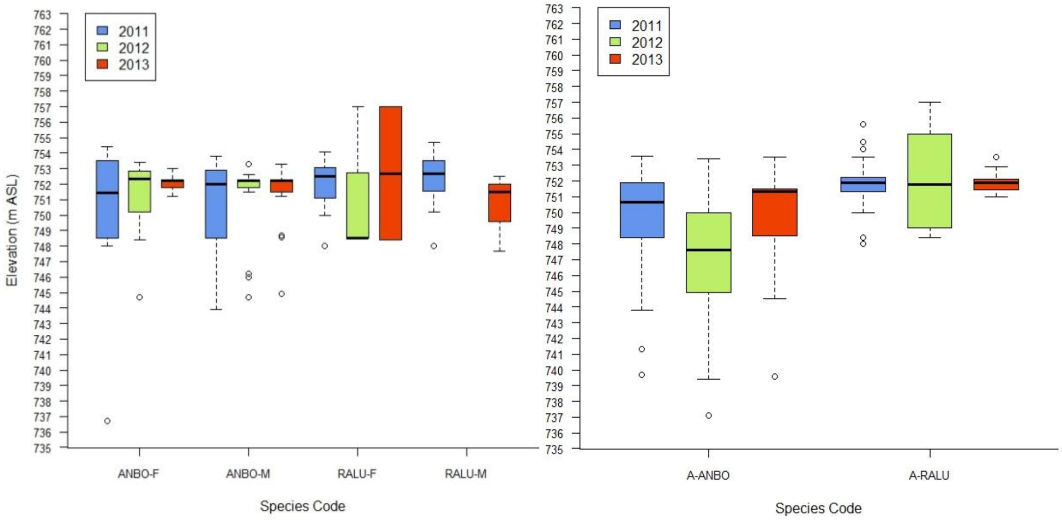

Figure 5-5: Elevation distribution of adult Western Toad (ANBO) and Columbia Spotted Frog (RALU) males and females (left panel) and egg masses (right panel) documented in and adjacent to the drawdown zone regions of Kinbasket Reservoir in 2011, 2012, and 2013. ANBO = Western Toad, RALU = Columbia Spotted Frog; M = Male F = Female

The elevation at which Western Toad and Columbia Spotted Frog were detected varied by reach, more so for Western Toad (Figure 5-6), but the amount of variation was generally not significant. The only exception was the frequency of detection for Columbia Spotted Frogs (adults and egg masses combined) at Ptarmigan Creek, which were associated with mid and high elevations (χ^2=7.7, p=0.03). The analysis of the Freeman-Tukey deviates did not yield any significant results (at α = 0.05), but this is likely due to the greater frequency of observations at high elevations in 2011 (n=17, compared to < 3).

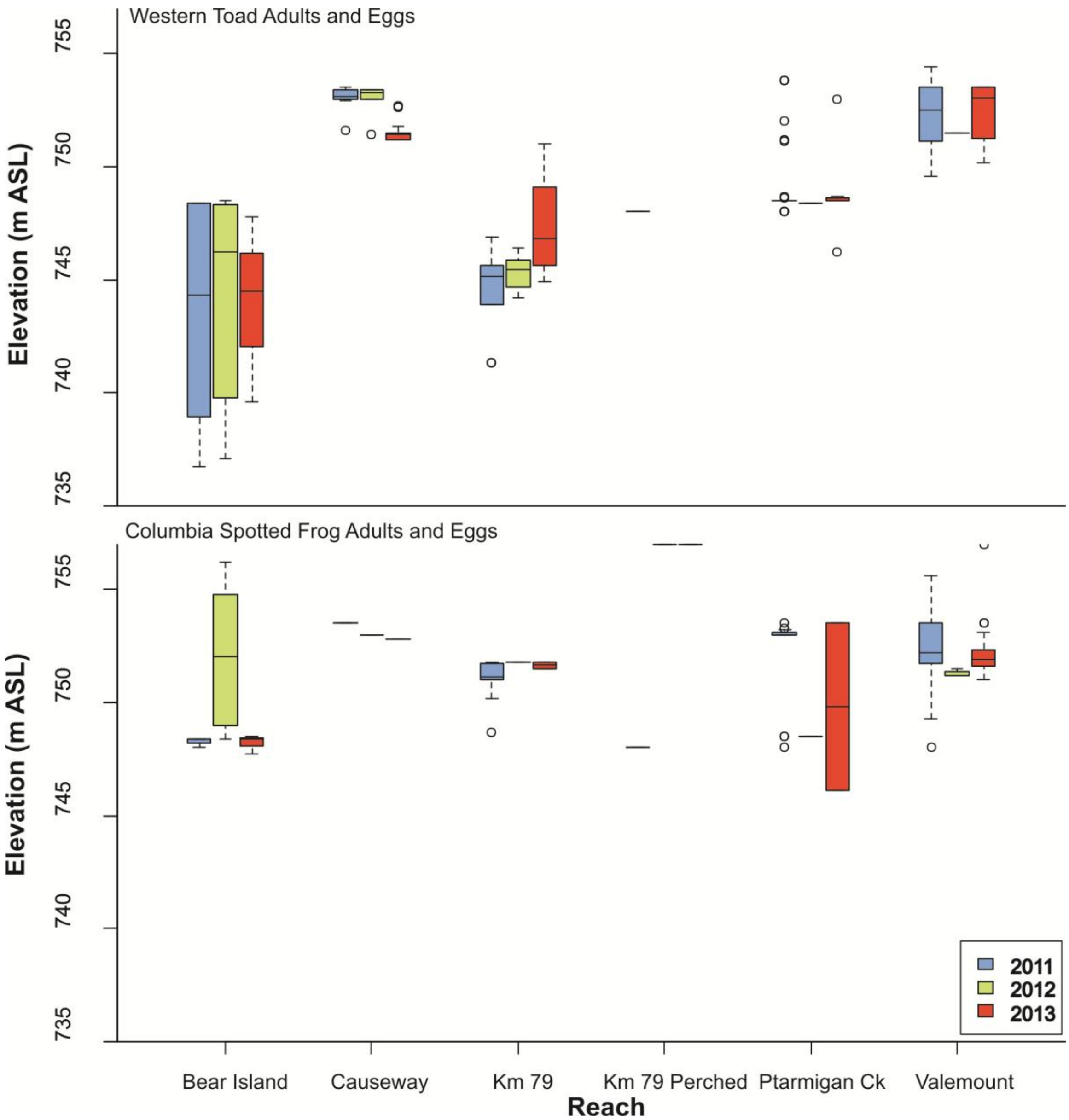

Figure 5-6: Elevation (m ASL) at which egg masses and adults of Western Toad (top) and Columbia Spotted Frog (bottom) were detected across reaches, 2011, 2012, and 2013. See Figure 3-1 for distribution of study sites (reaches)

5.3.3 Pond and Wetland Habitat in the Drawdown Zone

One hundred and eleven ponds were delineated in and adjacent to the drawdown zone of Kinbasket Reservoir. Vegetation communities in which amphibians were found were distributed between ~736 m and 754 m ASL (Figure 5-7A) with the clover-oxeye daisy (CO) community between 751 and 753 m ASL, the swamp horsetail (SH) community between 750 and 752 m ASL, wool-grass–Pennsylvania buttercup (WB) between 744 and 755 m ASL and the Kellogg's sedge (KS) community between 745 and 752 m ASL. Pond size ranged from 0.003 ha to 0.945 ha (N = 103; $\bar{x}$ = 0.09 ha; Σ = 11.4 ha). Most ponds mapped were < 0.15 ha (Figure 5-7B), and overall, there was no significant relationship between pond size (area) and elevation ($F_{1,101}$ = 0.17; p = 0.89; Figure 5-7B). Not surprisingly, the elevation distribution of Western Toad and Columbia Spotted Frog occurrences aligned well with the elevation distribution of ponds in the drawdown zone (Figure 5-7C, D).

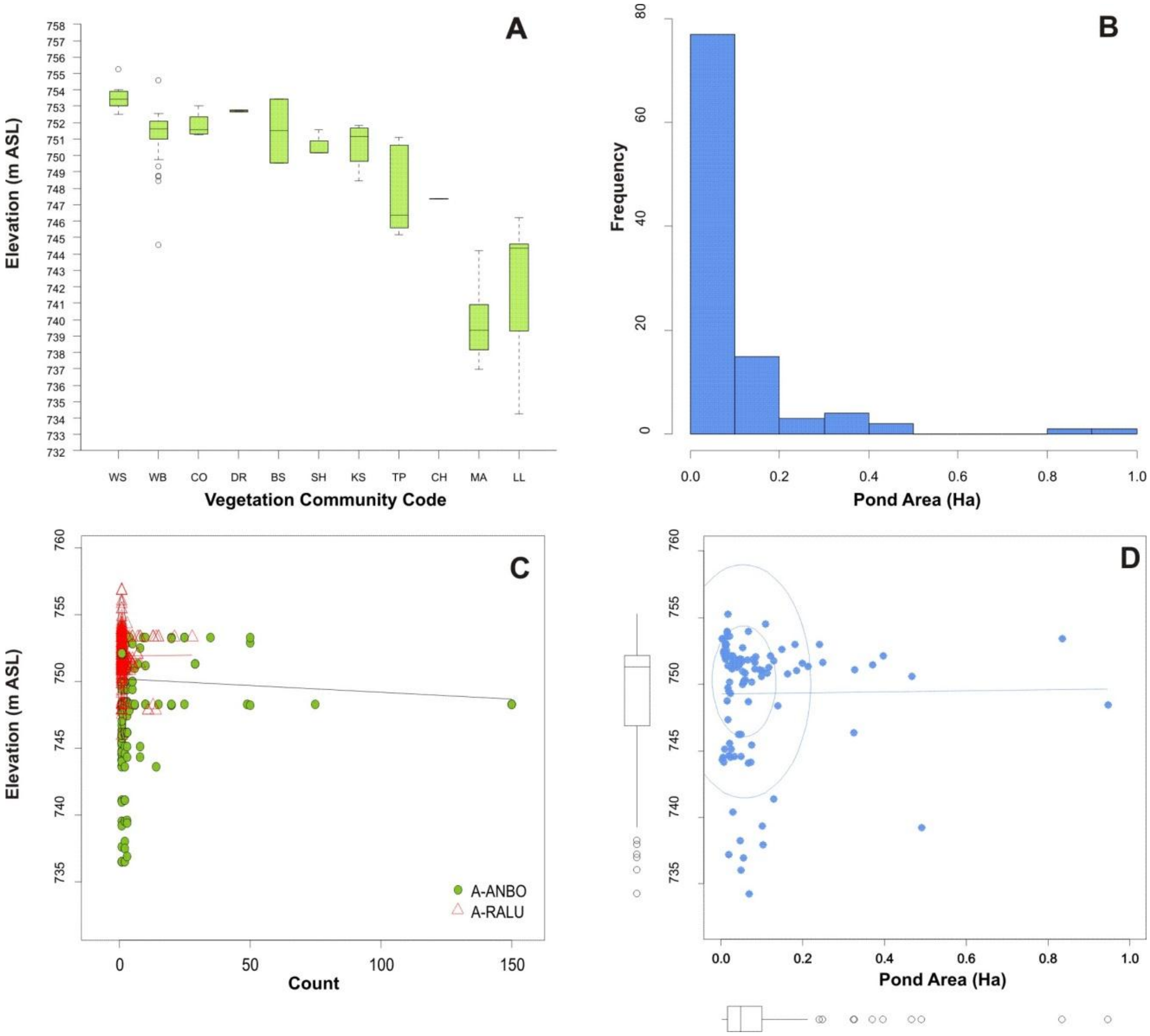

Figure 5-7: Elevation distribution of vegetation communities in which amphibian habitat occurs (A), size-frequency distribution of ponds within those habitats (B), elevation distribution of Columbia Spotted Frog (A-RALU) and Western Toad (A-ANBO) adults and egg masses, and elevation distribution of ponds (by area) in the drawdown zone of Kinbasket Reservoir. Amphibian data from 2011 to 2013 pooled. See Figure 5-8 for vegetation community codes

5.3.4 Vegetation Community Associations

Habitat use by Western Toads and Columbia Spotted Frogs was compared to the vegetation community mapping that was completed for CLBMON-10. Associations with vegetation community types varied substantially by year (Figure 5-8), suggesting that both species are fairly general in their selection and use of habitats. Overall, Western Toads detection were most often associated with drier clover-oxeye daisy (CO) habitats, whereas Columbia spotted frogs were found most often in the wetter wool-grass–Pennsylvania buttercup (WB) habitats. Neither species was detected with bluejoint reedgrass (BR), woody debris (WD), or reed canarygrass (RC) community types. Both species occurred in the Kellogg's sedge (KS) and swamp horsetail (SH) habitats across years, which is consistent with the results from 2011 (Hawkes and Tuttle 2012). The general use of habitats in the drawdown zone by both species suggests that even if vegetation communities change over time, the patterns of amphibian use of the drawdown zone are likely to persist. This is because species distributions are more likely a reflection of suitable breeding habitat and other determinants of habitat quality, than vegetation community alone.

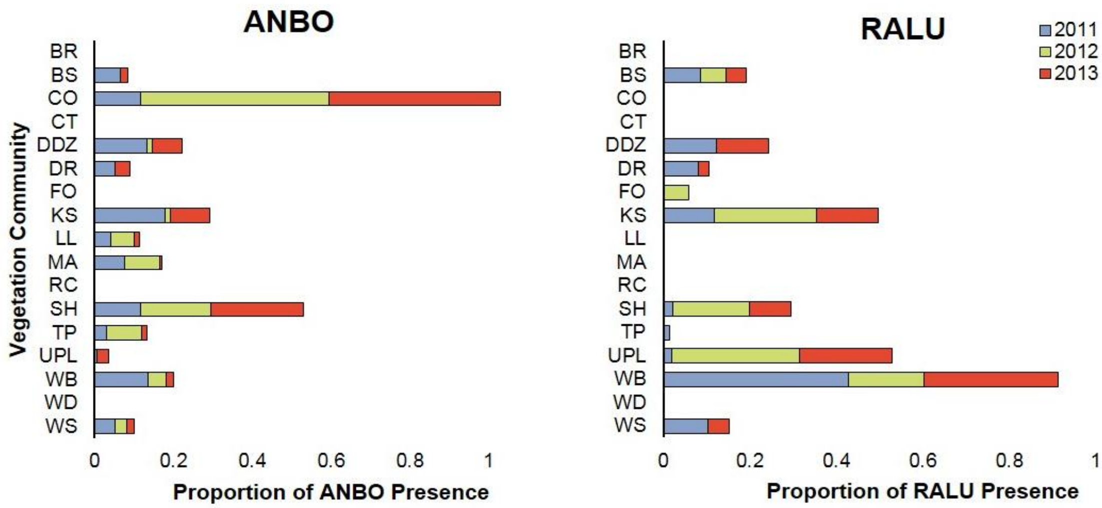

Figure 5-8: Distribution of Western Toads (left) and Columbia Spotted Frogs (right) by vegetation community class and year in the drawdown zone of Kinbasket Reservoir (for adults and egg masses only). Presence of adults and egg masses in each vegetation class was standardized by detection totals for each year to account for differences in sampling effort between years. ANBO = Western Toad, RALU = Columbia Spotted Frog; BR = bluejoint reedgrass, BS = buckbean-slender sedge, CO = clover–oxeye daisy, CT= cottonwood-trifolium, DDZ = Drawdown Zone (≤ 754.38m ASL, no vegetation association recorded), DR = driftwood, FO = forest, KS = Kellogg's sedge, LL = lady's thumb-lamb's quarter, MA = marsh cudweed–annual hairgrass, RC = reed canarygrass, SH = swamp horsetail, TP = toadrush-pond water starwort, UPL = Upland (> 754.38m ASL, no vegetation association recorded), WB = wool-grass–Pennsylvania buttercup, WS = willow–sedge. See Hawkes et al. (2013) for descriptions of each habitat type

The vegetation communities with the most detections (Western Toad: CO and SH; Columbia Spotted Frog: WB and KS) were situated between ~744 and 753 m ASL (Figure 5-7A). A large proportion of all ponds mapped in the drawdown zone (48.4 per cent; 5.5 ha) occurred in these four vegetation communities (CO: 4.9 per cent; 0.56 ha; SH: 2.9 per cent; 1.2 ha: WB: 29.9 per cent; 3.4 ha; KS: 10.7 per cent; 1.2 ha), so the presence of amphibians in these communities is not surprising. Few observations occurred in the toadrush-pond water starwort (TP) community despite >10 per cent of all ponds occurring there. The lack of observations is likely because the TP community typically occurs at lower elevations than the other four communities (Figure 5-7A).

Regression trees revealed that season, vegetation community, and pond area were important determinants of Western Toad adult and egg mass distributions (64.4 per cent of the variance explained; relative error = 0.356, c.v. error= 0.751).

Season was most important in determining toad distribution, since presences were very low in summer compared to spring. However, in the spring, Western Toad presence was determined by vegetation type, with approximately half of all occurrences associated with clover–oxeye daisy (CO) and swamp horsetail (SH) habitats (average presence = 0.468). Notably, the frequency of occurrence of CO/SH vegetation in Spring surveys was considerably lower than other vegetation classes (Figure 5-9; n= 61 c.f. n= 719). Consistent with the above results on toad detections among vegetation types, toad presence was disproportionately recorded in the CO and SH vegetation community habitats, despite that only 7.8% of ponds mapped in the DDZ were classified as CO/SH vegetation type. Pond area helped further explain toad distribution in CO and SH habitats, with no toads occurring in ponds ≥ 0.19 ha. However, toads that were present in other vegetation communities of the drawdown zone, were associated with large ponds (≥ 0.33 ha).

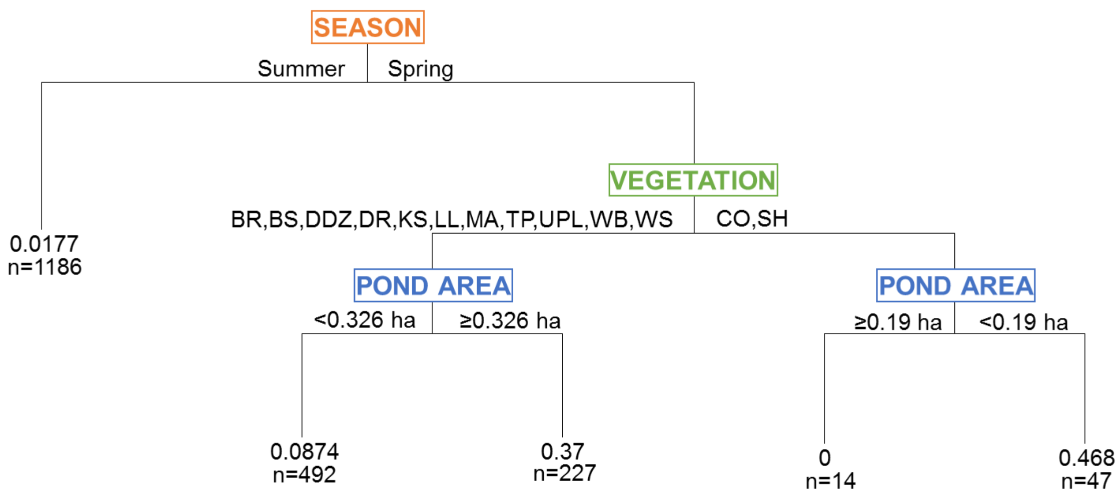

Figure 5-9: Regression tree describing the habitats occupied by Western Toads in the drawdown zone of Kinbasket Reservoir. Major environmental determinants of toad adult and egg mass presence are given in hierarchical order at each node. The average presence and frequency at which variable combinations occur (n) are given at each terminal branch. See Figure 5-8 for vegetation community codes

For Columbia Spotted Frogs, elevation and pond area, in addition to vegetation community, were important determinants of adult and egg mass occurrences in the drawdown zone of Kinbasket Reservoir (25.9 per cent of the variance explained; relative error = 0.741, c.v. error= 0.778). Vegetation community type explained 12 per cent of the variation in frog presence, with 54 per cent of frogs occurring in association with buckbean-slender sedge (BS), forest (FO), wool-grass–Pennsylvania buttercup (WB), and unclassified upland habitats (UPL). For frogs observed below 751.3 m ASL in these habitats, pond area was an important determinant (3 per cent of the total variation), such that frogs were most frequent at ponds with moderate to large areas (0.092 ha to 0.267 ha). Columbia Spotted Frog adults and eggs were not associated with bluejoint reedgrass (BR), clover–oxeye daisy (CO), cottonwood-Trifolium (CT), lady's thumb-lamb's quarter (LL), marsh cudweed–annual hairgrass (MA), and reed canary grass (RC) vegetation communities or to habitats <750.3 m ASL in the drawdown zone. The interactions between environmental variables in these regression trees illustrate the complex nature of habitat associations for both species and supports the notion that species are associated with a wide range of vegetation communities.

