Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIRS

Implementation Year 4

Reference: CLBMON-37

Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment

Study Period: 2012

LGL Limited
environmental research associates
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KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBMON-37
Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment




Final Report 2012

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From left to right: Valemount, BC, Common Garter Snake (*Thamnophis sirtalis)* © Krysia Tuttle; Bush Arm, BC, Western Toad (*Anaxyrus boreas*) tadpoles, Bush Arm, Kinbasket Reservoir, Western Toad, Revelstoke Reach, and Painted Turtle (*Chrysemys picta*) © Virgil C. Hawkes, LGL Limited.

EXECUTIVE SUMMARY

This year marked the fourth year of monitoring under CLBMON-37, a 10-year amphibian and reptile life history and habitat use monitoring study in the drawdown zones (DDZs) of Kinbasket and Arrow Lakes Reservoirs. Initiated in 2008, this study is intended 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. In 2011, an additional study CLBMON-58 was incorporated to specifically address 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.

In 2012, through a variety of survey methods (egg mass surveys, visual encounter surveys, auditory surveys, pitfall traps) we documented the presence of four amphibian and four reptile species in Kinbasket and Arrow Lakes Reservoirs. Western Toads (*Anaxyrus boreas*) and Columbia Spotted Frogs (*Rana luteiventris*) were the most commonly encountered species, usually in wetlands within reed canarygrass (*Phalaris arundinacea)* – lenticular sedge (*Carex lenticularis*) mesic habitats (Arrow), or clover-oxeye daisy (*Leucanthemum vulgare*), Kellogg's sedge or willow-sedge habitats (Kinbasket).

Most amphibian and reptile detections were distributed within an elevational band of 744 to 754 m ASL for Kinbasket Reservoir and 435 to 445 m ASL for Arrow Lakes Reservoir. 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 either DDZ was a function of seasonal habitat availability. Direct impacts from reservoir levels in 2012 were observed at all sites in Kinbasket and Arrow Lakes Reservoirs because water levels were higher earlier in the year and had inundated ponds that still had developing tadpoles. Western Toads (SARA species of Special Concern) were likely the most affected by early inundation, and very few metamorph toads were observed in either reservoir during July.

Monitoring will continue in 2014 as part of CLBMON-37 and then every second year until 2018, and will follow the same methods used in 2012. Data collection in Kinbasket Reservoir under CLBMON-58 will resume in 2013. Long data sets are required to address most of the management questions. The continued use of pitfall trapping at various monitoring locations (e.g., Valemount Peatland, Bush Arm) is suggested in order to increase the likelihood of documenting seasonal habitat use of the DDZ by inconspicuous species such as Long-toed Salamanders (*Ambystoma macrodactylum*).

The status of CLBMON-37 after Year 5 (2012) with respect to the management questions and management hypotheses is summarized below. See Section 2.2 for expanded null hypotheses. An "**X**" indicates that the management hypothesis is associated with a given management question.