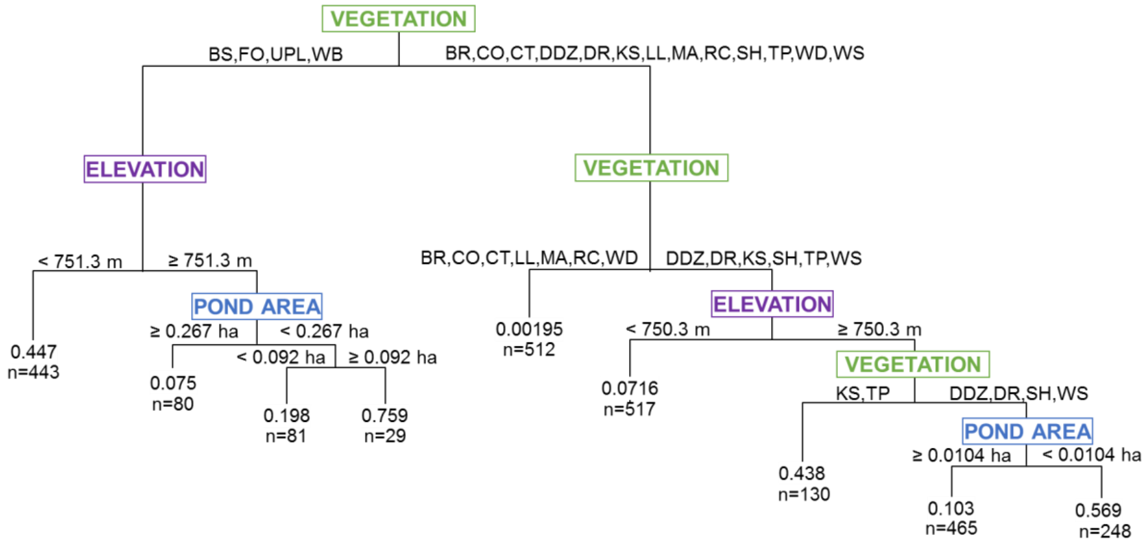

Figure 5-10: Regression tree describing the habitats occupied by Columbia Spotted Frogs in the drawdown zone of Kinbasket Reservoir. Major environmental determinants of toad adult and egg mass presence are given in hierarchical order at each node. The average presence and frequency at which variable combinations occur (n) are given at each terminal branch. See Figure 5-8 for vegetation community codes

Results associated with each of the hypotheses and alternate hypotheses are presented below.

5.4 H1: Annual and seasonal variation in water levels in Kinbasket Reservoir (due to reservoir operations), the implementation of soft operational constraints, and the effects of Units 5 and 6 in Mica Dam on Kinbasket Reservoir, do not directly or indirectly impact reptile and amphibian populations

5.4.1 Soft Operational Constraints

Section 4.4.1.1 of the Columbia River Water Use Plan (BC Hydro 2007) indicates that the Consultative Committee did not recommend any operational constraints on Kinbasket Reservoir. As such, an assessment of the implementation of soft constraints is relevant to Arrow Lakes Reservoir only.

5.4.2 Effects of Mica 5/6

Data collected between 2011 and 2013 represent the period prior to the installation of units 5 and 6 at Mica Dam. During this time, the operation of Kinbasket Reservoir was different than in previous years (Figures 3-2 and *5-11*). Specifically, Kinbasket Reservoir was filled beyond the normal operating maximum in 2012 and 2013, an operation that had not been implemented since 1997 (Figure 5-11). This information is used to facilitate a qualitative assessment of the effects that the installation of units 5 and 6 might have on amphibians using the drawdown zone of Kinbasket Reservoir.

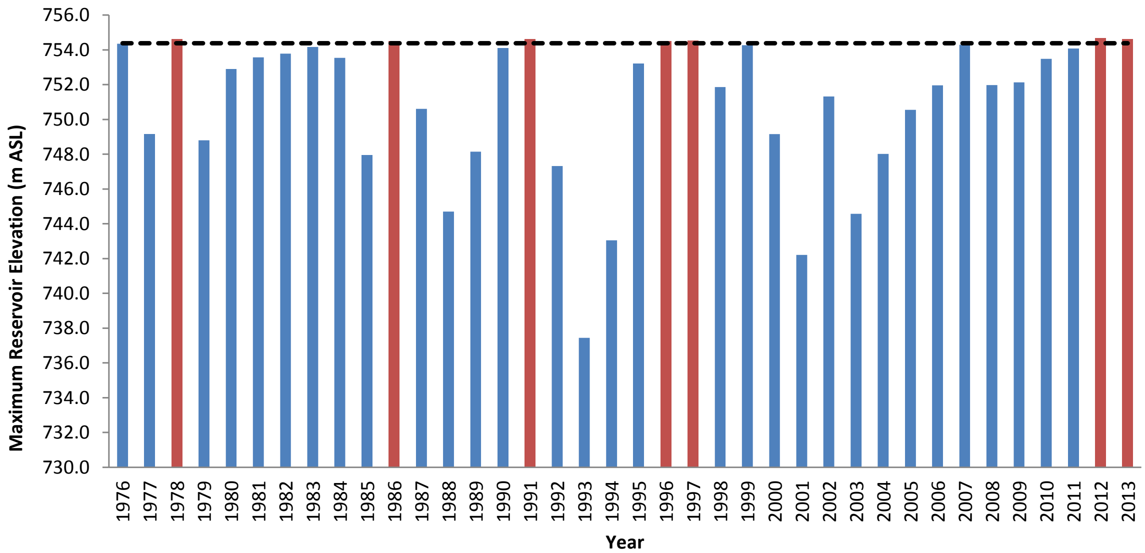

Figure 5-11: Maximum reservoir elevations (metres above sea level, m ASL) achieved in Kinbasket Reservoir, 1976 to 2013. Red bars indicate years when Kinbasket Reservoir was operated beyond the normal operating maximum (black dashed line)

The installation of Units 5 and 6 at Mica Creek is predicted to increase reservoir elevations by 0.6 m during the summer months, which coincides with the period of larval amphibian development. The current operating regime of Kinbasket Reservoir includes a drawdown in the late winter followed by rapid filling in the spring and early summer, with full pool normally attained by late July or August (Figure 3-2). This pattern is repeated annually with some year-to-year variation. Specifically, reservoir fill maxima were higher and occurred earlier in the past 3 years (2011 to 2013), than in all previous monitoring years (i.e., 2008 to 2010; Figure 3-2). Consequently, the potential risk of direct mortality to amphibians and loss of suitable habitats (see Section 5.9) has increased relative to 2008 (Figure 5-12).

A lack of observations of direct effects of reservoir operations on the development, survival, and mortality of amphibians in the drawdown zone of Kinbasket Reservoir precludes a quantitative answer of this management question at present. Observations of delayed development resulting from temperature changes correlated to reservoir filling would be required. Similarly, observations of mortality events such as a large number of dead tadpoles at the leading edge of the reservoir as it fills would be needed to quantify the direct effect of reservoir operations on amphibians. Further, without detailed knowledge of overwintering sites, metamorph habitat use and overwinter survival, we are not able to quantify the effects that the installation of Mica Units 5 and 6 might have on amphibian larval development. However, a qualitative assessment of (Figure 5-12) suggests that overall, the impact of reservoir operations on amphibian larval development is likely to be minimal, given that the timing of inundation occurs after eggs have hatched. Likewise, an increase of 0.6 m over annual reservoir elevations does not appear to change the level of risk.

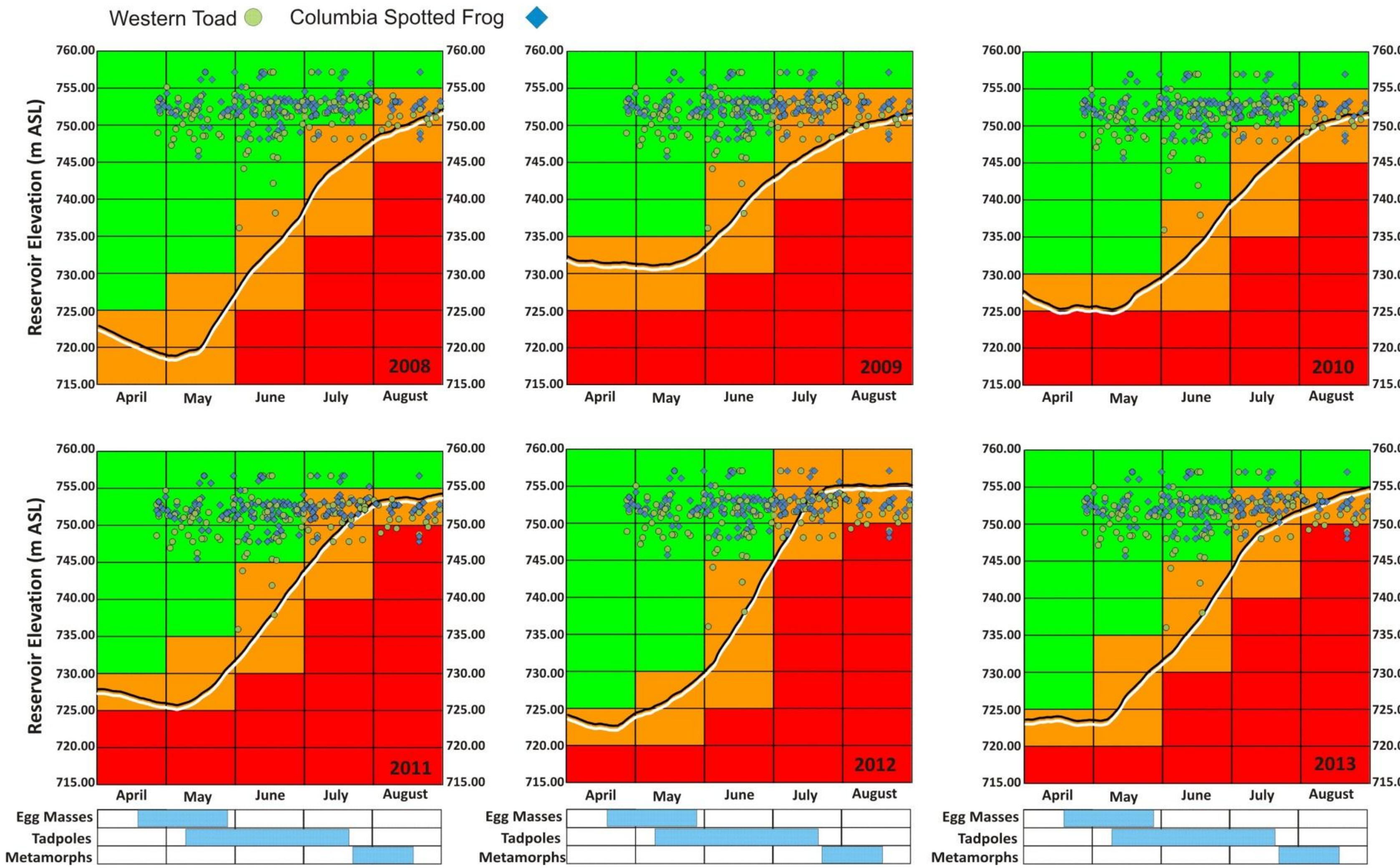

Figure 5-12: Risk matrix portraying risk of increasing reservoir elevations to pond-breeding amphibians and their habitats at various elevations in the drawdown zone of Kinbasket Reservoir, depending on time of year. Reservoir elevation data from April 1 through August 31 in 2008-2011 are plotted (white line) along with the predicted increase in elevation resulting from the installation of Mica 5/6 (black line). The phenology of various amphibian life stages are shown relative to date and elevation. The colours represent high risk (red), moderate risk (orange) and no risk (green). Data points represent observations of Western Toads of Columbia Spotted Frogs at various elevations. Data from all years pooled and displayed on each plot.

Most habitats used by amphibians in the drawdown zone are inundated late in tadpole development, close to the time of metamorphosis. As tadpoles are able to swim freely at the time of inundation, we assume they follow the edge of the reservoir as water elevation increases, as has been observed in other reservoirs (Hawkes and Tuttle 2009, Hawkes et al. 2011). This assumption is bolstered by the observation of toadlets near key breeding sites in the Valemount Peatland, at Ptarmigan Creek, and in Bush Arm. Young-of-the-year froglets have not been observed emerging from breeding ponds, but the size of young frogs observed in the drawdown zone each spring suggests that some frogs born the previous year are successfully overwintering.

Inundation affects the availability and suitability of pond habitats located in the drawdown zone, which are used by local populations of amphibians and reptiles for breeding and foraging. Western Toads (SARA species of Special Concern) are likely the most affected by early inundation. Western Toads breed in ponds at lower elevations than other species in the drawdown zone. For example, at Bear Island and Bush Arm KM 79, Western Toad egg masses were documented in low elevation, mud-bottomed ponds (with little vegetation) between 734 and 749 m ASL (see Section 5.9). Ponds situated between 735 and 740 m ASL were at moderate risk by early June, with their habitats being completely inundated by mid-June (Figure 5-12). Timing of inundation for these lower ponds is ~ one month earlier than most other amphibian habitats, occurring just shortly after the last frog egg masses are typically detected. Additionally, Western Toad metamorphs have not been observed at Bear Island (but this may be a function of site access). Columbia Spotted Frogs are less likely to be impacted by inundation, as they tend to lay their eggs in higher elevation ponds (Figure 5-5).

The following sections test each of the hypotheses associated with CLBMON-58 (and CLBMON-37) and lend support to our assessment of the effects that the installation of units 5 and 6 at Mica Dam will have on amphibians using habitats in the drawdown zone of Kinbasket Reservoir.

5.5 H1$_A$: Reservoir operations do not result in a decreased abundance of amphibians or reptiles in the drawdown zone.

Assessments of the elevation distribution of Western Toad and Columbia Spotted Frog suggests relatively consistent use of the drawdown zone by these species over time (Figure 5-5). To assess whether reservoir operations (i.e., the filling of Kinbasket Reservoir) affect the relative abundance of Western Toad and Columbia Spotted Frog, we plotted detection rates (the number of observations per hour) relative to season and reservoir elevation. In general, reservoir elevations are lowest in the spring and increase through the summer (Figure 3-2). Most amphibian observations are made in the spring because animals are conspicuous and aggregating at breeding ponds, which are distributed throughout the drawdown zone (see Section 5.9).

Detection rates for Western Toads generally drop off over the summer until mid to early August when toad metamorphs migrate from their breeding ponds to their upland overwintering sites. This information is not captured in Figure 5-13 because reservoir elevations generally preclude sampling in the drawdown zone at that time of year (see Figure 3-2). Columbia Spotted Frogs are more aquatic than toads and tend to stay close to their breeding ponds all year and although detection rates decline as the reservoir elevation increases, they are detected throughout the active season (i.e., spring through summer; Figure 5-13). Overall, detection rates vary annually, but that is to be expected given the natural variation typically exhibited by these species. The relationship between reservoir operations and the relative abundance of amphibians is not entirely clear at this point, but it appears that reservoir operations are not affecting relative abundance, at least not during the three years of data assessed.

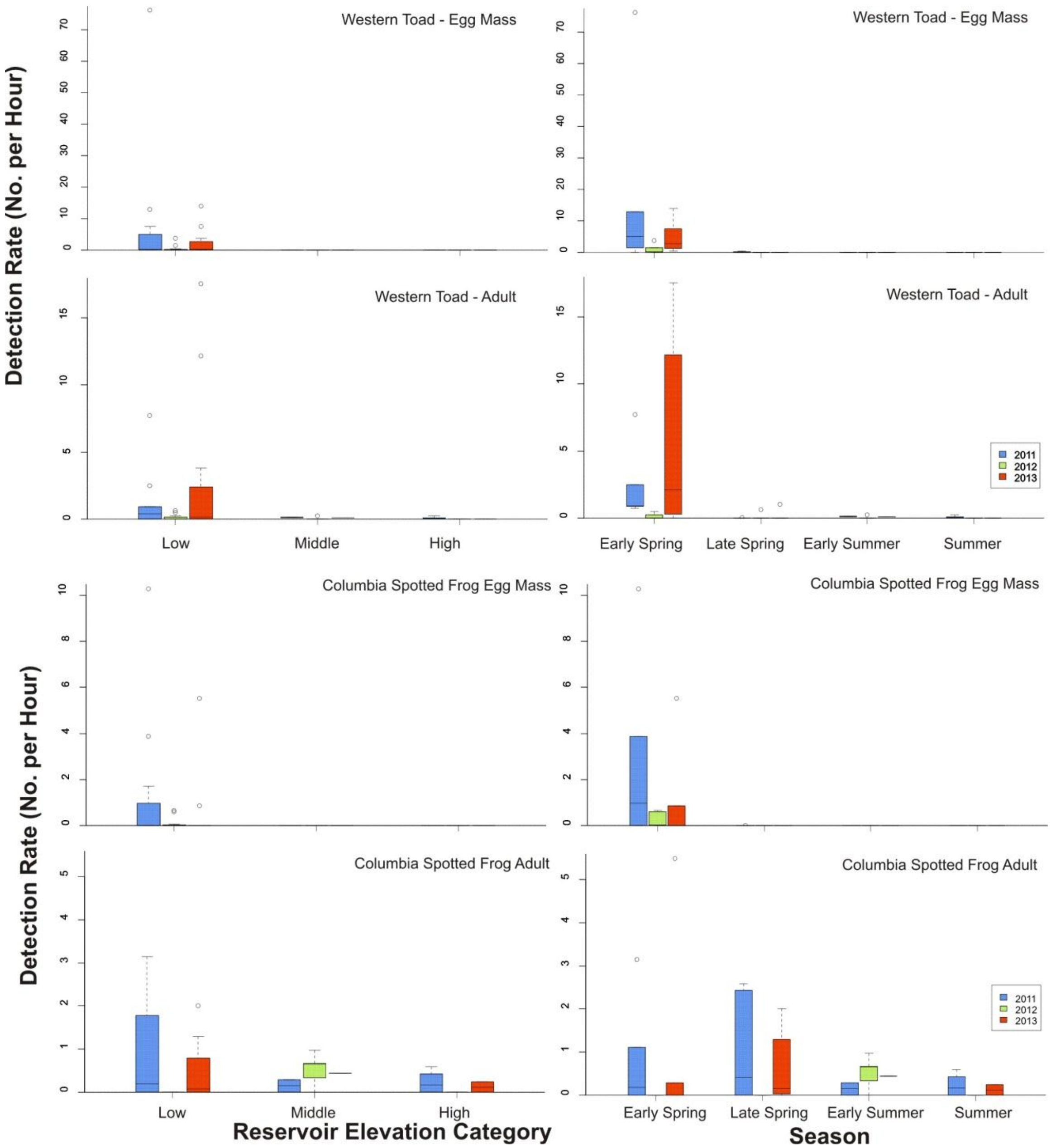

Figure 5-13: Variation in detection rates for Western Toad (top) and Columbia Spotted Frog (bottom panel) relative to reservoir elevation (low: <733 m ASL, middle: 745–747 m ASL, and high: 751–753 m ASL) and time of year (early spring, April 1 to May 18; late spring, May 19 to June 21; early summer, June 22 to July 21; and summer, June 22 to August 19). Replicates are reaches

5.6 H1$_B$: Reservoir operations do not increase the stage specific (e.g. larval, juvenile, or adult) mortality rates of amphibians or reptiles in the drawdown zone.

Our current understanding of the use of the drawdown zone by amphibians and reptiles is that certain species use the DDZ to fulfill most of their life history stages (e.g., Western Toad and Columbia Spotted Frog), while others (e.g., Long-toed Salamander and garter snakes) appear to use the DDZ to fulfill specific stages (Table 5-3).

Table 5-3: Observed life history activity of amphibian and reptile species in the drawdown zone of Kinbasket Reservoir from 2011 to 2013. Any 'Yes' indicates a direct observation of the life history activity or stage, whereas the rest are inferences

Species	Life History Activity			
	Breeding	Growth	Foraging	Overwintering
Columbia Spotted Frog (A-RALU)	Yes	Yes	Yes	Unknown
Western Toad (A-ANBO)	Yes	Yes	Yes	Unlikely
Long-toed Salamander (A-AMMA)	Yes	Yes	Likely	Unlikely
Western Terrestrial Garter Snake (R-THEL)	Unknown	Yes	Yes	Unlikely
Common Garter Snake (R-THSI)	Unknown	Yes	Yes	Unlikely

Life stage-specific mortality rates have not been directly measured for any species, but instances of mortality have been observed and can be related to natural causes. For example, high rates of Western Toad depredation were observed at Ptarmigan Creek in 2012 (by an unidentified avian predator) and toad drowning is not unusual. There are also times when toad egg strings are not fertilized (Figure 5-14), which could lead to reduced fecundity, but not mortality. We have not observed depredation or unfertilized egg masses of Columbia Spotted Frog.

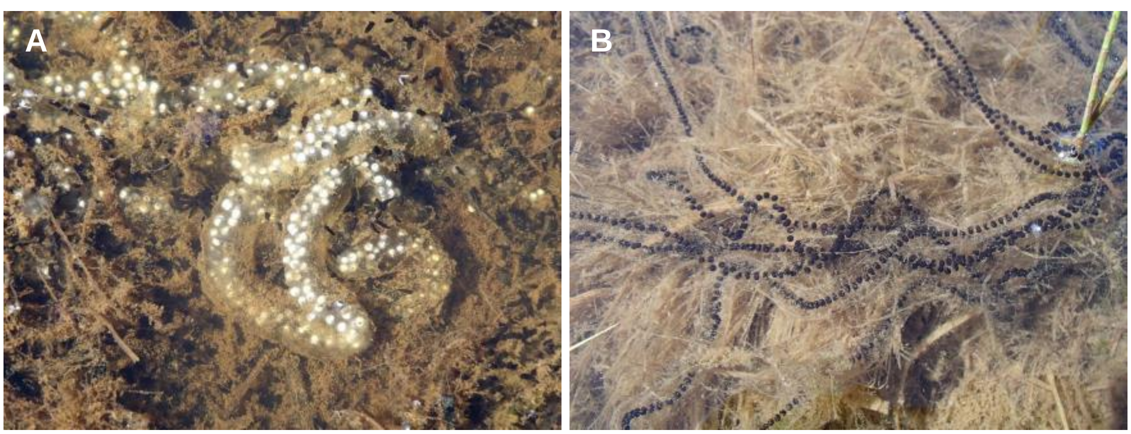

Figure 5-14: Photo of unfertilized Western Toad eggs (A; white orbs) surrounded by recently hatched Western Toad tadpoles (from another egg string) and fertilized Western Toad eggs (B)

Egg string and egg mass stranding have been observed at various locations in the drawdown zone (e.g., Bear Island in 2013; Figure 5-15). The number of Western Toad egg strings and Columbia Spotted Frog egg masses that were stranded were difficult to accurately count, but were fewer than 10 for each species in all years of study. Egg mass stranding is usually related to decreasing hydroperiod at oviposition sites, which can be a major cause of death to developing embryos. The egg mass stranding phenomenon is not unique to drawdown zones (e.g., Marco and Blaustein 1998). Local environmental conditions can influence the hydroperiod of breeding ponds and are likely to confound reservoir effects that may be linked to egg mass stranding.

Figure 5-15: Stranded Western Toad egg string at Bear Island, June 2013.

Despite not being able to directly measure mortality, we can infer the health of amphibian populations thorough an assessment of biomass, which can be affected by changes in the environment. For both male and female Western Toads there was a significant effect of length and of year (mean snout-urostyle length and mass varied among years; $p < 0.0001$ for both male and females). For both sexes, the interaction term was not significant, meaning that the slope of mass vs. snout-urostyle length did not vary among years: the three lines (one for each year) are approximately parallel, but distinctly separated. For any given snout-urostyle length, toads were heaviest in 2013 and lightest in 2012 (Figure 5-16). Given that slopes do not vary among years, it appears that the health of the population has not changed over the three years. Unfortunately, small sample sizes of Columbia Spotted Frogs in 2012 and 2013 preclude a similar assessment.

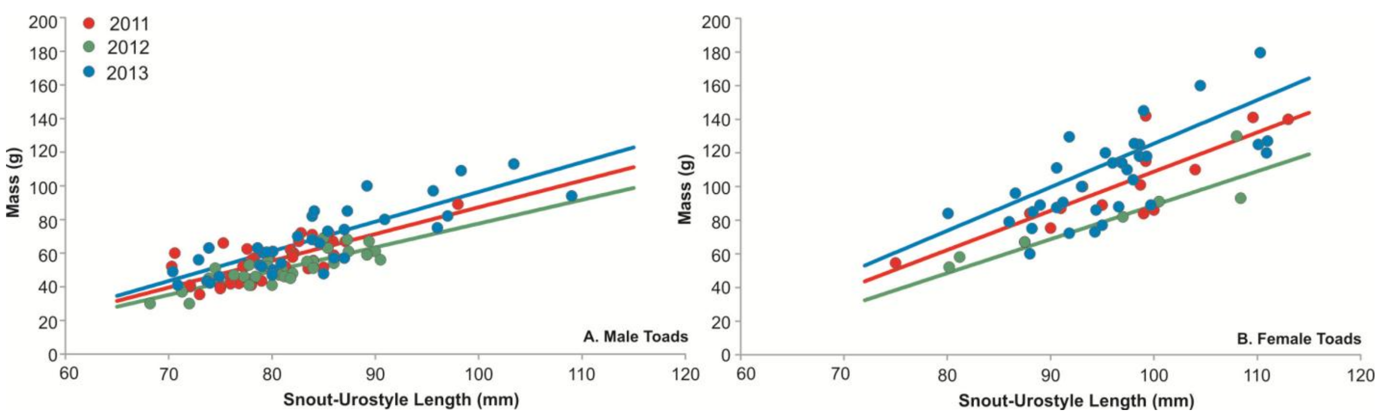

Figure 5-16: Relationship between snout-urostyle length (mm) and body mass (g) for adult male and female Western Toads captured in the drawdown zone of Kinbasket Reservoir 2011, 2012, and 2013

Table 5-4: Size ranges and linear regression coefficients for Western Toad and Columba Spotted Frog males and females. All species regressions were significant ($P < 0.001$) except for Columbia Spotted Frog females in 2012 ($P = 0.3$). -- indicates no data; SUL = Snout-Urostyle Length

				SUL (mm)		Mass (g)				
Species	**Year**	**Sex**	**N**	**Min**	**Max**	**Min**	**Max**	R^2	**Slope**	**Int**
Western Toad	2011	Female	14	75.0	113.0	54.5	142.0	0.70	2.3	-124.9
	2011	Male	40	70.3	98.0	35.4	89.1	0.53	1.6	-71.7
	2012	Female	8	80.2	108.4	52.0	130.0	0.83	2.0	-109.2
	2012	Male	30	68.2	90.5	30.0	69.0	0.68	1.4	-63.6
	2013	Female	33	80.1	111.0	60.0	179.5	0.49	2.5	-132.0
	2013	Male	35	70.4	109.0	41.0	113.0	0.68	1.8	-80.4
Columbia Spotted Frog	2011	Female	23	59.0	80.4	16.5	54.0	0.88	1.5	-70.3
	2011	Male	56	43.0	79.9	5.8	60.0	0.66	0.7	45.3
	2012	Female	3	72.7	76.2	28.0	46.0	0.79	0.2	68.5
	2012	Male	--	--	--	--	--	--	--	--
	2013	Female	--	--	--	--	--	--	--	--
	2013	Male	4	50.3	69.4	13.8	40.0	0.95	0.7	41.0

5.7 $H1_C$: Reservoir operations do not result in decreased site occupancy of amphibians or reptiles in the drawdown zone.

5.7.1 Proportion of Mapped Sites

We surveyed 100 ponds in six survey sites in all three years. The proportion of sites where a species was detected at least once varied by year and survey site (Table 5-5). Overall, occupancy ranged from 100 per cent to 0 per cent. Inconspicuous species like Long-toed Salamander (A-AMMA) occurred at two survey sites and occupied much as 43 per cent of available habitats at the Bush Arm Causeway in 2011 to as little as 2 per cent in the Valemount Peatland. Western Toad (A-ANBO) occupied all sites in all years with the exception of the perched wetland at KM 79 in 2012 and 2013. The proportion of sites occupied by Columbia Spotted Frog was similar for survey sites in Bush Arm (e.g., Bear Island and Causeway) and varied for Canoe Reach (e.g., Valemount Peatland. The proportion of sites occupied by a given species is based only on ponds mapped in the drawdown zone. Columbia Spotted Frogs did occur in the Valemount Peatland in 2012, but their locations did not overlap with a mapped wetland or pond. However, as site occupancy may also be a function of detectability, these parameters are subsequently examined together (see Section 5.7.2).

Table 5-5: Proportion of sites occupied at each survey site for each species of amphibian and reptile known to use habitats in the drawdown zone of Kinbasket Reservoir between 2011 and 2013. A = amphibian, R = reptile; AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake.

		A-AMMA			A-ANBO			A-RALU			R-THEL			R-THSI		
Survey Site	**Ponds**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**	**2011**	**2012**	**2013**
KIN Bush Arm Bear Island	22	0.00	0.00	0.00	**0.41**	**0.27**	**0.18**	**0.05**	**0.14**	**0.05**	0.00	0.00	0.00	0.00	0.00	0.00
KIN Bush Arm Causeway	7	**0.43**	**0.29**	**0.29**	**0.57**	**0.29**	**0.57**	**0.14**	**0.14**	**0.14**	0.00	0.00	0.00	**0.14**	0.00	**0.14**
KIN Bush Arm km 79	21	0.00	0.00	0.00	**0.33**	**0.19**	**0.29**	**0.24**	**0.05**	**0.10**	0.00	0.00	0.00	0.00	0.00	**0.05**
KIN Bush Arm km 79 Perched Wetland	1	0.00	0.00	0.00	**1.00**	0.00	0.00	**1.00**	**1.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
KIN Ptarmigan Creek	1	0.00	0.00	0.00	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.00	0.00	0.00	0.00	**1.00**	0.00	0.00
KIN Valemount Peatland	48	**0.04**	**0.02**	**0.02**	**0.27**	**0.02**	**0.17**	**0.73**	0.00	**0.23**	0.00	0.00	0.00	**0.15**	**0.02**	0.00
Survey Sites Per Year		2.00	2.00	2.00	6.00	5.00	5.00	6.00	5.00	4.00	0.00	0.00	0.00	3.00	1.00	2.00
Proportion of Total Mapped Sites		0.05	0.03	0.03	0.35	0.14	0.23	0.44	0.07	0.15	0.00	0.00	0.00	0.09	0.01	0.02

5.7.2 Site Occupancy Modelling

Occupancy and detectability were modelled to (1) determine the probability that a pond was occupied and (2) the probability of detecting a species given site occupancy. Estimated occupancy and detectability varied over time, which is to be expected given the large natural variation and population fluctuations associated with amphibians because of environmental stochasticity. For Western Toad, a model with constant occupancy (Ψ), colonization (γ), and extinction (ε), but that allowed detection probabilities (ρ) to vary by season (spring and summer) within a year is the model with the most support (Table 5-6). There is some support for a model that includes elevation as a covariate, but because elevation is confounded by season, the model without elevation is considered the one with the strongest support. For Columbia Spotted Frog, a model with constant occupancy, but that allowed extinction, colonization and, detection probability to vary as a function of year was the model with the strongest support (Table 5-6). There is equivalent support for a model that includes elevation as a covariate that influences the estimates of these parameters. There is also reasonable support that detection probability varies as a function of season.

Table 5-6: Ranking of models for detectability (ρ) and occupancy (Ψ) for Columbia Spotted Frog and Western Toad in the drawdown zone of Kinbasket Reservoir, southeastern BC. Models in bold have the highest support

Western Toad	AIC	ΔAIC	No. Par	-2Log (*L*)
Ψ,γ(),ε(),ρ (t)	**368.08**	**0**	**9**	**350.08**
Ψ,γ(),ε(),ρ(t+elev)	380.62	12.54	9	362.62
Ψ(yr),γ(yr),ε(yr + elev), ρ(yr + elev)	398.15	30.07	6	386.15
Ψ(.),γ(yr + elev),ε(yr + elev), ρ(yr + elev)	398.15	30.07	6	386.15
Ψ (yr + elev),γ(yr + elev),ε(yr + elev), ρ(yr + elev)	398.15	30.07	6	386.15
Ψ(.),γ(yr), ρ(yr),p(yr)	398.15	30.07	6	386.15
Ψ(.),γ(.),ε(.),ρ(.)	410.66	42.58	4	402.66
Ψ(.),ρ(yr)	418.44	50.36	2	414.44
Ψ(.),ρ(.)	418.44	50.36	2	414.44
Ψ(yr), ρ(.)	418.44	50.36	2	414.44

Columbia Spotted Frog	AIC	ΔAIC	No. Par	-2Log (*L*)
Ψ(.),γ(yr),ε(yr), ρ(yr)	**267.33**	**0**	**6**	**255.33**
Ψ(.),γ(yr),ε(yr), ρ(yr + elev)	**267.33**	**0**	**6**	**255.33**
Ψ(yr + elev),γ(yr),ε(yr), ρ(yr + elev)	**267.33**	**0**	**6**	**255.33**
Ψ,γ(),ε(),ρ(t)	270.88	3.55	9	252.88
Ψ,γ(),ε(),ρ(t+elev)	272.72	5.39	11	250.72
Ψ,γ(),ε(),ρ()	282.21	14.88	4	274.21
Ψ(.),ρ(yr)	364.84	97.51	2	360.84
Ψ(.),ρ(.)	364.84	97.51	2	360.84
Ψ(yr), ρ(.)	364.84	97.51	2	360.84

Estimated occupancy was higher for Columbia Spotted Frog than Western Toad in all three years (Figure 5-17). The estimated probability that Western Toads occupied ponds in the drawdown zone of Kinbasket Reservoir was relatively constant over the three year period: 2011: 0.52 (SE = 0.07); 2012: 0.48 (SE = 0.08), and 2013: 0.46 (SE = 0.12). Estimated occupancy for Columbia Spotted Frogs ranged from a high of 0.96 (SE = 0.05) in 2011 to a low of 0.53 (SE = 0.37) in 2012. Estimated occupancy in 2013 was 0.74 (SE = 0.03). In other words, there was a 96 per cent probability that a pond was occupied by frogs in 2012, 53 per cent in 2012, and 74 per cent in 2013 (Figure 5-17), alluding to a decrease in site occupancy from 2011 to 2013.

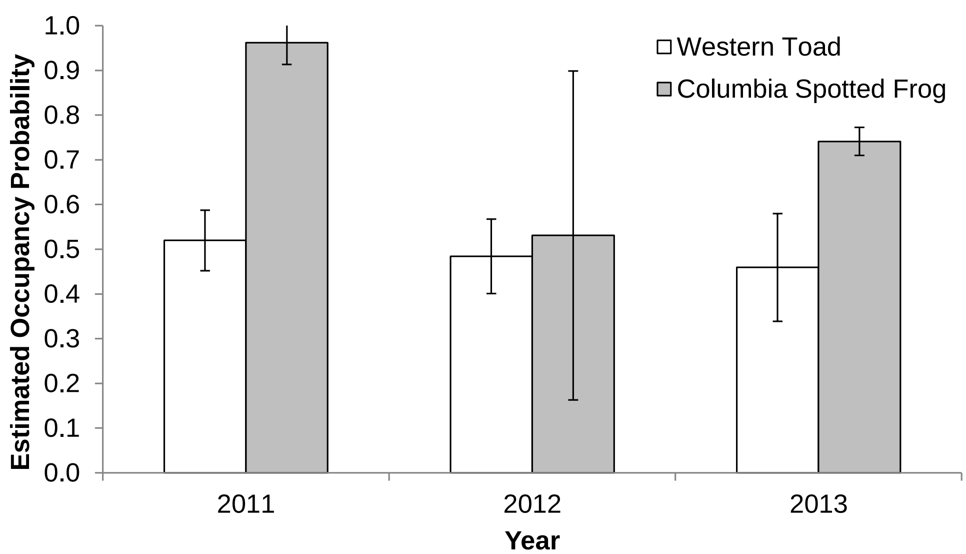

Figure 5-17: Estimated occupancy (± SE) of Western Toad and Columbia Spotted Frog in the drawdown zone of Kinbasket Reservoir 2011, 2012, and 2013. Estimates for 2011 are actual values; estimates for 2012 and 2013 are derived from the model

When a pond was occupied, the probability of detecting Western Toads varied by year and season, such that detection probabilities were lowest in 2012 and higher in the spring in all three years (Figure 5-18). A similar trend was observed for Columbia Spotted Frog. The high estimated detection probability for 2011 suggests that species non-detections were a reflection of actual absence of that species, rather than the result of an imperfect survey. This coincides with survey effort, which was greatest in 2011 and lowest in 2012. Given the large variation in detectability probabilities and variable survey effort across years additional data are required to more precisely estimate occupancy and detectability. Regardless, the occupancy and detection probability estimates are consistent with what is known regarding the natural variation associated with amphibian populations because of environmental stochasticity (e.g., Hansen et al. 2012).

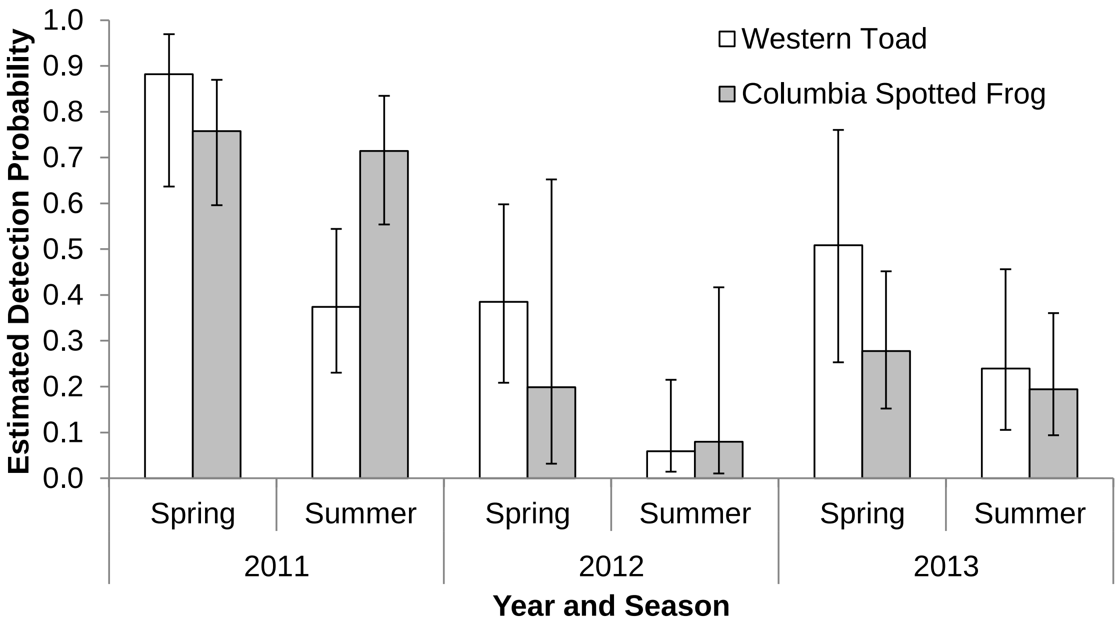

Figure 5-18: Estimated detectability (± 95% Confidence Limits) for Western Toad and Columbia Spotted Frog in the drawdown zone of Kinbasket Reservoir 2011, 2012, and 2013

5.8 $H1_D$: Reservoir operations do not result in decreased productivity of amphibians or reptiles in the drawdown zone.