Management Themes and Questions	Management Hypotheses								Year 5 (2012) Status
	1_A	1_B	1_C	1_D	1_E	2_A	2_B	2_C	
Life History and Habitat Use	X	X	X	X	X	X	X	X	These questions are being addressed, and more years of data will permit testing of the management hypotheses. We can begin to address most questions in 2014 using the temporal data set from 2008 to 2014.
MQ1: Which species of amphibians and reptiles occur (utilize habitat) within the drawdown zone and where do they occur?	X	X	X		X			X	Amphibian and reptile communities have been identified and mapped for each monitoring site in the DDZ of Kin and Arr Reservoirs from 2008 to 2012. The data collected to date provide a good understanding of the distribution of amphibians and reptiles in the drawdown zones (see Table 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?	X	X		X		X	X		Currently, large populations of certain species occur in each reservoir (Columbia Spotted Frogs, Western Toads for Kinbasket and Western Toads and Pacific Chorus Frogs in Arrow). In 2014, using the data from 2008 to 2014, we will be well positioned to report on the abundance, diversity and productivity of most amphibian populations.
MQ3: During what portion of their life history (e.g., breeding, foraging and overwintering) do amphibians and reptiles utilize the drawdown zone?	X	X	X	X	X				This question is being addressed each year for each species, and more years of data will provide a larger data set to statistically analyze. For most species, we will be able to address this question in 2014; for others (e.g., Long-toed Salamanders), more data are required.
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)?			X		X			X	We can correlate species presence to vegetation communities mapped in each drawdown zone, and have characterized the water chemistry of ponds with amphibians. As with the previous question, a longer time series of data is required, but starting in 2014, we will begin to test for differences in the spatial extent, structure and composition of vegetation communities associated with amphibian and reptile observations.
Reservoir Operations and Habitat Change	X	X	X	X	X				The results of sampling from 2008 to 2012 suggest there are subtle impacts on amphibian and reptile populations due to the temporal and spatial availability of habitats resulting from reservoir operations. More work is required to address these management questions and test the associated hypotheses, particularly with respect to amphibian and reptile productivity.
MQ5: How do reservoir operations influence or impact amphibians and reptiles directly (e.g., desiccation, inundation, predation) or indirectly through habitat changes?	X	X	X	X	X				Several years of data are required to validate our hypotheses (see section 2.2) regarding how the operating regime is related to the temporal and spatial habitat use and productivity of amphibian and reptile communities. Detailed studies that monitor ponds at various elevations of the drawdown zone across the period of activity (April–September) are required to address this management question.
MQ6: Can minor adjustments be made to reservoir operations to minimize the impact on amphibians and reptiles?	X	X	X	X	X				There are likely operational changes that can be implemented to maintain the existing amphibian and reptile communities (e.g., keep reservoir elevations below 745 m ASL or 434 m ASL through the end of July), but those changes need to be evaluated with respect to their feasibility. Changes to reservoir operations also need to be considered with respect to how those changes will affect habitat availability (both spatially and temporally) and whether those changes will affect our ability to address any of the management questions.

Management Themes and Questions	Management Hypotheses								Year 5 (2012) Status
	1_A	1_B	1_C	1_D	1_E	2_A	2_B	2_C	
Physical Works						X	X	X	Most of these management questions and associated hypotheses (H_2) are related to one another and require data collection after physical works are implemented. We may be able to hypothesize about the effects of physical works, but those hypotheses would need to be tested after implementation of works.
MQ7: Can physical works projects be designed to mitigate adverse impacts on amphibians and reptiles resulting from reservoir operations?						X	X	X	We can address MQ8 and the effects of revegetating the DDZ on amphibian and reptile use of habitat by comparing observations in treatment areas with observations outside revegetated zones. Additional years of data are required to reveal trends and annual variance.
MQ8: Does revegetating the drawdown zone affect the availability and use of habitat by amphibians and reptiles?						X	X	X	At this stage we are unable to assess the relationship between revegetating the drawdown zone of either reservoir and the availability and use of habitat by amphibians and reptiles. However, based on the finding of Fenneman and Hawkes (2012), it is unlikely that the current extent of revegetation in Kin will affect habitat use. More research is necessary to assess this for Arr.
MQ9: Do physical works projects implemented during the course of this monitoring program increase amphibian and reptile abundance, diversity or productivity?						X	X	X	The efficacy of physical works projects implemented during the course of this monitoring program may increase amphibian and reptile abundance, diversity or productivity; however, this cannot be assessed at this time because the physical works have not been implemented in Arr or considered for Kin.

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

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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). 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). 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. 2011; Kupferberg et al. 2011). To date, most studies on the effects of impoundment have focused primarily on the instream and riparian effects on fishes 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; Eskew et al. 2011; Kupferberg et al. 2011). The need to understand the operational aspects of reservoir effects upstream of dams on wildlife and their habitat remains high (Hawkes 2007; Brandão and Araújo 2008), and that is the focus of this study (Hawkes and Tuttle 2009a, 2010a; Hawkes et al. 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 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. In 2011, an additional monitoring study (CLBMON-58) was initiated to assess whether the incremental increase in reservoir levels impact amphibian or reptile populations in Kinbasket Reservoir (Hawkes and Tuttle 2012). 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 any impacts by using physical works.

This report summarizes the findings of Year 5 (2012) monitoring surveys for BC Hydro's Monitoring Program CLBMON-37: *Kinbasket and Arrow Lakes Reservoirs: Amphibian and Reptile Life History and Habitat Use Assessment*.

1.1 Study Species

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 make them ideal study organisms. Furthermore, amphibians have relatively low movements or dispersion, which may amplify 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). Reptile populations are also vulnerable to habitat loss and fragmentation, and since many species of snakes rely on amphibians as a critical component of their diet (Rossman et al. 1996; Matthews et al. 2002), they are linked to the same threats that affect amphibian populations.

Of the 16 species of amphibians and reptiles that occur in the Columbia Basin, seven species of amphibians and six species of reptiles potentially occur along the impounded waters of the Columbia River (Table 1-1). Five of these species are considered at risk by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC); the Northern Leopard Frog (*Lithobates pipiens*) is listed as Endangered, and Western Toad (*Anaxyrus boreas*), Western Skink (*Plestiodon skiltonianus*), Rubber Boa (*Charina bottae*) and Painted Turtle (*Chrysemys picta*) are 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 and Arrow Lakes Reservoirs

Group and Species	Species Code	Status†	
		CDC	COSEWIC*
Amphibian			
Northern Leopard Frog (*Lithobates pipiens*)	LIPI	R	E
Columbia Spotted Frog (*Rana luteiventris*)	**RALU**	Y	
Wood Frog (*Lithobates sylvatica*)	LISY	Y	
Pacific Chorus Frog (*Pseudacris regilla*)	**PSRE**	Y	
Western Toad (*Anaxyrus boreas*)	**ANBO**	Y	SC
Long-toed Salamander (*Ambystoma macrodactylum*)	**AMMA**	Y	
Coeur d'Alene Salamander (*Plethodon idahoensis*)	PLID	Y	SC
Rocky Mountain Tailed Frog (*Ascaphus montanus*)	ASMO	R	
Reptile			
Western Painted Turtle (*Chrysemys picta*)	**CHPI**	B	SC
Western Terrestrial Garter Snake (*Thamnophis elegans*)	**THEL**	Y	
Common Garter Snake (*Thamnophis sirtalis*)	**THSI**	Y	
Rubber Boa (*Charina bottae*)	**CHBO**	Y	SC
Racer (*Coluber constrictor*)	COCO	B	SC
Pacific Northern Rattlesnake (*Crotalus oreganus*)	CROR	B	T
Western Skink (*Plestiodon skiltonianus*)	**PLSK**	B	SC
Northern Alligator Lizard (*Elgaria coerulea*)	**ELCO**	Y	

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

2.0 STUDY OBJECTIVES

2.1 Study Design

In 2008, BC Hydro initiated 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.

Over the past five years, LGL Limited has studied the abundance, distribution and habitat use of amphibian and reptile populations in the drawdown zones of both Kinbasket and Arrow Lakes Reservoirs (Table 2-1). We have developed analytical techniques and study design approaches to ensure the management questions identified in Section 2.2 can be addressed. CLBMON-37 began in 2008 and will be continued in 2014, 2016 and 2018.

Table 2-1: Monitoring years by reservoir for CLBMON-37 and CLBMON-58

Year	Kinbasket CLBMON-58	Kinbasket and Arrow Lakes CLBMON-37	Reference
2008		Year 1	Hawkes and Tuttle 2009a
2009		Year 2	Hawkes and Tuttle 2010a
2010		Year 3	Hawkes et al. 2011
2011	Year 4		Hawkes and Tuttle 2012a
2012		**Year 5**	**Annual report and comprehensive report**
2013	Year 6		Annual report
2014		Year 7	Annual report
2015	Year 8		Annual report
2016		Year 9	Annual report
2017	Year 10		Annual report
2018	Year 11	Year 11	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. 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 (as per CLBMON-58). Thus, the ten MQs can be grouped into four broad themes:

CLBMON-37 – 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 – 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 – 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 (CLBMON-58 only):