Amphibian productivity has not been explicitly studied in Kinbasket Reservoir. The data collected thus far indicate that at least two species of pond-breeding amphibian, Western Toad and Columbia Spotted Frog, are using habitats in the drawdown zone for breeding. The detection of amphibian egg masses varied for both Columbia Spotted Frog and Western Toad (Figure 5-13), but the observed variation is expected. Although we can calculate detection rates for these species, most of the information we have is qualitative and based on observations. We have observed all life stages of these species (i.e., eggs, tadpoles, toadlets, subadults, and adults). Too few data exist for the other species of amphibians to discuss how reservoir operations might affect their productivity.

For at least one species, the Western Toad, productivity does not appear to be affected by reservoir operations. For example, Western Toad metamorphs have been observed at Ptarmigan Creek, various locations in the Valemount Peatland (e.g., Pond 12), and from the Bush Arm Causeway in most years of study. Each spring, numerous adult Western Toads are documented in the drawdown zone, and egg strings are observed in many of the same locations each year. Adult male to female ratios calculated for each year (2011: 1.9:1; 2012: 3.6:1; and 2013: 1.4:1) are consistent with values reported in the literature (Olson et al. 1986), lending support to a stable population of toads in the areas of Kinbasket Reservoir being studied.

Western Toads live for 9 or 10 years and return to the same breeding site annually even if other suitable habitats are available. Females do not lay eggs every year and may only do so once in their lifetime. The fact that adults return to the same breeding site each year suggests that the local population size ensures that Western Toads persist in the drawdown zone; however, it is not known if habitats in the drawdown zone function as a source or sink for certain amphibian populations. Preliminary mark-recapture data indicate that either the population is very large or that population turnover is very high (based on the lack of individual recaptures), but more work is required to assess population size and use of breeding sites by individual adult toads.

For Columbia Spotted Frogs, the most reliable male to female sex ratio was calculated using 2011 data (2.8:1). Males may take between two and four years to reach sexual maturity, while females may not breed until their fifth or sixth year. A typical lifespan of the Columbia Spotted Frog may be 10 years or more. Columbia Spotted Frogs breed in several locations in the drawdown zone (Valemount Peatland, KM 79 in Bush Arm), but more information regarding the age and sex structure of the Columbia Spotted Frog populations using habitats in the drawdown zone is required to answer this management question.

Qualitatively, it appears that the productivity of both Western Toad and Columbia Spotted Frog is consistent between years (Figure 5-13). However, we are currently only assessing these species in the drawdown zone of the reservoir. In the absence of a suitable control or baseline data, we don't know for certain how the productivity of any species of amphibian might be affected by reservoir operations.

Reptile productivity is not being assessed via CLBMON-58. Assessing reptile productivity (i.e., garter snakes) would require studies using radiotelemetry to determine where garter snakes overwinter and during what season and to what extent these species use the drawdown zone. Our current understanding of reptile use of the drawdown zone is limited to opportunistic observations made during the spring and summer only and these observations are generally of basking or foraging adults.

5.9 $H1_E$: Reservoir operations do not reduce the availability and quality of breeding habitat, foraging habitat and overwintering habitat for amphibians or reptiles in the drawdown zone.

Habitat availability was assessed in a GIS by delineating the total area sampled each year (i.e., terrestrial and aquatic habitat at each survey site) and calculating how much of that area was available on a monthly basis relative to reservoir operations. As expected, a strong negative correlation exists between the availability of all types of habitat and reservoir elevations (2008: r = -0.89; 2009: r = -0.95; 2010: r = -0.92; 2011: r = -0.95; 2012: r = -0.95; 2013: r = -0.93) with habitat availability decreasing with time. The change in habitat availability is most evident in June and July, when reservoir elevations are increasing (Figure 5-19).

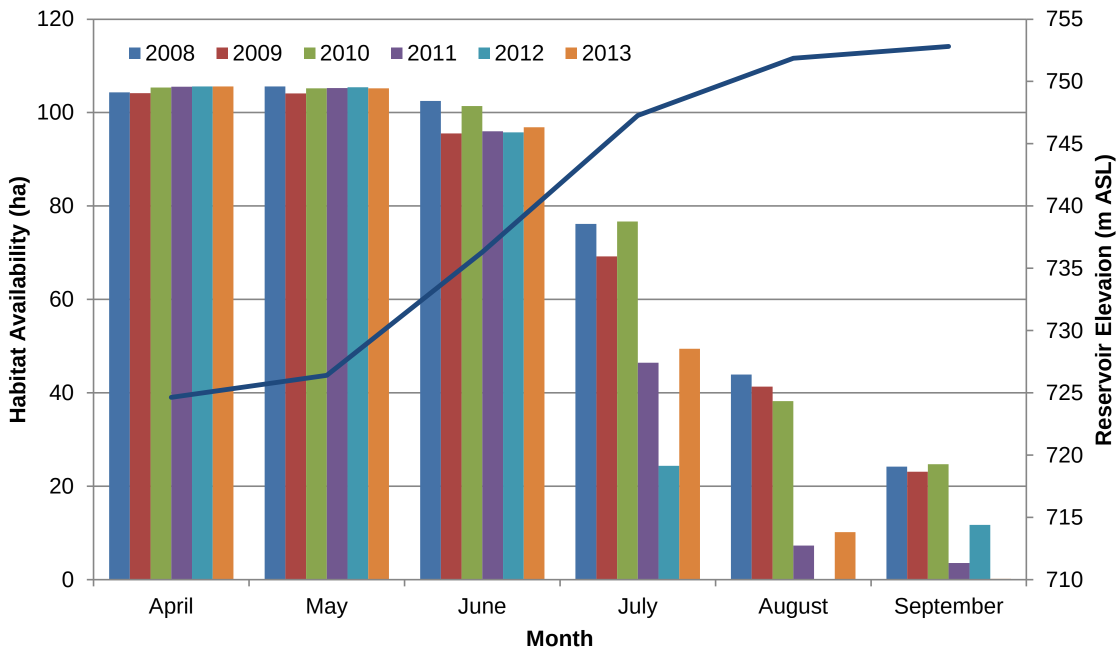

Figure 5-19: Annual Change in habitat availability (bars) relative to month and average reservoir elevation (line) for year 2008 to 2013 in Kinbasket Reservoir

The availability of amphibian and reptile habitat in the drawdown zone is discussed in the context of (1) breeding habitat, which is defined as those habitats in which amphibian egg masses are deposited or where reptiles give birth, (2) foraging habitat, where amphibians and reptiles obtain prey, which includes both aquatic and terrestrial habitats, and (3) overwintering habitat, or those habitats necessary for the overwinter survivorship of amphibians and reptiles.

5.9.1 Breeding Habitat

The amphibian species using the drawdown zone of Kinbasket Lakes Reservoir are pond-breeding amphibians that breed in wetlands, ponds, quiescent backwaters of streams, and sometimes lake margins. Ninety five[1] ponds representing 9.59 ha were delineated in the drawdown zone in five distinct survey sites. Total pond area per site ranged from 0.9 ha at Ptarmigan Creek (*N* = 1 pond) to 4.9 ha in the Valemount Peatland (*N* = 48 ponds) and most ponds are situated at elevations between 745 m and 753 m ASL (Figure 5-20).

[1] Only ponds with mean elevations <756 are considered here, which is why the number of ponds differs from those discussed in Section 5.7.2

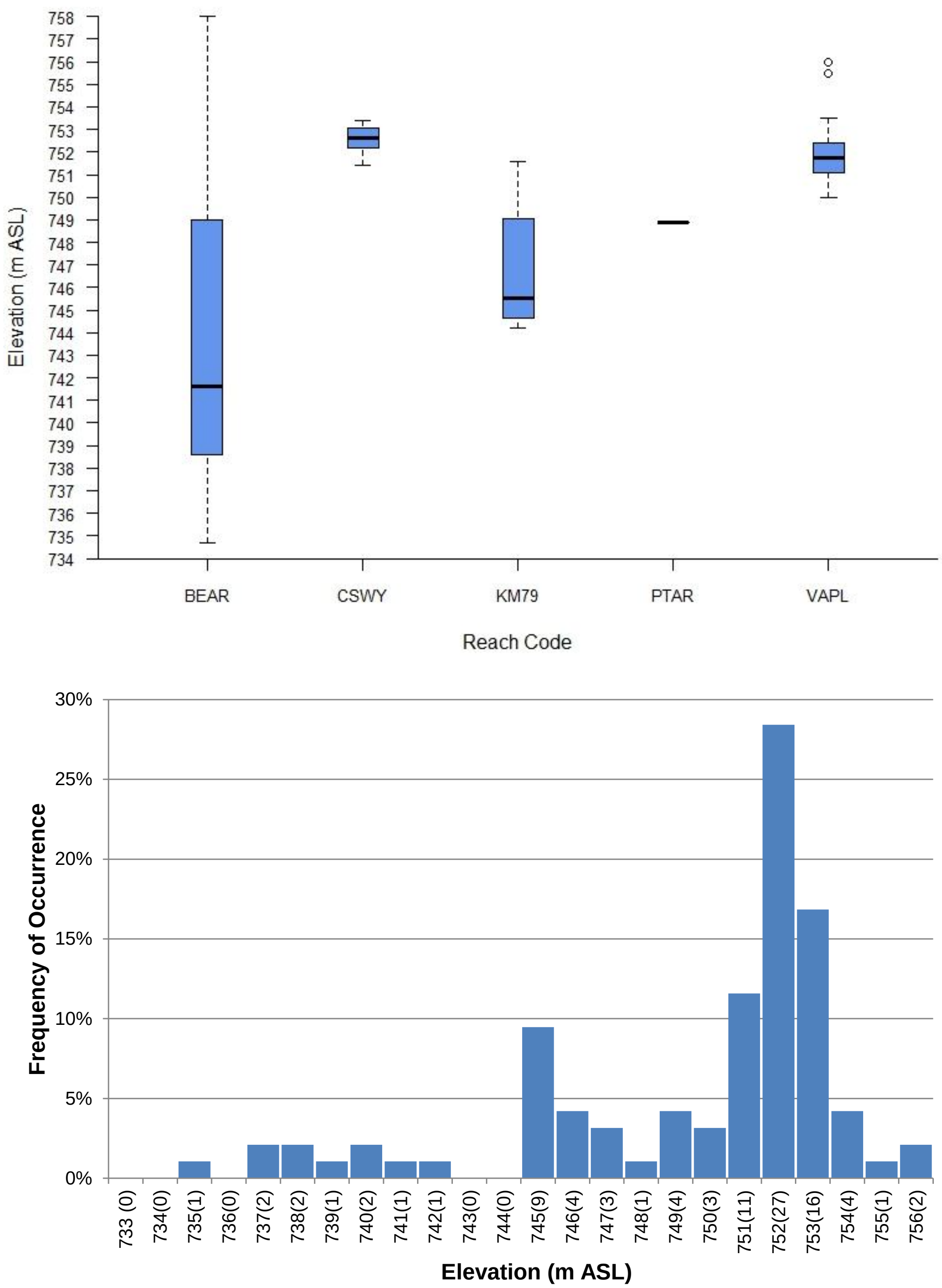

Figure 5-20: Elevation distribution of ponds (top panel) delineated in and adjacent to the drawdown zone at Bear Island (BEAR), the Bush Arm Causeway (CSWY), Bush Arm at km 79 (KM79), Ptarmigan Creek (PTAR) and the Valemount Peatland (VAPL) and the proportion of ponds occurring at elevations ranging from 733 to 756 m ASL (bottom panel). Sample size in parentheses

The quality (i.e., availability) of breeding habitat is affected by reservoir elevation on an annual basis. To demonstrate how reservoir elevation affects the availability, and hence quality of breeding habitat, habitat availability was plotted relative to reservoir elevation in 2011, 2012, and 2013. In 2011, the majority of ponds (i.e., those situated between 745 and 753 m ASL) were available until June 10. Beyond this point, the amount of breeding habitat steadily declined until July 29, at which time all 9.59 ha of pond habitat were inundated. In 2012, most ponds were available until June 13, but were completely inundated by July 17. Similarly, all ponds were available through June 12 in 2013 and were completely inundated by August 7 (Figure 5-21).

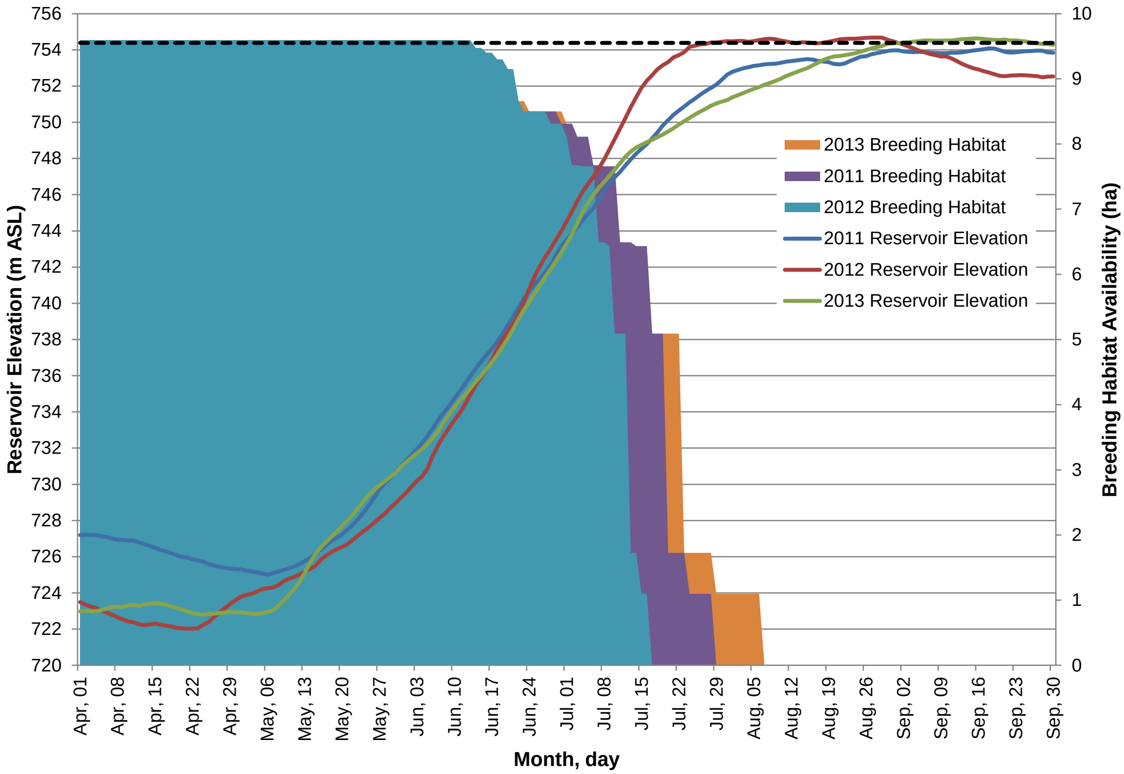

Figure 5-21: Relationship between breeding habitat availability (pond area) and reservoir elevations for the period April 1 through September 30, 2011 to 2013

The timing of inundation and occupancy of ponds (see Section 5.7) coupled with the observation of breeding toads and frogs and egg masses indicates that reservoir operations do not preclude breeding in ponds in the drawdown zone. Most pond-breeding amphibian egg masses were laid prior to inundation (Figure 5-12), and based on our observations of all life stages of Western Toads (eggs, tadpoles, toadlets, subadults, and adults), the reduction in habitat availability associated with inundation does not appear to be associated with reduced reproductive success (see Section 5.8). Observations of metamorphosed toads at the Valemount Peatland, Ptarmigan Creek, and Bush Arm Causeway in early to late August 2011, 2012, and 2013 suggests that toad egg strings and tadpoles can tolerate some level of disturbance from reservoir operations. However, the degree to which reservoir operations might affect the success of observed breeding (in terms of the proportion of eggs that survive to metamorphosis) is not well-understood and cannot currently be quantified.

Sixty-five of the 95 ponds mapped in the drawdown zone were used to compare ponds with respect to their potential as breeding "hotspots" (i.e., ponds with high species diversity and abundance of adults and egg masses). The pond located at

Ptarmigan Creek ("PC-1") is the largest pond in our study area (9,457 m^2) and not surprisingly, exhibits the greatest potential for breeding amphibian and reptile communities, housing the highest number of species (3 species; ANBO, RALU, THSI) and individuals (417 detections; Figure 5-22). Although eggs and adults of Long-toed Salamanders were not observed at this pond, larvae of this species were detected in June 2013, thus increasing site diversity (4 species). Ptarmigan Creek also supports a large population of Common Garter Snakes (41 detections). The second largest pond (8,337 m^2), located at Valemount Peatland ("VP-12"), is also identified as a hotspot for reptile and amphibian communities in the Kinbasket drawdown zone, having supported the second highest number of adults and eggs (296 detections) and maximum species richness (3 species; Figure 5-22).

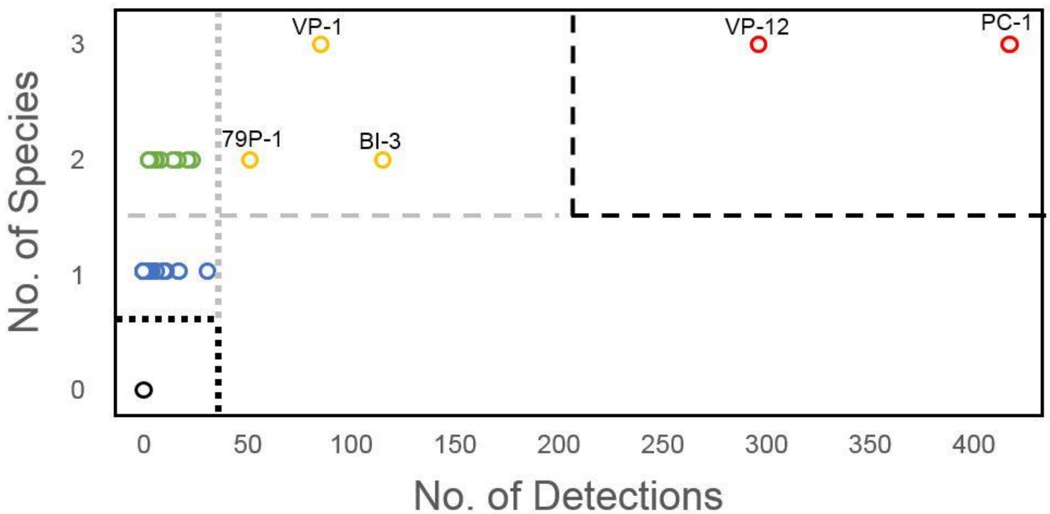

Figure 5-22: Plot of ponds (*N*=65) according to observed species richness and abundance of amphibians and reptiles (adults and egg masses). The plot is delineated according to the relative potential of ponds to serve as diversity hotspots for breeding amphibians and reptiles. Dashed lines delineate portions of the plot that identify hotspots (*N*=2, red, upper right quadrant), "warmspots" (*N*=3, yellow, center), and "coldspots" (*N*=32, blue, lower left). Some ponds (*N*=10, green, upper left) housed moderate species diversity, yet at low abundances, whereas many other ponds (*N*=18, black, plot origin) were not observed to support breeding communities. Select ponds are identified by their site and pond number (BI= Bush Arm, Bear Island; 79P= Bush Arm, KM 79 Perched Wetland; PC= Ptarmigan Creek; VP= Valemount Peatland; pond numbers as per Table 9-1, Appendix 9).