H_1 Annual and seasonal variation in water levels in Kinbasket or Arrow Lakes Reservoirs (due to reservoir operations), the implementation of soft operational constraints, and the effects of Units 5 and 6 in Mica Dam on Kinbasket Reservoir (CLBMON-58 only), 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 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 zones of Kinbasket and Arrow Lakes Reservoirs 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-37. 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							√	√	√	√

Hypotheses will be formally tested in the comprehensive report due in 2013 using time series that span the 2008–2012 period. In some cases (e.g., MQ1), we currently have sufficient data to address the management question. In others (e.g., portions of MQs 2 and 4), alternative approaches are required. Each year of the study has specific monitoring objectives designed to address one or more of the above management questions.

2.3 CLBMON-37 Year 4 – Monitoring Objectives

The primary objective of CLBMON-37 is to monitor amphibian and reptile populations relative to reservoir elevations at locations in the DDZs of Kinbasket and Arrow Lakes Reservoirs using standardized survey methods. Eight objectives were developed for CLBMON-37 in 2012 and were designed to address one or more of the above management questions (Table 2-3). Some of the questions will be addressed in multiple years (e.g., MQs 1 and 4), whereas other questions will be addressed after several years of data gathering (e.g., MQs 8 and 9).

Table 2-3: Relationship between the 2012 objectives and the nine management questions derived for CLBMON-37. Management questions evaluated by specific objectives are indicated by coloured shading

	Management Questions								
	Life History and Habitat Use				Reservoir Operations and Habitat Change		Physical Works		
2012 Study Objectives	1	2	3	4	5	6	7	8	9
1. Document the amphibian and reptile species that occur in or adjacent to the DDZ of each reservoir	■		■						
2. Monitoring the abundance, diversity, distribution, and productivity of the different life stages of amphibians and reptiles in the DDZ		■	■						
3. Determine seasonal patterns of habitat use (e.g., breeding, rearing, foraging, overwintering)		■		■					
4. Identify the specific habitat features associated with each species				■					
5. Identify whether the annual reservoir operating regime creates conditions that contribute to changes in life history or seasonal habitat use of amphibians and reptiles within the DDZ		■		■	■	■			
6. Identify whether the annual reservoir operating regime affects amphibian and reptile habitat within the DDZ				■	■	■			
7. Assess the effectiveness of revegetation in each reservoir to enhance habitat for amphibians and reptiles				■			■	■	■
8. Inform how physical works and revegetation can be designed to mitigate adverse impacts to amphibian and reptile populations							■	■	■

3.0 STUDY AREA

3.1 Physiography and Climatology

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.

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.

3.2 Kinbasket Reservoir

Located in southeastern B.C., Kinbasket Reservoir is surrounded by the Rocky and Monashee Mountain ranges, and 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 (Figure 3-1). 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 3-2).

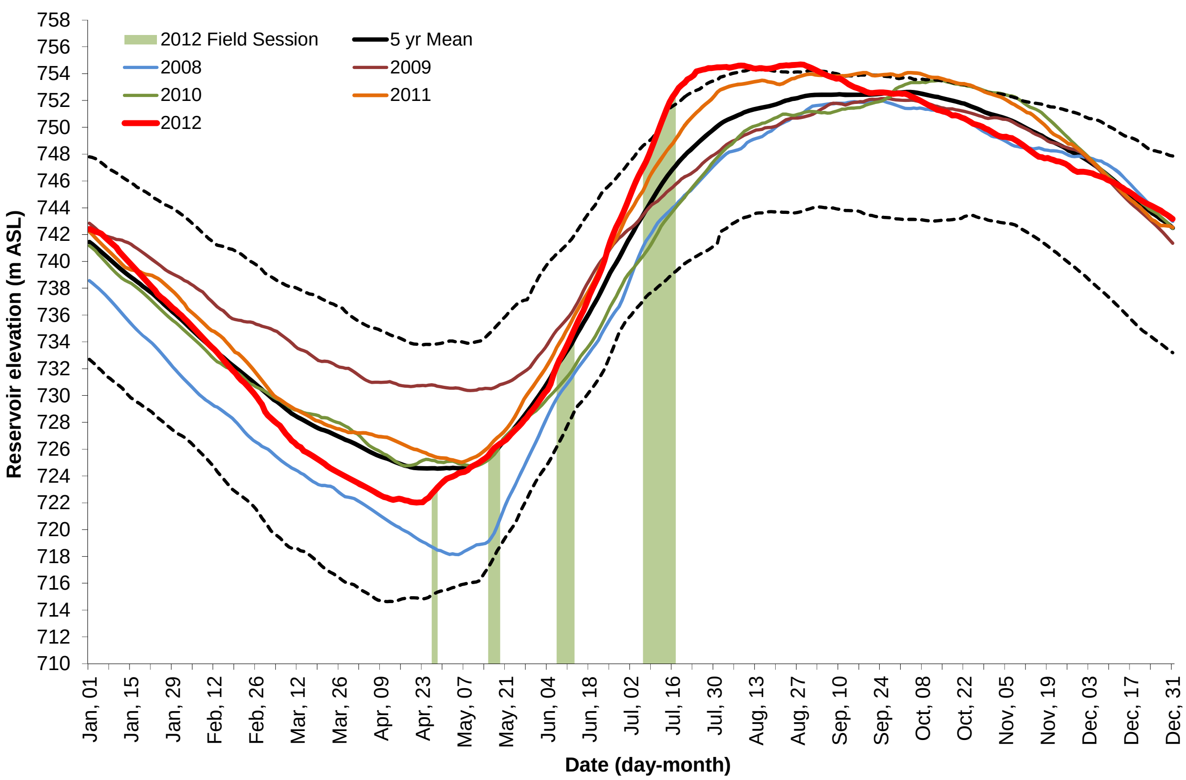

Figure 3-1: Kinbasket Reservoir elevations for 2008 through 2012. Green bars indicate the timing of field sessions for 2012