Three pond "warmspots" were delineated in the drawdown zone of Kinbasket Reservoir (Figure 5-22). Interestingly, a small pond at Valemount Peatland ("VP-1") housed a high diversity of amphibians (3 species: AMMA, ANBO, RALU), and relatively high abundance (85 detections), considering the size of the pond (105 m^2). Additionally, one juvenile Common Garter Snake was detected in this pond in July 2011. A moderate sized pond (1382 m^2) located at Bear Island ("BI-3"; Figure 5-22) housed two species (ANBO, RALU) in high numbers (115 detections). Few adults were observed at this pond; most detections were comprised of eggs of Western Toads (92 detections) and Columbia Spotted Frogs (14 detections). The large (2,966 m^2) perched wetland area at KM 79 of Bush Arm (Figure 5-22, "79P-1") housed moderate numbers of adults and eggs of Western Toads and Columbia Spotted Frogs, while also housing other life stages of these two species. These five highly ranked ponds may be particularly important for breeding populations of reptiles and amphibians in the drawdown zone of Kinbasket Reservoir. These ponds occur at high reservoir elevations (min= 749 m ASL, mean= 751 m ASL, max= 754 m ASL) with inundation dates ranging from early July (at 79P-1) to late August (at VP-12). Although 18 ponds were not observed to support any adult or eggs of amphibian and reptiles, many of these supported other life stages of these species.

5.9.2 Foraging Habitat

Amphibians and reptiles forage in a variety of aquatic and terrestrial habitats and both of these general habitat types occur in the drawdown zone of Kinbasket Reservoir. During each year the availability of foraging habitat decreased rapidly as soon as reservoir elevations reached ~ 740 m ASL (Figure 5-23). Adult amphibians consume terrestrial and aerial insects, tadpoles are algae grazers, and toadlets eat insects and other small invertebrates. Reptiles (snakes) consume insects, worms, gastropods, small mammals and amphibians. The availability of aquatic (i.e., pond) habitat varies relative to time of year and reservoir operations (Figure 5-21). A similar trend is observed for all foraging habitat (i.e., terrestrial and aquatic) and as expected there is a strong linear relationship between reservoir elevation and habitat availability (Figure 5-23) with R^2 values close to 1 for all years (see R^2 values in Figure 5-23). The annual trends are similar with only the timing and duration of inundation of each elevation band varying (see Table 5-7).

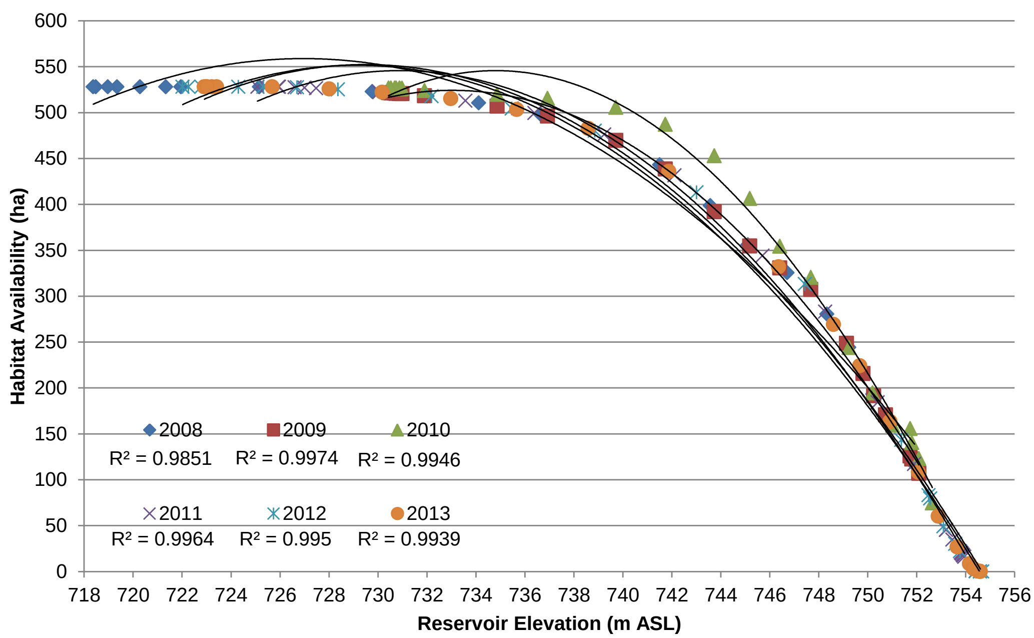

Figure 5-23: The relationship between reservoir elevation and foraging habitat availability in the drawdown zone of Kinbasket Reservoir for the period April 1 to September 30 2008 to 2013. A 2nd order polynomial trend line was fit to the data in each year to obtain the coefficient of determination

Table 5-7: Proportion of time between April and September (n = 183 days) that Kinbasket Reservoir exceeded a given range of elevations.

m ASL	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
741-742	0.58	0.60	0.49	0.44	0.21	0.44	0.40	0.34	0.55	0.59	0.55	0.48	0.53	0.46	0.54	0.54	0.52
742-743	0.58	0.58	0.47	0.43	0.05	0.44	0.37	0.23	0.54	0.58	0.54	0.46	0.51	0.45	0.52	0.53	0.51
743-744	0.57	0.56	0.45	0.40		0.43	0.26	0.19	0.51	0.56	0.52	0.44	0.48	0.43	0.51	0.52	0.50
744-745	0.55	0.54	0.44	0.39		0.42	0.09	0.16	0.50	0.54	0.50	0.42	0.46	0.42	0.49	0.50	0.49
745-746	0.54	0.52	0.43	0.37		0.40		0.11	0.48	0.52	0.49	0.39	0.43	0.39	0.48	0.50	0.49
746-747	0.51	0.50	0.42	0.36		0.39		0.07	0.46	0.51	0.48	0.37	0.40	0.37	0.46	0.49	0.47
747-748	0.49	0.48	0.40	0.30		0.37			0.41	0.49	0.46	0.34	0.37	0.35	0.45	0.47	0.46
748-749	0.48	0.45	0.39	0.17		0.35			0.35	0.48	0.44	0.32	0.34	0.33	0.43	0.46	0.44
749-750	0.45	0.40	0.37	0.04		0.32			0.28	0.45	0.43	0.27	0.31	0.31	0.42	0.45	0.42
750-751	0.44	0.29	0.34			0.23			0.16	0.43	0.42	0.23	0.24	0.27	0.40	0.44	0.38
751-752	0.42	0.14	0.32			0.06				0.37	0.40	0.18	0.16	0.19	0.38	0.43	0.35
752-753	0.39		0.28								0.36		0.06	0.03	0.35	0.42	0.30
753-754	0.34		0.19								0.19			0.01	0.32	0.32	0.25
>754.38																0.17	0.14

5.9.3 Overwintering Habitat

Field work for CLBMON-58 occurs during the snow-free period, usually between the middle to end of April and end of September each year. The availability or quality of amphibian and reptile overwintering habitat in the drawdown zone of either Kinbasket Reservoir has not been assessed. Questions related to the availability and quality of overwintering habitat cannot be answered using existing data.

5.10 $H2_A$: Revegetation and physical works do not increase species diversity or seasonal (spring/summer/fall) abundance of amphibians or reptiles in the drawdown zone.

5.10.1 Revegetation

The revegetation prescriptions applied were never considered relevant or beneficial to amphibians and reptiles nor were they implemented explicitly to benefit amphibians and reptiles. The planting of sedge plugs and live stakes in mostly upland habitats did not appear to improve habitat around important breeding habitats or improve habitat connectivity between upland over-wintering habitats and drawdown zone habitats (see results in Hawkes et al. 2013). Although the hypothesis asks whether revegetation increases species diversity or abundance, we did not test this for the aforementioned reasons. It is the opinion of the authors that revegetation did not, at least in the years covered by this report, increase species diversity or abundance of amphibians and reptiles in the drawdown zone. This observation is consistent with the findings of Fenneman and Hawkes (2012) and Hawkes et al (2013). Further, the fall abundance of amphibians and reptiles has not been assessed as the high reservoir level precludes surveys in the drawdown zone during that season.

5.10.2 Physical Works

Physical works are not currently proposed for Kinbasket Reservoir and as such, we are unable to test this hypothesis. Given that we have documented all expected species from most areas, it is unlikely that physical works will increase species diversity. If wetlands were constructed in or adjacent to the drawdown zone and those wetlands were protected from inundation through tadpole metamorphosis, the abundance of certain species may increase over time, but this is speculative. The removal of woody debris from specific areas of the drawdown zone is likely to improve habitat suitability for amphibians and reptiles, but this has not been directly studied.

5.11 $H2_B$: Revegetation and physical works do not increase amphibian or reptile productivity in the drawdown zone.

5.11.1 Revegetation

The revegetation prescriptions applied were never considered relevant or beneficial to amphibians and reptiles nor were they implemented explicitly to benefit amphibians and reptiles. The relationship between revegetation prescriptions applied in the drawdown zone and amphibian and reptile productivity has not been assessed. There is a potential link between increasing food resources (e.g., invertebrates and small mammals) and productivity and aspects of this are being studied as part of the Kinbasket Reservoir Wildlife Effectiveness study (CLBMON-11A). Amphibians and reptiles are not focal taxa in that study.

5.11.2 Physical Works

At present we are unable to test this hypothesis as there have not been any physical works implemented in the drawdown zone of Kinbasket Reservoir. If wetlands were built as a physical works and those wetlands were protected from inundation through tadpole metamorphosis, the productivity of certain species may increase over time, but this is speculative. The removal of woody debris from specific areas of the drawdown zone is likely to improve habitat suitability for amphibians and reptiles, but this has not been directly studied.

5.12 $H2_C$: Revegetation does not increase the amount or improve habitat for amphibians and reptiles in the drawdown zone.

As stated above, the revegetation prescriptions applied were never considered relevant or beneficial to amphibians and reptiles nor were they implemented explicitly to benefit amphibians and reptiles. Certain types of physical works (e.g., woody debris removal) have the potential to improve habitat for amphibians and reptiles in the drawdown zone. Woody debris removal is specific areas (e.g., Valemount Peatland, Ptarmigan Creek, Bush Arm) are recommended as these areas contain high quality amphibian and reptile habitat and abundant woody debris.

6.0 DISCUSSION

The relationship between habitats occurring in the drawdown zone of hydroelectric reservoirs and their use by wildlife has not been well-studied. While suitable habitat may exist in the drawdown zone, reservoir operations can affect the suitability and availability of those habitats within and between years. In Kinbasket Reservoir, the relationship between reservoir operations and the distribution and occurrence of amphibians and reptiles has been studied since 2008. Beginning in 2011, a more intensive study on amphibian survivorship was implemented to understand what the implications of increasing reservoir elevations by 0.6 m during the summer months might be. The predicted increase is related to the installation of units 5 and 6 at Mica Dam, which should be completed in 2014.

Amphibian and reptile populations appear to be persisting in the drawdown zone of Kinbasket Reservoir, and our data suggest that the number and size of adult Western Toads and Columbia Spotted Frogs is sufficient to maintain these populations under current conditions. Furthermore, the occupancy and detection probability estimates derived for Western Toad and Columbia Spotted Frog are consistent with what is known about the natural variation of amphibian populations because of environmental stochasticity.

Reservoir operations do affect the availability and suitability of habitats in the drawdown zone, with large reductions in total available habitat occurring on annual basis. Despite the observed changes in water physicochemical parameters and the reduction in total habitat available, both Western Toad and Columbia Spotted Frog breed successfully in ponds situated in the drawdown zone. Preliminary data suggest that increasing reservoir elevations by as much as 0.6 m in the summer months is unlikely to negatively impact Western Toad and Columbia Spotted Frog populations directly. However, there are likely to be direct effects on amphibian habitat resulting from the vertical and horizontal movement and depositions of large rafts of wood debris.

Although we can quantify habitat use by amphibians, we are not currently able to quantify whether survivorship will be affected by reservoir operations that result in higher elevations at specific times of the year. Survivorship and mark-recapture studies typically involve the use of radio-telemetry to study the fate of tagged animals over a period of time. Without these data, we will not be able to answer questions relating to overwinter habitat use, whether individuals return to and use the same ponds for breeding annually, and how amphibians and reptiles respond directly to increasing reservoir elevations.

We feel that the opportunity exists to introduce additional methods with which to study amphibians and reptiles in the drawdown zone of Kinbasket Reservoir. Specifically, radiotelemetry studies of Western Toad, Columbia Spotted Frog, and possibly Common Garter Snake will help answer several management questions that will remain unanswered suing current methods. In addition to using different sampling techniques, we suggest that wood debris be removed from selected ponds in the drawdown zone to improve amphibian habitat suitability. These topics are discussed in further details below, under Management Questions, and in the recommendations.

6.1 MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?

For the purposes of CLBMON-58 this management question has been answered. All five expected species have been documented using the drawdown zone and adjacent upland habitat of Kinbasket Reservoir (Table 5-2). The most commonly occurring species are Western Toad, Columbia Spotted Frog and Common Garter Snake. These three species are widespread across B.C. (Matsuda et al. 2006) and are locally abundant at most of the monitoring locations. The most productive sites in Kinbasket Reservoir are Bush Arm MM 79 marshes, Valemount Peatland and Ptarmigan Creek (Figure 5-22). In certain years, the Bush Arm Causeway is also productive.

There are historical records of Wood Frog (*Lithobates sylvaticus*) from the drawdown zone of Kinbasket Reservoir, but this species has not been observed during field work for this or other studies (e.g., CLBMON-37, 10, 9, and 61). The currently understood range of Wood Frog (Matsuda et al. 2006) may not overlap the drawdown zone of Kinbasket Reservoir. Similarly, the Pacific Chorus Frog (*Pseudacris regilla*) has not been documented from the drawdown zone of Kinbasket Reservoir during field work for CLBMON-37 or 58 and it is assumed not to occur in the study area.

Because this question is considered answered, it should not be included in future iterations of CLBMON-58.

6.2 MQ2: What is the abundance, diversity, and productivity (reproduction) of amphibians and reptiles utilizing the drawdown zone and how do these vary within and between years?

6.2.1 Amphibian Abundance, Diversity and Productivity

Amphibian abundances (detection rates) vary from year to year and in general, there are more detections in the spring than in the summer or early fall (Figure 5-13). Spring surveys coincide with the peak of the breeding season when most adults are migrating to and from breeding ponds and are therefore more conspicuous. This trend was apparent in all years and in particular, for Western Toad. The season variation observed in the drawdown zone may be similar to the seasonal variation associated with non-reservoir populations of toads and frogs, but this has not been studied.

Amphibian species diversity (i.e., the number of amphibian species) does not vary relative to year or season, but detection rates do (see previous section), which is not surprising. Amphibian populations naturally exhibit large degrees of variation with the number detected a function of current environmental conditions, overwinter survival, and predation pressure (Hansen et al. 2012). Some species (e.g., Long-toed Salamander) are often difficult to locate because they have an early breeding period and are inconspicuous during the remainder of the year (Wilkinson and Hanus 2002). Although Long-toed Salamanders have been documented from only a few locations, they are likely distributed throughout Kinbasket Reservoir and adjacent upland habitats, particularly in areas with suitable breeding habitat.

Amphibian productivity has not been explicitly studied in Kinbasket Reservoir. We currently know which amphibian species (Western Toads, Columbia Spotted

Frogs, and Long-toed Salamanders) use the DDZ for reproduction (inferring productivity) and data collected for two species (Western Toad and Columbia Spotted Frog) indicate that all life stages of this species (i.e., eggs, tadpoles, toadlets, subadults, and adults) use habitats in the drawdown zone. However, too few data on other species of amphibians exist to discuss how reservoir operations might affect their productivity. To better assess the variation in amphibian productivity across time, increased effort is required to measure reproductive success and survivorship of eggs and tadpoles of pond-breeding amphibians at various elevations in the drawdown zone. This would require intensive site-specific monitoring of ponds used by pond-breeding amphibians, particularly Western Toads and Columbia Spotted Frogs, to determine their productivity and survival in various habitats in the drawdown zone.

Qualitatively, it appears that the productivity of both Western Toad and Columbia Spotted Frog is consistent between years (Figure 5-13), as egg masses and adults have been repeatedly detected at the same pond locations each year (e.g., Ptarmigan Creek, various locations in the Valemount Peatland, and KM 79). Further, in the absence of a suitable control or baseline data from ponds outside of the drawdown zone of Kinbasket Reservoir, we cannot know for certain how productivity is affected by reservoir operations. Within year assessments of productivity are not relevant and are therefore not discussed.

6.2.2 Reptile Abundance, Diversity and Productivity

Reptile abundances (detection rates) vary annually and seasonally; however, small samples sizes limit our ability to discuss within-season trends.

Reptile species diversity consists of two species that occur in and adjacent to the drawdown zone of Kinbasket Reservoir. One species, Common Garter Snake has been observed annually using habitats in the drawdown zone (especially at Ptarmigan Creek). Western Terrestrial Garter Snakes have not been observed in the drawdown zone, but are known to occur in the upland habitats immediately adjacent to the drawdown zone. No other reptile species are expected to occur in the study area.

Reptile productivity is not readily assessed under CLBMON-58, largely because reptile productivity is not linked to the presence or absence of water. Reproduction occurs near overwintering sites (Garstka et al. 1982; Kromher 2004) which are likely outside of the DDZ (and this requires telemetry studies to locate the overwintering sites and verify reproductive behaviour; see Section 5.9.3). However, because of the value of DDZ habitats to pond-breeding amphibians, which snakes use as a primary food resource, reservoir operations could impact reptile populations. While it is relatively easy to measure direct productivity in captured female snakes (e.g., counting eggs internally in gravid females), it does not follow that females are necessarily using the DDZ in the same way foraging snakes are, since females generally do not feed as frequently during pregnancy (Tuttle and Gregory 2009). Assessing reptile productivity requires intensive studies using radiotelemetry and is well-suited to a graduate program. However, this also requires annual, not bi-annual studies. A radiotelemetry study could be implemented annually in Kinbasket Reservoir during field work for CLBMON-37 and 58.

6.3 MQ3: During what portion of their life history (e.g., breeding, foraging, and over-wintering) do amphibians and reptiles utilize the drawdown zone?

Our current understanding of the use of the drawdown zone by amphibians and reptiles is that anuran species use the DDZ to fulfill most of their life history stages (e.g., breeding and foraging), while others (e.g., Long-toed Salamander, garter snakes) appear to use the DDZ to fulfill specific stage (Table 6-1). We do not have enough data for Long-toed Salamanders or on both species of garter snake to determine how they are using the DDZ. Long-toed Salamanders are not always easy to detect, so their perceived use of the DDZ may be related to their cryptic nature and not necessarily to their absence from the DDZ. Use of the drawdown zone for overwintering is considered unlikely for four of the five species, but Columbia Spotted Frogs may overwinter in ponds in the drawdown zone. Water bodies deep enough that they do not freeze on the bottom are required for overwintering frog adults, juveniles and possibly larvae (Bull and Hayes 2002; Bull 2005). Freezing depth has not been assessed for ponds in the drawdown zone of Kinbasket Reservoir, but radio-tagged frogs could be monitored during winter to assess overwintering habits and is necessary to answer this part of Management Question 3.

Table 6-1: Observed life history activity of amphibian and reptile species in the drawdown zone of Kinbasket Reservoir

Species	Breeding	Foraging	Overwintering
Columbia Spotted Frog	Yes	Yes	Unknown
Western Toad	Yes	Yes	Unlikely
Long-toed Salamander	Yes	Likely	Unlikely
Western Terrestrial Garter Snake	Unknown	Yes	Unlikely
Common Garter Snake	Unknown	Likely	Unlikely

6.4 MQ4: Which habitats do reptiles and amphibians use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Many species of amphibians that occur in and adjacent to the drawdown zone depend on aquatic habitats to fulfill their life requisites (Duellman and Trueb 1986; Duellman 2007; Wells 2007). Reptiles, on the other hand, use habitats in the DDZ mainly for foraging because amphibians are their primary prey. The species of amphibians using the drawdown zone of Kinbasket Reservoir are all pond-breeders. In the spring these species migrate to ponds, breed, lay eggs, and then move into their spring and summer foraging habitat. Small, isolated wetlands can be critical to the persistence of amphibians that possess complex life cycles (Hopkins 2007). These habitat features are common in the drawdown zone of Kinbasket Reservoir and are affected on an annual basis to varying degrees depending on the elevation at which they are situated (Figure 5-20) and on reservoir operations (Figure 3-2). At present we have delineated pond and non-pond habitat for the drawdown zone and assessed how biotic and abiotic pond qualities are related to amphibian use and vary with respect to reservoir operations.

Pond depth has not been assessed for all ponds delineated, but amphibian observations occurred in water ranging from 2 to 20 cm and most observations were made within 100 cm of the shore line. Ponds delineated in the drawdown zone were typically vegetated with species such as *Potamogeton pusillus* (small pondweed), *Nuphar polysepala* (Rocky Mountain Pond-lily) *Potamogeton sp.* (unidentified species), *Sparganium angustifolium* (Narrow-leaved Bur-reed), *Myriophyllum spp.* (Eurasian Water-Milfoil/Siberian Water Milfoil), and *Equisetum fluviatile* (Swamp Horsetail). Ponds occurring at elevations < ~739 m ASL were typically unvegetated and can be characterizes as shallow ponds with fine organic sediment comprising the bottom substrate. These ponds were used only be Western Toad.

We correlated species presence with vegetation communities mapped in the drawdown zone (using vegetation communities classified under CLBMON-10), and measured the water chemistry of ponds with and without amphibians. Most species were found in the wetland-associated habitat types (swamp-horsetail, wool-grass–Pennsylvania buttercup, clover–oxeye daisy, and Kellogg's sedge) (see Section 5.3.4). Western Toads used a wider range of elevations (737–754 m ASL) than did Columbia Spotted Frogs (747–756 m ASL). This was especially noticeable at Bush Arm km 79, where each species appear to use entirely different portions of the DDZ for breeding. Western Toad and Columbia Spotted Frog presence in breeding ponds was dependent on vegetation community, pond size, and elevation to varying degrees (see Section 5.3.3); however, in general, both species used a wide range of pond sizes and tend to occupy most available habitat.

In general, amphibians tend to use breeding ponds that are small, shallow, and warm; the size of the ponds used is constrained by habitat availability in the drawdown zone. These ponds typically have high levels of dissolved oxygen and ponds used by Columbia Spotted Frogs tend to have higher per cent cover of aquatic macrophytes. Columbia Spotted Frog tends to be found at higher elevations, in wet habitats associated with the wool-grass–Pennsylvania buttercup vegetation community. In contrast, Western Toad tends to use a wide range of elevations and is most often present in drier habitats in association with the clover-oxeye daisy vegetation community. Ponds used by Western Toads for breeding were typically devoid of vegetation.

6.5 MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?

Direct impacts of reservoir operations on amphibians and reptiles have not been observed in the drawdown zone of Kinbasket Reservoir. We have observed desiccation at breeding ponds, but this is likely related to natural causes. Egg string and egg mass stranding has been observed at various locations in the drawdown zone (e.g., Bear Island in 2013; Figure 5-15) and is usually associated with decreasing hydroperiod at oviposition sites, which can be a major cause of death to developing embryos. This phenomenon is not unique to drawdown zones (e.g., Marco and Blaustein 1998). Local environmental conditions can influence the hydroperiod of breeding ponds and are likely confounding any potential reservoir effects that may be linked to egg mass stranding. The normal operating regime of Kinbasket Reservoir is to fill in the spring between April and June (Figure 3-2) and because this coincides with the egg-laying period for amphibians, it is unlikely that reservoir-caused desiccation is an issue.

Water physicochemical parameters measured in ponds in the drawdown zone suggest little evidence of an effect of dissolved oxygen, pH, water temperature, or conductivity on amphibian use or development (see Section 5.2). At certain areas (e.g., Bush Arm Causeway) the rapid decline of water temperatures following inundation (Figure 5-3A) likely influences tadpoles development to some degree (Crowder et al. 1998; Ultsch et al. 1999). Tadpoles in various stages of development are regularly documented at this location and are typically smaller than tadpoles at other sites. However, these tadpoles metamorphose into toadlets and migrate from their breeding ponds at around the same time as other toads suggesting the effects of temperature are relatively short-lived. For example, thousands of toadlets were observed at the Bush Arm Causeway and in the Valemount Peatland in early August 2013, suggesting little effect of temperature on the timing of metamorphosis.

Turbidity was visually assessed and was typically low (i.e., the water in the ponds sampled was clear). Turbidity was affected by the spring freshet in specific areas such as the Bush Arm Causeway, but it is not known if this affected amphibians. Moreover, inundation due to freshet is not related to reservoir operations and has been observed each year since 2008 and amphibians continue to return to and use the site for breeding. The spring freshet likely attenuates the changes observed in dissolved oxygen and water temperature observed at the Bush Arm Causeway (Figure 5-3A).

Reservoir operations do impact habitat through changes in availability of breeding and foraging habitat of amphibians and reptiles using the drawdown zone, both directly and indirectly (Figure 5-21 and Figure 5-23). Habitat availability varies by month and year relative to reservoir operations, and is a function of reservoir elevation (see Section 5.9). The number of amphibian and reptile observations often decreased as reservoir elevations increased, and at some sites, no species were documented in the later stages of summer when reservoir elevations were high. The seasonal changes in habitat availability affect the distribution of amphibians and the additive effects of annual displacement are currently unknown. Although inundation affects habitat availability directly, we observed only minor changes in water physicochemical parameters (Section 5.2) and all life stages of both species were observed during each year of study. Similarly, the constant year-to-year size and mass of adult Western Toads and Columbia Spotted Frogs (Figure 5-16) suggests that the size of the adult population is stable, which could be an indication of a healthy population (Deichmann et al. 2008). Because amphibians are persisting in the drawdown zone, we can speculate that the annual reduction of habitat availability does not dramatically effect local amphibian populations; however, we do not know if the populations are supressed relative to populations in non-reservoir habitats.

Habitat change may also be assessed in terms of changes in vegetation community. Assessing direct or indirect effects of vegetation community changes on amphibian and reptile populations can be accomplished by assessing habitat availability as a function of reservoir elevation (see MQ4, above) and through the use of vegetation community data obtained for other programs, such as CLBMON-10. This may prove to be quite valuable as Western Toad and Columbia Spotted Frog are associated with a few particular vegetation communities in the drawdown zone of Kinbasket Reservoir (Section 5.3.4). With respect to habitat type, data from CLBMON-10 should be used to determine if the habitats that amphibians and reptiles use change over time relative to reservoir operations. Hawkes et al. (2010) reported that the vegetation communities defined in the DDZ of Kinbasket Reservoir had not changed since 2007, at least not at the landscape scale, but that the composition of certain species and communities had changed. In particular, there has been an increase in vegetation species richness and per cent cover. These changes are believed to be related to reservoir operations (Hawkes et al. 2013), but it is not clear how they might affect reptile and amphibian populations over time.

6.6 MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?

Based on our observations over the last three years, there is no evidence that reservoir operations need to be adjusted to minimize the impacts on amphibians and reptiles. However, this is based only on data collected during the snow-free period and have no data with which to draw any conclusions regarding reservoir operations and the suitability of overwintering pond habitats for Columbia Spotted Frogs, nor do we know if any other species overwinter in the drawdown zone. This assessment applies only to Western Toad and Columbia Spotted Frog, for which our data were robust for ecological analyses. We do not currently have sufficient data to provide an assessment for Long-toed Salamander.

The limited amount of breeding habitat available in the drawdown zone should be considered relative to reservoir operations. Some ponds at lower elevations in Bush Arm are used by Western Toads for breeding (e.g., breeding ponds at Bear Island). These ponds are situated between 735 and 744 m ASL, and although they comprise a small number of ponds (Figure 5-20), they could be considered for protection to minimize impacts to toads. By protection, we suggest that delaying the inundation of elevations between 735 and 736 m ASL into late June would likely afford enough time for eggs to hatch into tadpoles and provide enough time for the tadpoles to grow in size such that the effects of inundation would be minimized.

The variable manner in which Kinbasket Reservoir in managed creates somewhat of a conundrum with respect to this management question. In general, the operation of Kinbasket Reservoir in 2011, 2012, and 2013 does not appear to have had a direct effect on amphibians and reptiles using the drawdown zone. However, because reservoir operation changes from year to year, it is difficult to identify any one management approach to consider making adjustments to. In spring and summer amphibians use habitats in the drawdown zone for breeding and foraging. The development of eggs into larvae, and those larvae into froglets or toadlets occurs over the summer, with young-of-the-year Western Toads migrating from their natal ponds in early to mid-August. Columbia Spotted Frogs overwinter in ponds and they may or may not overwinter in ponds in the drawdown zone.

6.7 MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?

There are currently no plans to implement physical works in the drawdown zone of Kinbasket Reservoir (with the exception of CLBWORKS-1, which aims to revegetate portions of the drawdown zone). However, there are areas that could benefit from the development of physical works that are designed to offset the effects of reservoir operations on amphibian and reptile populations. This could be accomplished primarily by developing physical works that protect important habitats from becoming inundated during the spring and summer months.

The construction of dykes (for example) could be used to protect habitats at Bear Island and KM 79 from inundation. Additionally, habitat for amphibians and reptiles could either be created or improved in specific areas of the drawdown zone. Hawkes and Fenneman (2011) describe a successful project that created habitat in the drawdown zone of a hydroelectric reservoir. Similarly, Hawkes and Howard (2012) developed several wildlife enhancement prescriptions for Arrow Lakes Reservoir which could be applied to areas of Kinbasket Reservoir in order to improve overall habitat suitability.

The removal of wood debris from wetland and pond habitat would benefit amphibians by directly improving habitat suitability in those ponds. The accumulation of wood debris can be detrimental to wetlands for several reasons. First, wood debris displaces existing terrestrial and aquatic vegetation as it accumulates over time affecting the surface and the bottom of ponds. Second, vertical and lateral movement of large wood debris due to fluctuating water levels can cause mechanical damage to established vegetation. Third, the leachate from the large accumulations of wood material can be highly coloured, acidic, of very high oxygen demand, and toxic to aquatic life (Tao et al. 2005). Consistent with these effects, neither Western Toad nor Columbia Spotted Frog was detected in ponds characterised by woody debris accumulation (Figure 5-7). Following the installation of Mica units 5 and 6, the frequency of inundation at higher elevations (i.e., >751 m ASL) is predicted to increase. A parallel increase in the accumulation of wood debris in wetlands and ponds is therefore expected. Wood debris removal would mitigate the effects of wood debris on wetland function, productivity, and habitat suitability.

6.8 MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?

Portions of the DDZ of Kinbasket Reservoir were revegetated using a variety of techniques, including live staking, seeding, seedlings and fertilizers (CLBWORKS-1). The revegetation program did not include improvements to amphibian and reptile habitat suitability as a primary objective. Given the failure of the revegetation program in Kinbasket Reservoir (Hawkes et al. 2013) there is no evidence to support an effect of revegetation on the availability and use of habitat in the drawdown zone by amphibians and reptiles.

6.9 MQ9: Do physical works projects implemented during the course of this monitoring program increase the abundance of amphibians and reptiles abundance, diversity, or productivity?

See Section 6.7.

6.10 MQ10: Do increased reservoir levels in Kinbasket Reservoir during the summer months resulting from the installation of Mica 5 and 6 negatively impact amphibian populations in the drawdown zone through increased larval mortality or delayed development?

For both Western Toad and Columbia Spotted Frog our data do not support a qualitative assessment of increased larval mortality rates or delayed development. For example, we know that all life stages of Western Toad and

Columbia Spotted Frog use the drawdown zone at different times during the active season (April through September). In all years of study, we have documented adult toads and frogs and eggs at the same locations (e.g., Valemount Peatland, Bear Island, Bush Arm Causeway, and Ptarmigan Creek). Metamorph toadlets have also been documented emerging from the same drawdown zone locations in multiple years, which provides an indication of how this species uses (and possibly relies upon) habitats within the drawdown zone to fulfill its life requisites; however, assessing mortality rates is not possible using the data collected to date. We have not observed juvenile Columbia Spotted Frogs emerging from the breeding ponds, but the small size of individuals observed in subsequent sample years suggests that eggs hatched the previous year and some juveniles overwintered successfully.

Our inability to quantify mortality rates is related to our inability to track individual egg masses over time because of changes in reservoir elevations, which precludes tracking egg strings or egg masses at different elevations from the time of deposition to metamorphosis. As such, stage-specific (i.e., hatching rates or proportion of tadpoles that metamorphose) mortality rates are unlikely to be accurately measured or reported during this study.

The risk analysis (Figure 5-12) suggests that current or future reservoir operations may not adversely affect larval development unless inundation occurs early in developmental cycle of amphibians (i.e., during the egg stage or very early in the larval development stage), which generally lasts through early June (Figure 5-12). The data collected to date suggest that the only area where there may be potential impacts to reproductive success or larval development is in ponds situated in the lower elevations of the drawdown zone at Bear Island, which are used by Western Toads and inundated earlier in the year than most ponds. However, we are not able to quantify the magnitude of this impact with existing data.

Based on reservoir operations between 2011 and 2013, an increase in reservoir elevation of 0.6 m is unlikely to have a large effect on amphibian and reptile populations that use the drawdown zone of Kinbasket Reservoir. This conclusion is somewhat confounded by the fact that Kinbasket Reservoir was surcharged (i.e., filled beyond the normal maximum) in 2012 and 2013, which is atypical (Figure 3-2 and Figure 5-11). Considering the maximum reservoir elevations achieved since 1978 we see that without units 5 and 6 at Mica (i.e., the period 1978 to 2013) Kinbasket Reservoir was surcharged seven times or ~19 per cent of the time. Adding 60 cm to each year Ito simulate the addition of units 5 and 6 at Mica Dam) increases the frequency of surcharge to 36 per cent, or 13 of the 36 years considered (Figure 6-1).

However, the anticipated increase in reservoir surcharging is not likely to directly affect amphibian populations. Important habitats will be impacted, particularly those ponds situated above 751 m ASL (which represents ~64 per cent of all ponds mapped in the drawdown zone; Figure 5-20). Impacts will be mainly related to changes in habitat suitability associated with wood deposition and scouring, erosion, and changes to aquatic and riparian vegetation communities (see Table 6-2). The effects of these changes are not likely to result in immediate effects to habitat quality, and are likely to be studied directly by CLBMON-61. Data from that program should be examined to determine how wetland productivity is affected as a result of the installation of units 5 and 6 at Mica Dam.

The reported changes should also be put in the context of impacts to amphibian populations using those habitats in the drawdown zone.

Surcharge may represent the worst case scenario with respect to reservoir management, mainly because of the potential effects on wetland habitat suitability. Effects on amphibians resulting from surcharge also need to be considered relative to the date at which maximum reservoir elevations were achieved. Between 1978 and 2013, Kinbasket Reservoir achieved full pool between August, 2 (1987) and October 29 (2003). The average date of full pool was August 25. In years when Kinbasket was surcharged, the reservoir reached full pool between August 2 (2007) October 2 (1997) with an average fill date of September 1. By this time (i.e., August 25 or September 1), amphibian eggs have hatched and free swimming tadpoles are either beginning to metamorphose or have fully transformed to froglets and toadlets. This further suggests that reservoir elevations and the current timing of full pool are not likely to directly impact amphibian populations using habitats in the drawdown zone of Kinbasket Reservoir. However, as stated previously, we do not know if the populations of Columbia Spotted Frogs and Western Toads are supressed relative to non-reservoir populations, and we won't know that unless suitable non-reservoir populations are studied.

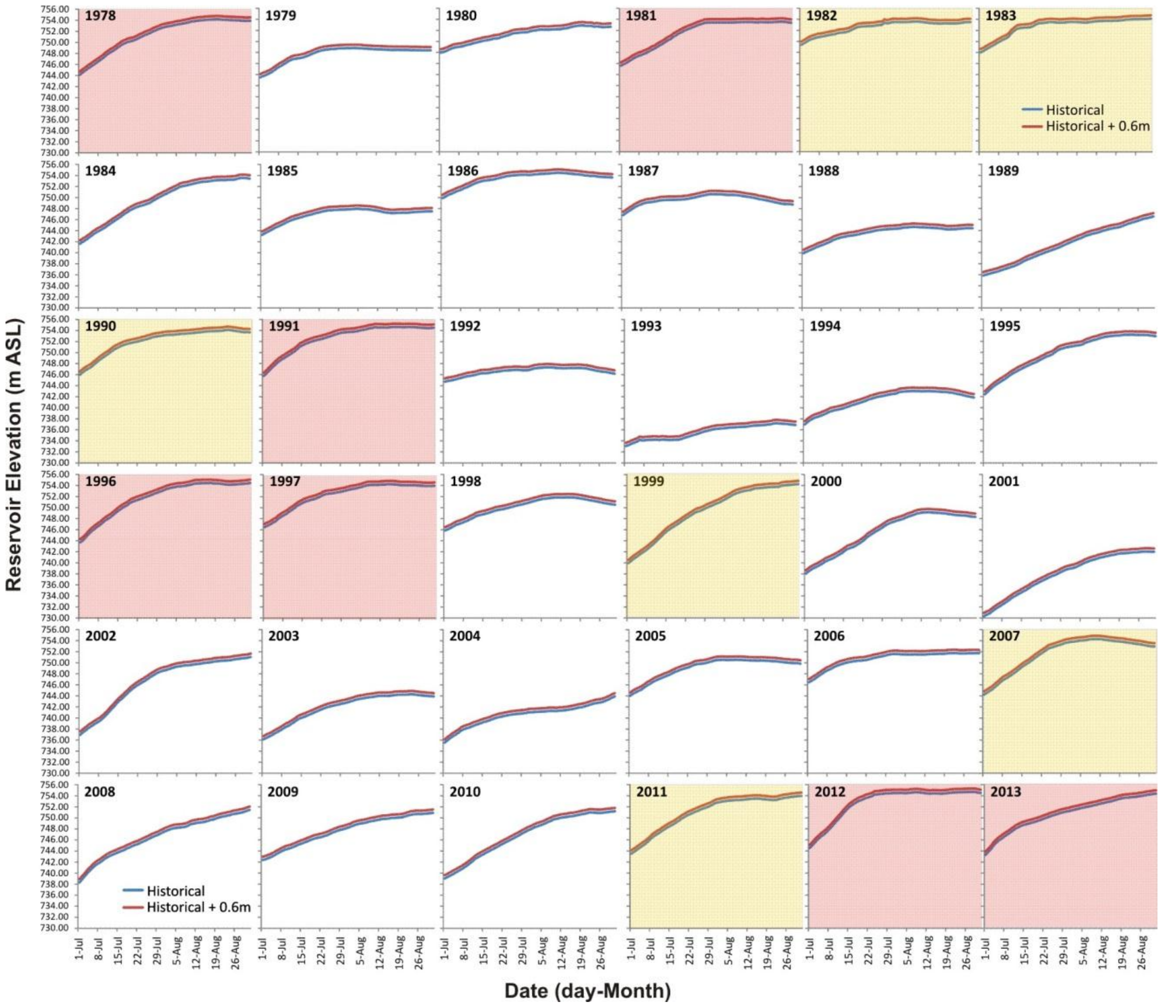

Figure 6-1: Historical reservoir elevations measured in July and August 1978 to 2013, with and without 60 cm added to simulate the addition of units 5 and 6 at Mica Dam. Red shading indicates the years Kinbasket was filled to elevations > 754.38 m ASL (i.e., surcharged). Yellow shading indicates the additional years when Kinbasket would have been surcharged if the reservoir was filled 60 cm more than the historical maximums

If the timing of full pool or surcharge changed relative to historical data, and in particular if reservoir filling occurred earlier in the summer (i.e., July) there could be impacts to various life stages of amphibians using the drawdown zone including changes to egg and larval development, increased predatory pressure, and potential changes to habitat suitability resulting from wood debris transport or changes to vegetation and physicochemical attributes (Table 6-2). Given that reservoir elevations are predicted to increase in the summer months, achieving full pool in July is not recommended and maximum reservoir elevations should be targeted for the current average date of August 25. This will ensure that amphibians using the drawdown zone, particularly those in ponds >751 m ASL, will have enough time to develop prior to inundation.

Table 6-2: Examples of potential effects on amphibians resulting from Kinbasket Reservoir elevations exceeding the normal maximum operating elevation by 0.6 m

Potential Impact	Effect on Amphibians	Life Stage
Increased rates of erosion	• Increased turbidity leading to reduced water quality, which could affect larval food resources and larval development • Increased sediment deposition leading to a reduction in water depth, pond area, water temperature, and overall pond suitability (as it relates to breeding)	• Egg masses • Larvae
Changes in vegetation composition and structure at upper elevations	• Reduced habitat suitability near the periphery of breeding habitats (e.g., reduced cover), which could increase rates of predation	• Adults • Sub-adults • Juveniles • Metamorphs
Changes in coarse woody debris conditions near or outside of the DDZ	• Changes to microhabitat conditions (e.g., reduced cover). Indirect effects to foraging opportunities dues to effects on insect communities	• Adults • Sub-adults • Juveniles • Metamorphs
Changes to aquatic characteristics (e.g., DO, conductivity, temperature, pH, etc.) in ponds near the periphery of the DDZ (or those that are not inundated under normal operating conditions	• Potential effects to egg and larval development. • Potential effects to overall suitability of the pond for breeding leading to pond-abandonment	• All life stages
Changes to the biological communities of ponds (e.g., introduction of fish, changes in semi-aquatic and aquatic macrophytes)	• Potential for increased predation risk by fish on amphibian eggs and larvae • Potential changes to available food resources required by developing amphibians	• Egg masses • Larvae

Wood debris is likely to have the greatest impact on amphibian habitat in the drawdown zone. Between 2007 and 2013, a large portion of Pond 12 in the Valemount Peatland was covered by wood debris (Figure 6-2). In 2007, the area of Pond 12 was approximately 0.83 ha. Based on 2012 imagery, the total pond area was 0.72 ha, amounting to a reduction of 0.11 ha. While this may seem trivial, this represents a one per cent loss of amphibian habitat in one of the most important ponds in the drawdown zone (Figure 5-22). With only 9.59 ha of habitat mapped, this could represent a significant loss. The total volume of wood debris that has accumulated in this pond is estimated to be ~8,000 m^3. A similar situation occurred at the Bush Arm Causeway. In this case, habitats that were available in 2007 (~ 0.2 ha) were not available between 2007 and 2012 (Figure 6-2). In 2013, much of the wood debris that had accumulated at this location had disappeared (V. Hawkes, pers. obs.), likely as a result of the 2012 surcharge that would have floated the wood debris to another location (or it was collected as part of the wood debris management plan). Hawkes et al (2013) reported that the driftwood vegetation community type had increased from 25.92 to 47.86 ha between 2007 and 2012, representing a significant increase in the accumulation of wood debris in the drawdown zone. As amphibians are not found to use ponds characterised by wood debris (the DR community in Figure 5-7), it is logical that continued accumulations in the drawdown zone pose a significant threat to amphibian habitats over time.

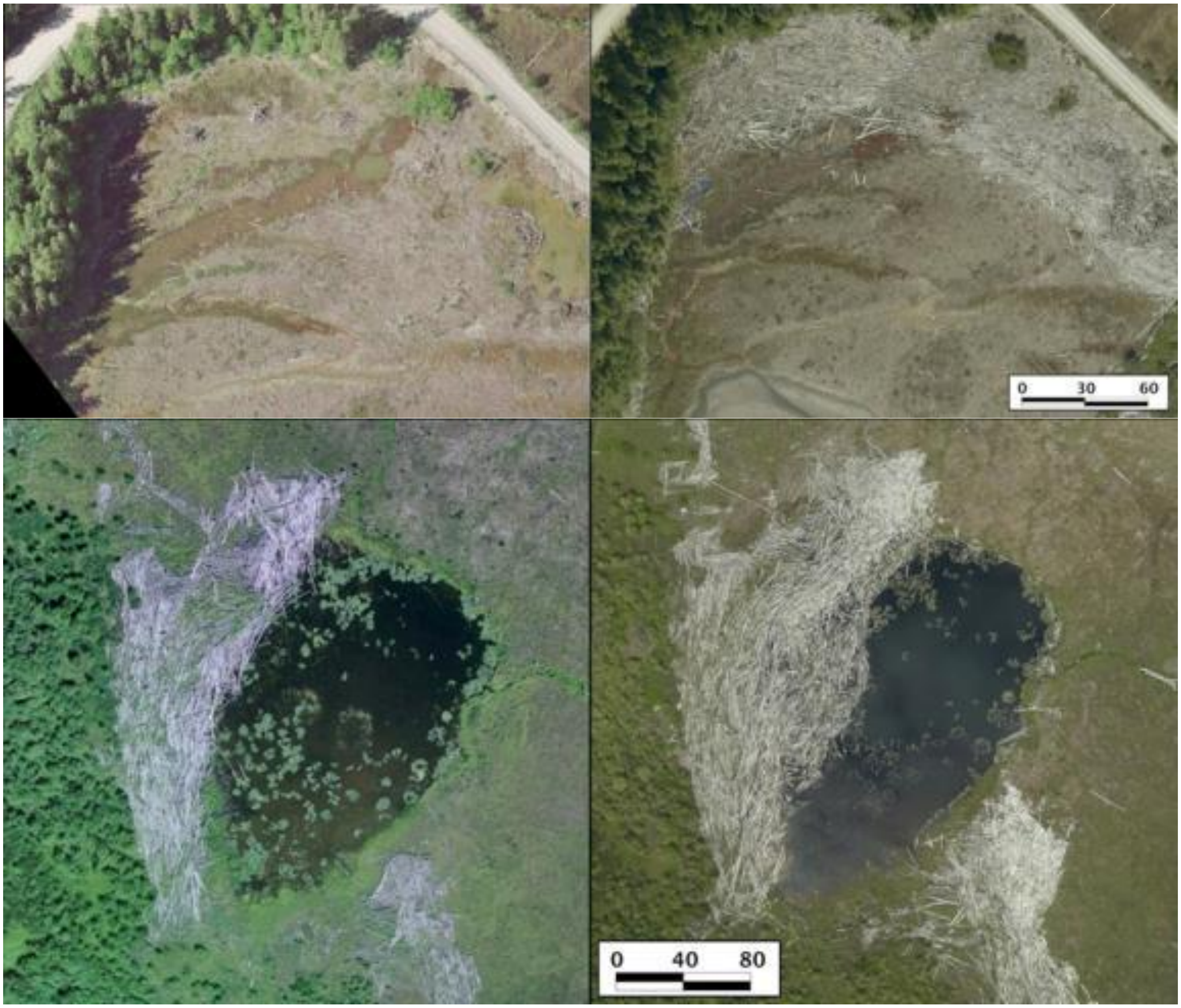

Figure 6-2: Accumulation of wood debris at the Bush Arm Causeway (above) and in pond 12 in Valemount Peatland (below) over a 5-year period (2007 to 2012, left to right). From Adama et al. (2013)

As previously mentioned, garter snake species are unlikely to be directly affected by increased reservoir elevations resulting from the installation of units 5 and 6 at Mica Dam, but could be directly affected if the abundance of primary food resources changes significantly (e.g., decrease in amphibians). Garter snakes are typically quite plastic in their use of habitat and therefore likely move in response to changes in habitat, food sources, basking locations, etc. What is unknown, and unlikely to be determined during this study due to the lack of radiotelemetry, is how energetically expensive these additional movements may be to snakes that have to follow amphibian food sources out of the drawdown zone. Radiotelemetry studies would also help elucidate the location of reptile overwintering sites, which may occur in the drawdown zone of Kinbasket Reservoir.

6.11 Management Questions - Summary

Our ability to address each of the management questions is summarized below (Table 6-3). The methods used are appropriate for collecting data that can be used to answer certain questions. For others, a different approach is required. For example, to answer questions regarding overwinter habitat use by amphibians and reptiles and to determine exactly how snakes are using the drawdown zone in all seasons, a telemetry study is required. Continued monitoring of amphibian and reptile populations in the drawdown zone should provide the necessary information to answer most management questions provided that new methods are used in subsequent years (i.e., beginning in 2014). To be sure we can answer some of the questions, recommended modifications to CLBMON-58 are provided below.

Table 6-3: Relationships between management questions (MQs), methods and results, Sources of Uncertainty, and the future of project CLBMON-58

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
1	Yes	Data collected since 2008 have resulted in the documentation of all expected species in the drawdown zone	• Annual sampling • Increased frequency of sampling (i.e., annually)	• Natural annual population variation • Inconspicuous species • Bi-annual sampling • Variable reservoir operations
2	Partially	4 years of site occupancy and detection rates data. Productivity estimated for some species	• Intensive productivity data collection for ANBO & RALU • Annual sampling for select amphibians • Constrain study to Revelstoke Reach and Burton Creek • Add other sites as physical works are implemented	• Natural annual population variation • Unknown rate of immigration may confound productivity estimates • Inconspicuous species • Mortality difficult to assess • Bi-annual sampling • Variable reservoir operations
3	Partially	4 years of site occupancy data across multiple sites and seasons	• Telemetry studies on Western Toads to assess overwinter habitat use. This may only need to occur once to determine whether this species is using habitats in the drawdown zone to overwinter	• Natural annual population variation • Inconspicuous species • Lack of knowledge regarding the use of the drawdown zone in the winter • Variable reservoir operations
4	Probably	3 years of macro and micro habitat data collection	• Reduce the number of monitoring sites • Focus on Western Toad and Columbia Spotted Frog • Telemetry study on Western Toads to assess habitat use • Re-evaluate existing habitat mapping and its relevance to amphibians and reptiles	• Habitat mapping is required at a scale relevant to amphibians and reptiles • Variable reservoir operations

MQ	Able to Address MQ?	Scope		Sources of Uncertainty
		Current supporting results	Suggested modifications to methods where applicable	
5	Maybe	4 years of data collected on the occurrence and distribution of amphibians and reptiles in the drawdown zone	• None	• Natural annual population variation • Variable reservoir operations • Habitat mapping is required at a scale relevant to amphibians and reptiles
6	Possibly	N/A	• Restrict reservoir elevations for one year to elevations < 751 m ASL to determine whether doing so alters the use of the drawdown zone by amphibians and reptiles.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • Lack of experimentation to assess how varying the time of inundation correlates to the use of the drawdown zone by amphibians and reptiles
7	Not at this time	N/A	• Implement physical works	• Physical works have not been implemented. Until they are we cannot answer this question.
8	Not at this time	N/A	• Ensure wetland-associated plants are included in the planting prescriptions associated with proposed and potential physical works.	• Revegetation of the drawdown zone has not been done in a replicated manner nor were the prescriptions designed to enhance amphibian and reptile habitat. Wetland-related plants would need to be planted to benefit amphibians and reptiles. Revegetation work is not applicable to this study.
9	Not at this time	N/A	• Implement physical works	• Physical works have not been implemented. Until they are we cannot answer this question.
10	Partially	Maximum reservoir elevations documented between 1978 and 2013 indicate that the average full pool date is August 25. At this time amphibians should be migrating out of the breeding ponds (Western Toads) or moving to overwintering sites in the drawdown zone of adjacent habitats (Columbia Spotted Frogs). This suggests that increasing reservoir elevations by 60 cm in the summer months should not directly impact amphibians. However, important habitats could be impacted.	• Use radiotelemetry to determine where Western Toads overwinter, whether Columbia Spotted Frogs overwinter in ponds in the drawdown zone, and to understand garter snake use of the drawdown zone in all seasons.	• Variable reservoir operations • Reservoir operations that result in complete inundation of the drawdown zone to elevations of ~754.38 m ASL • It is not clear if surcharge can be used as proxy for increasing the reservoir by 60 cm in the summer months.

7.0 RECOMMENDATIONS

The objective of CLBMON-58 is to monitor trends in amphibian and reptile populations (relative abundance, detection rates and productivity), determine the impact of reservoir operations on amphibians and reptiles (especially related to the impacts of Mica 5/6), determine their habitat use, and assess the impacts of any revegetation and physical works on species that use habitats within the drawdown zone of Kinbasket Reservoir.

In 2015, we will continue to monitor amphibian and reptile populations in the DDZ using the methods applied in previous years. Recommendations are made regarding how amphibians are sampled in the drawdown zone and regarding reservoir operations:

Sampling

1. Include a telemetry study on Western Toads, Columbia Spotted Frog, and Common Garter Snakes for a minimum of one year. This will provide valuable information on the use of the drawdown zone by these species and will remove uncertainty as to whether the drawdown zone provides overwintering habitat. Sample size would not have to be large; the objectives of the telemetry study would be to determine how these species interact with habitat in the drawdown zone of a seasonal basis and whether these species are using habitats in the drawdown zone for overwintering. Our current understanding of habitat use is limited to the active season between spring and fall. As such any correlation between reservoir operations and habitat use is limited to those operations observed between April and September. The relative effects of reservoir operations at any other time of the year are based on speculation. Radiotelemetry will help determine:

- how snakes position themselves relative to reservoir operations;
- what time of year they are most likely to use the drawdown zone;
- if amphibians comprise most of their diet (as suggested in Boyle 2012);
- where snakes are overwintering; and
- where Columbia Spotted Frogs are overwintering.
- how adult toads use the drawdown zone (at what time of the year) and whether they are returning to the same breeding ponds each year.

Without this information, it will not be possible to determine what the effects of normal or altered reservoir operations will be on amphibians and reptiles that use the drawdown zone of Kinbasket Reservoir.

Reservoir Operations

1. The inundation of elevations between ~735 and 754 m ASL should occur on or as close to the historical date calculated for the period 1978 to 2013 as possible. Kinbasket Reservoir was created ~ 37 years ago and although the operation of the reservoir has varied from year to year, amphibians continue to use the drawdown zone. If the timing, frequency, or duration of inundation of habitats between ~735 and 755 m ASL changes and amphibians no longer use those habitats for breeding, it may be easier to determine that reservoir operations are directly affecting amphibians.

2. Given that reservoir elevations are predicted to increase in the summer months as a result of the installation of units 5 and 6 at Mica Dam, achieving full pool in July is not recommended and maximum reservoir elevations should be targeted for the current average date of August 25. This will ensure that amphibians using the drawdown zone, particularly those in ponds >751 m ASL, will have enough time to develop prior to inundation

8.0 Additional Reporting Requirements

8.1 Data Deliverables

The following data deliverables have been or will be provided to BC Hydro and/or the B.C. Ministry of Environment to fulfill the Terms or Reference associated with CLBMON-58 or to fulfill the requirements of the wildlife sundry permit provided to LGL Limited for CLMON-37/58:

1.	Draft technical report	Submitted November 30, 2013
2.	300 word abstract	May 2014
3.	Revised sampling protocol	May 2014
4.	Copies of notes, maps, photos	May 2014
5.	Digital appendix (data)	May 2014

8.1.1 Data Provided to BC Hydro

An MS Access database containing all 2008 through 2013 data will be provided to BC Hydro with the submission of the final report. This database conforms to the standards established by the B.C. Ministry of Environment for wildlife species inventories.

8.1.2 Data Provided to the Ministry of Environment

Data collected under CLBMON-58 will be submitted to the B.C. Ministry of Environment Ecosystems Information Section as per the requirements of the Terms of Reference associated with CLBMON-37/58 and the Wildlife Sundry Permit issued to LGL Limited environmental research associates (78470-25) issued by the BC Ministry of Forests, Lands and Natural Resources.

8.2 SARA-listed Species

Location data for SARA-listed species and all other amphibians and reptiles observed in and adjacent to the drawdown zone will be provided to the B.C. Ministry of Environment as per the requirements of our wildlife sundry permit.

The only amphibian at risk documented in the drawdown zone of Kinbasket Reservoir is the Western Toad, which is a SARA Schedule 1 species of Special Concern. The Columbia Spotted Frog is a 'mid priority candidate' species for a COSEWIC status report (as of December 2013) candidate species. The status of this species remains not assessed and populations are considered to be stable throughout its range.

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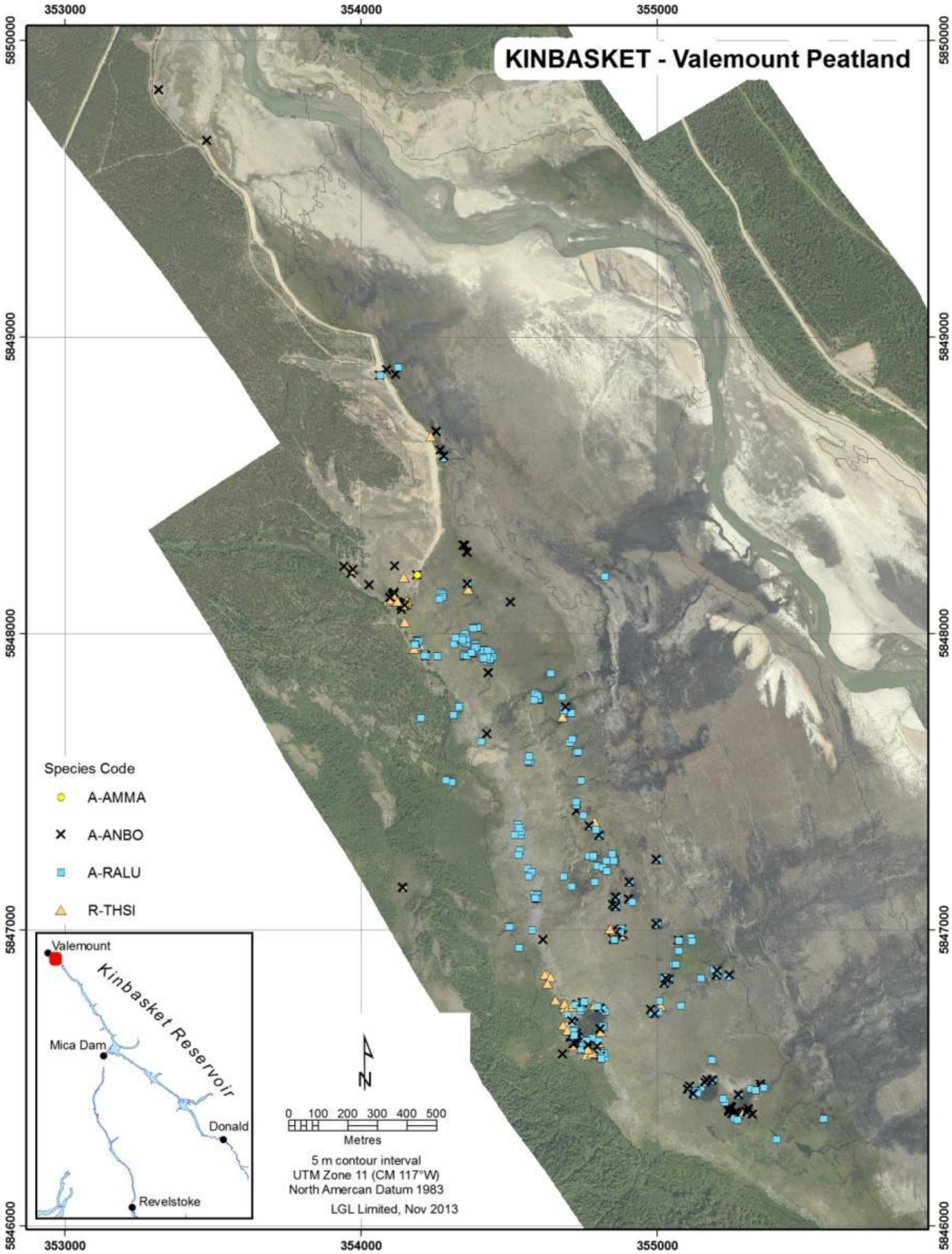
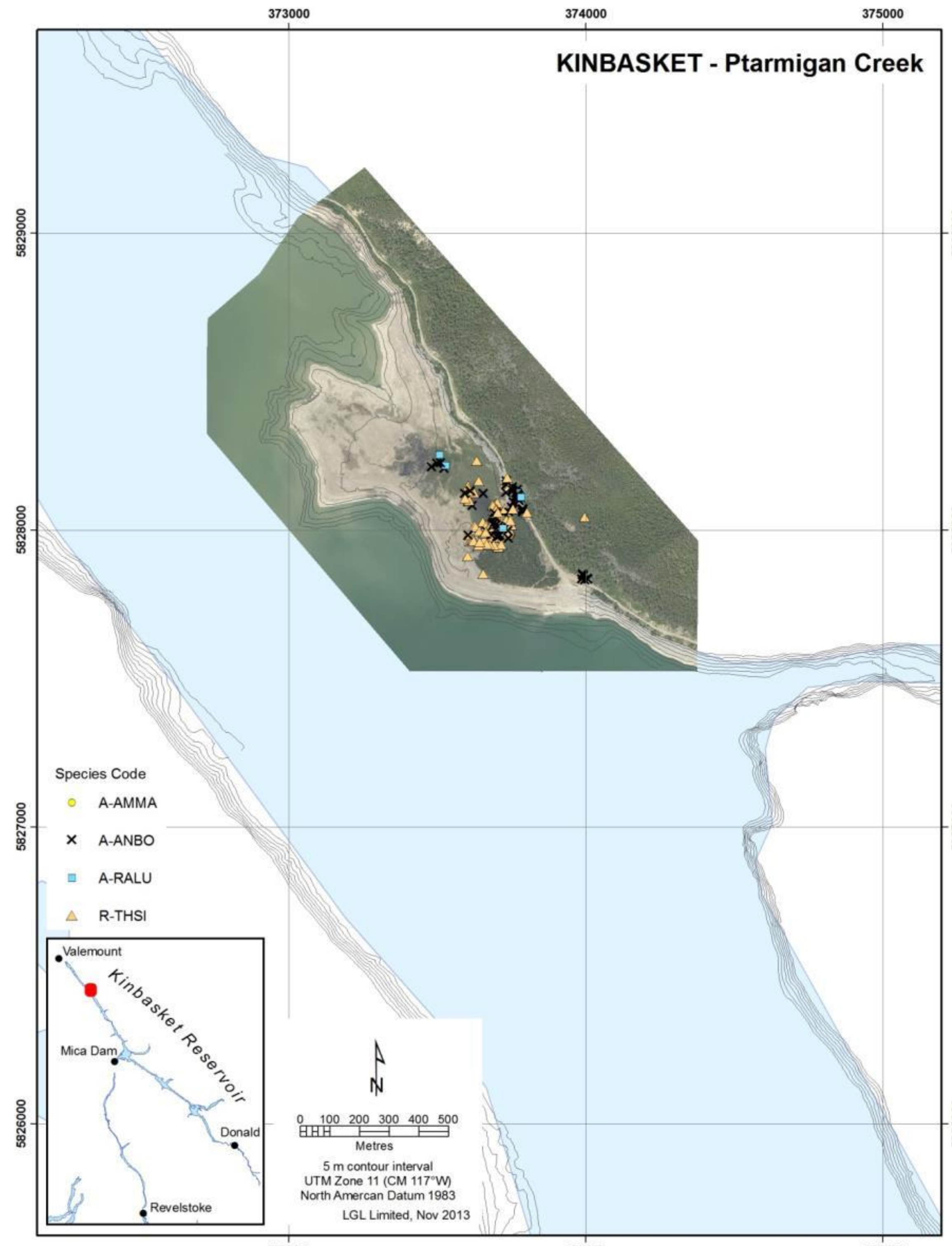
10.0 APPENDICES

Appendix 10-1: Survey locations and amphibian and reptile captures made in the drawdown zone of Kinbasket Reservoir, 2011, 2012, and 2013.

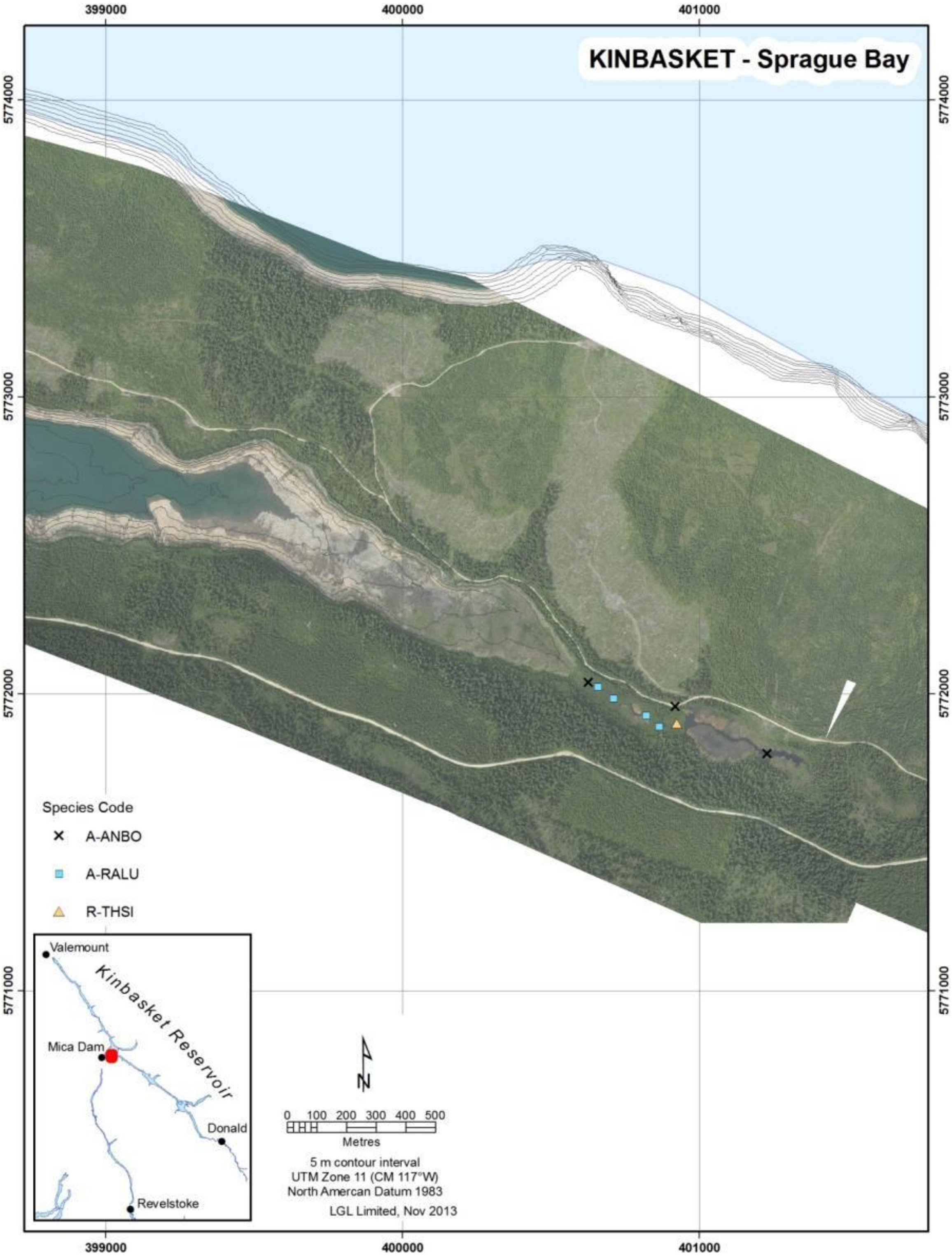
The following maps identify the survey locations visited in each reservoir and the species documented at those locations.



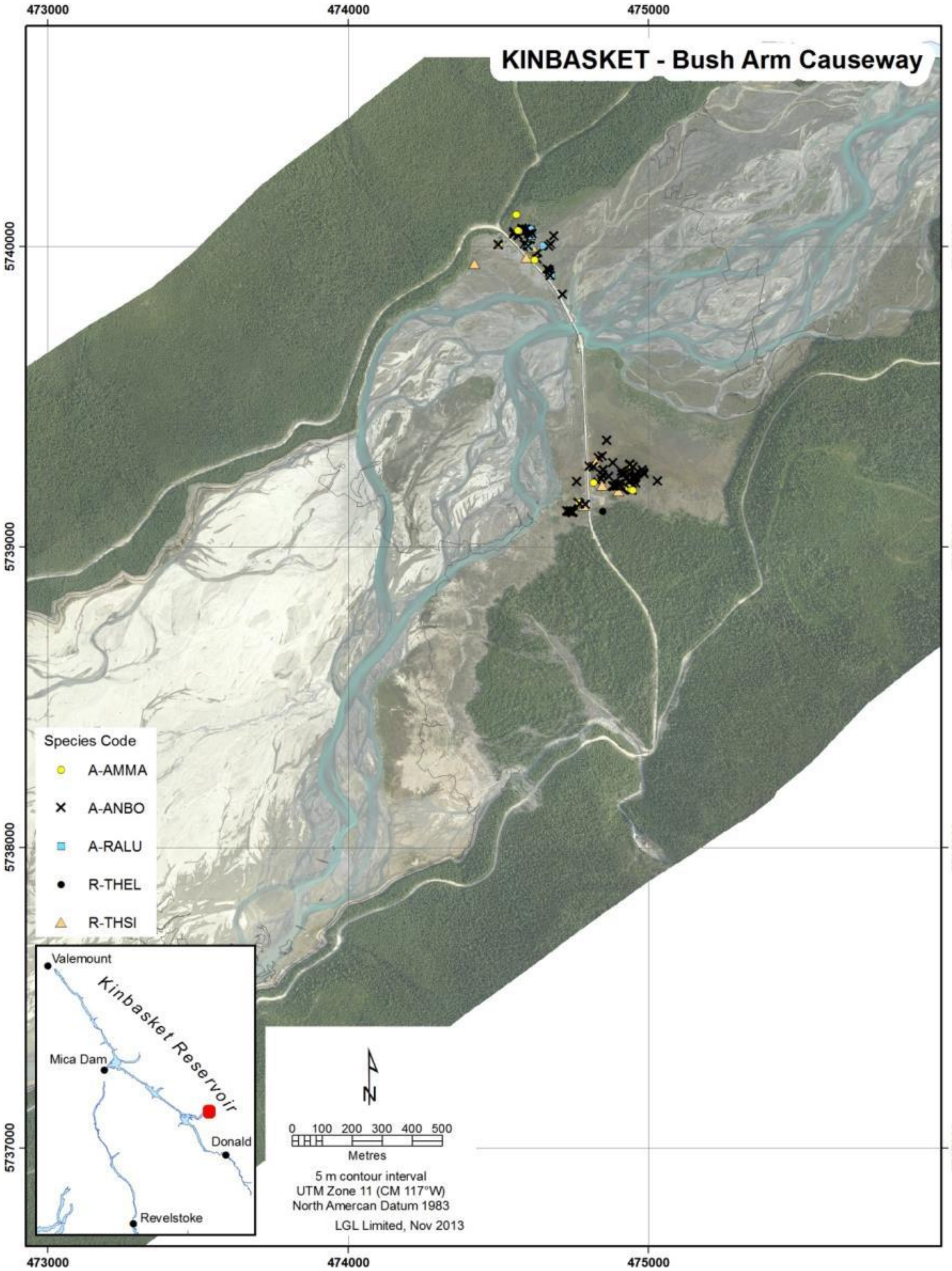
Map 10-1: **Species documented in the Valemount Peatland, Kinbasket Reservoir.** Species codes can be found in Table 1-1



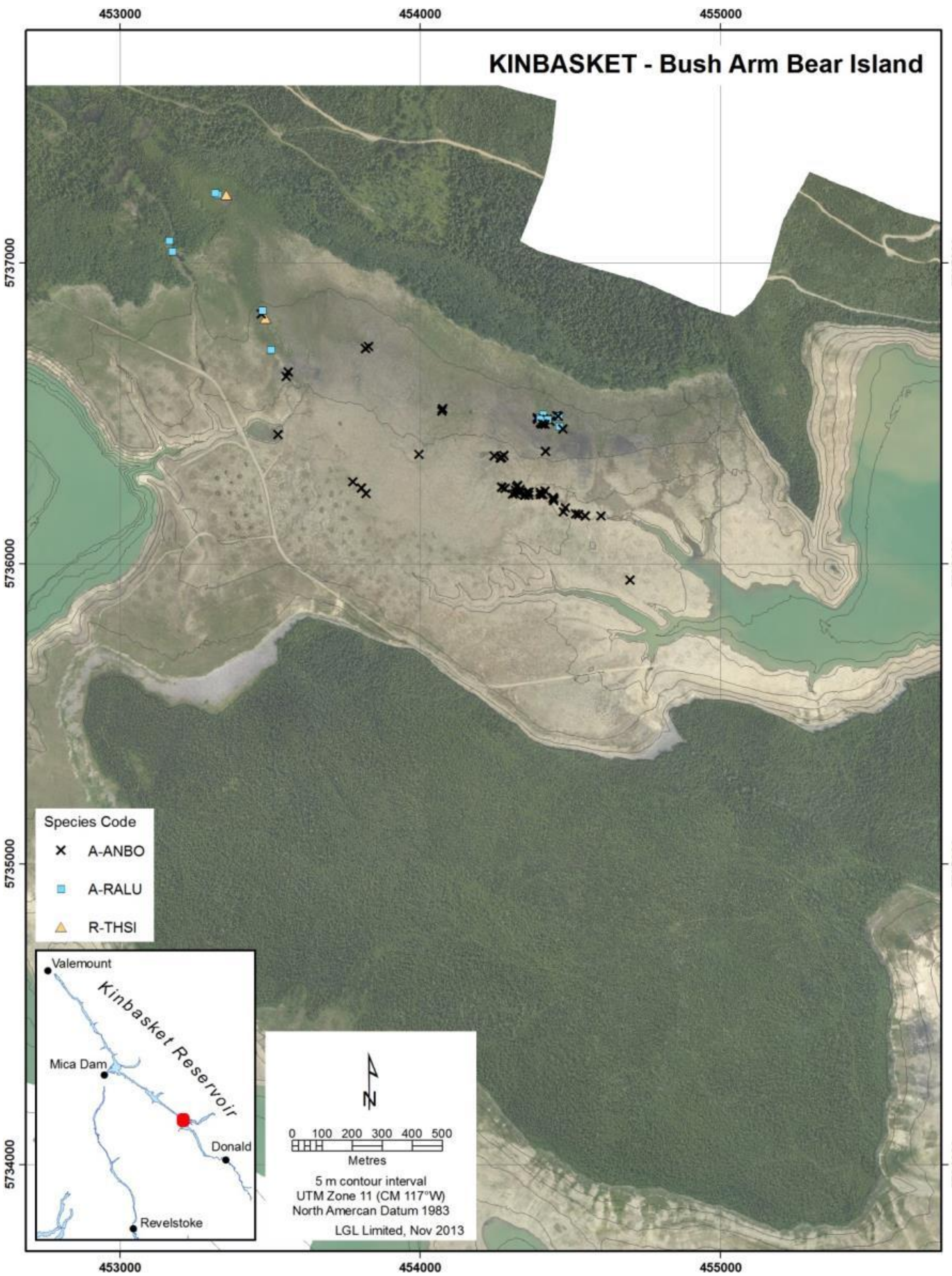
Map 10-2: Species documented at Ptarmigan Creek, Kinbasket Reservoir. Species codes can be found in Table 1-1



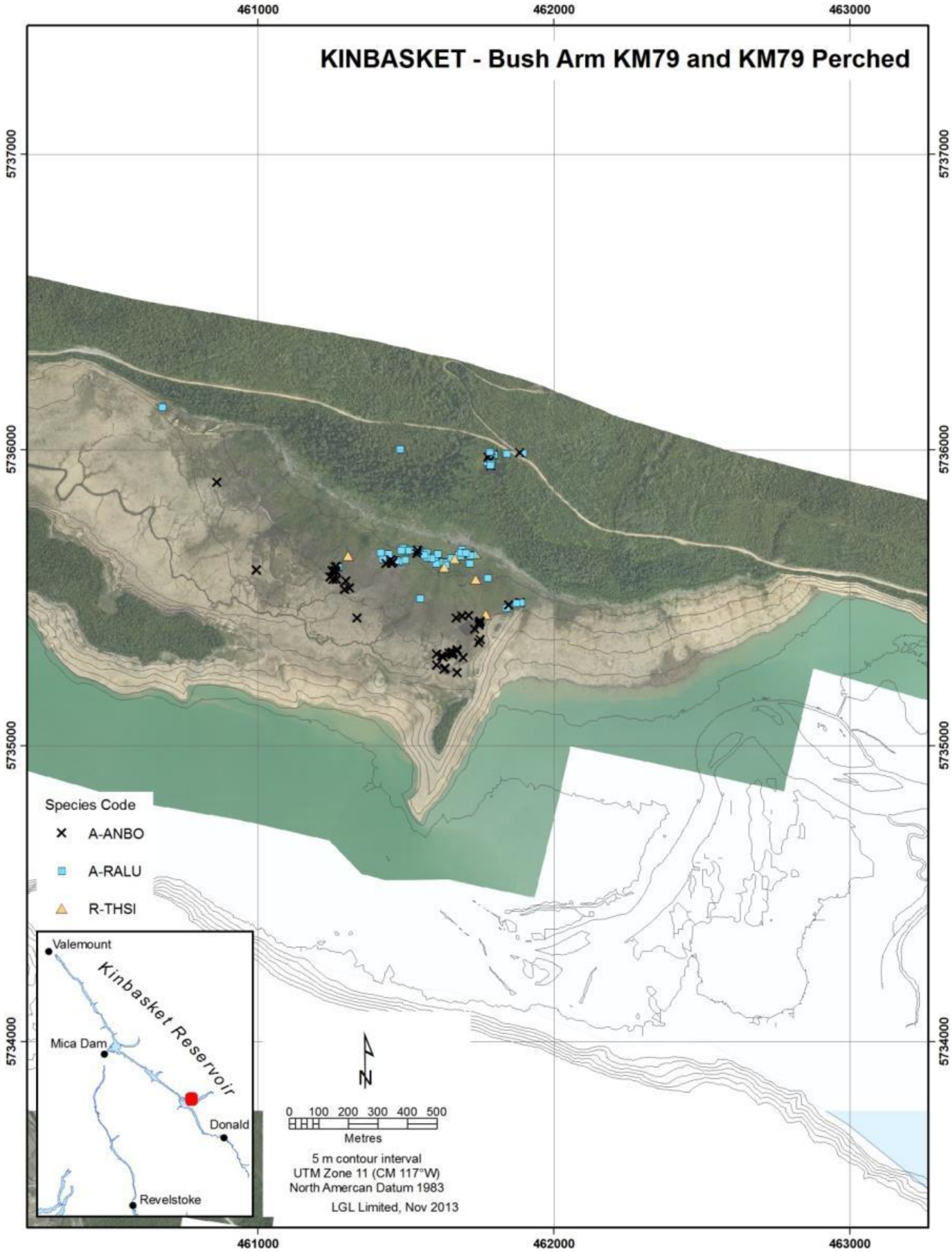
Map 10-3: **Species documented at Sprague Bay, Kinbasket Reservoir.** Species codes can be found in Table 1-1. Sprague Bay was not sampled in 2013



Map 10-4: Species documented at Bush Arm (Causeway), Kinbasket Reservoir. Species codes can be found in Table 1-1



Map 10-5: Species documented at Bear Island in Bush Arm, Kinbasket Reservoir. Species codes can be found in Table 1-1



Map 10-6: Species documented at km 79 marshes in Bush Arm, Kinbasket Reservoir. Species codes can be found in Table 1-1