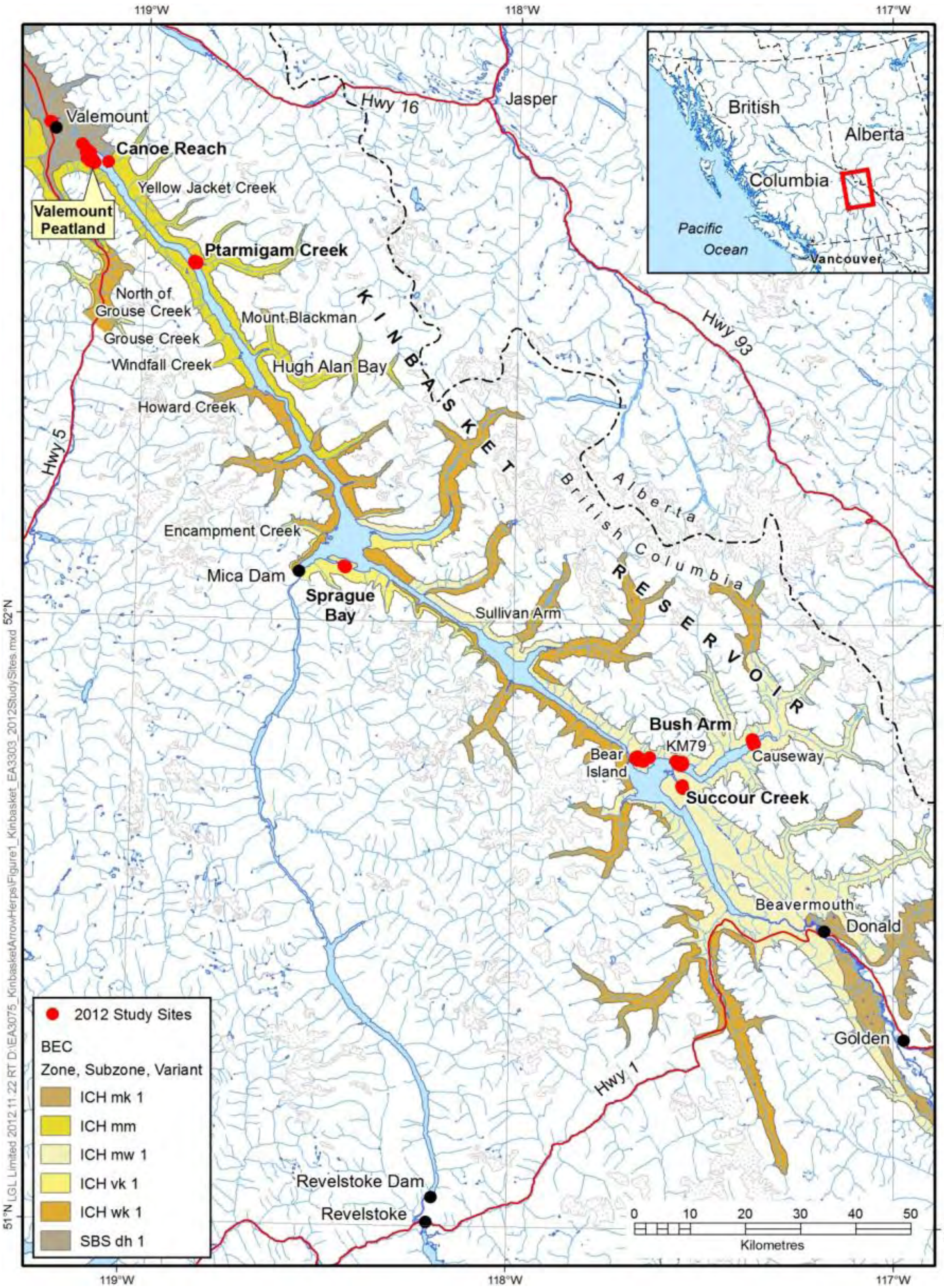

Figure 3-2: Location of Kinbasket Reservoir in British Columbia, and locations sampled for CLBMON-37 in 2012. Place names in bold are either monitoring sites or reference sites (see Table 3-1). Naming follows Hawkes et al. (2007)

3.2.1 Study Locations

Eight sites within the DDZ of Kinbasket Reservoir were selected for monitoring in 2012 to document the presence or non-detection of amphibians and reptiles (Table 3-1). Our site selection process was closely tied to the area of interest considered for CLBMON-10 (i.e., potential revegetation sites) following Hawkes et al. (2007). Sites were classified as a monitoring site or reference site outside the DDZ. Monitoring sites have further been classified as primary (DDZ-P = site visited during every field session in a given year) or secondary (DDZ-S = site visited at least once a year but not during every field session). Other upland ponds not affected by reservoir operations are considered as reference sites (REF = site visited once or more a year).

Table 3-1: Study areas and sites surveyed for amphibians and reptiles in Kinbasket Reservoir in 2012. Type of site was determined to be either a monitoring site in the DDZ (DDZ-P or DDZ-S) or a reference site outside the DDZ (REF). Sites in bold are located within the drawdown zone

Study Area	Site	Site Type	# Site Visits in 2012
Canoe Reach	**Valemount Peatland**	DDZ-P	7
	Ptarmigan Creek	DDZ-P	4
Bush Arm	**Bear Island**	DDZ-P	3
	Causeway (km 61)	DDZ-P	8
	Beaver Dam Marshes (km 79)	DDZ-P	2
	Perched wetland (km 79)	REF	3
	Succour Creek	DDZ-S	1
Mica Dam Area	**Sprague Bay**	DDZ-S	1

3.3 Arrow Lakes Reservoir

Arrow Lakes Reservoir is an approximately 230 km long section of the Columbia River drainage between Revelstoke and Castlegar, BC (Figure 3-3). Two biogeoclimatic zones occur within the study area: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF). The reservoir has a north-south orientation and is located in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east. The Hugh Keenleyside Dam, located 8 km west of Castlegar, spans the Columbia River and impounds Arrow Lakes Reservoir. Arrow Lakes Reservoir has a licensed storage volume of 7.1 MAF (BC Hydro 2007). The normal operating range of the reservoir is between 418.64 and 440.1 m elevation (Figure 3-4).

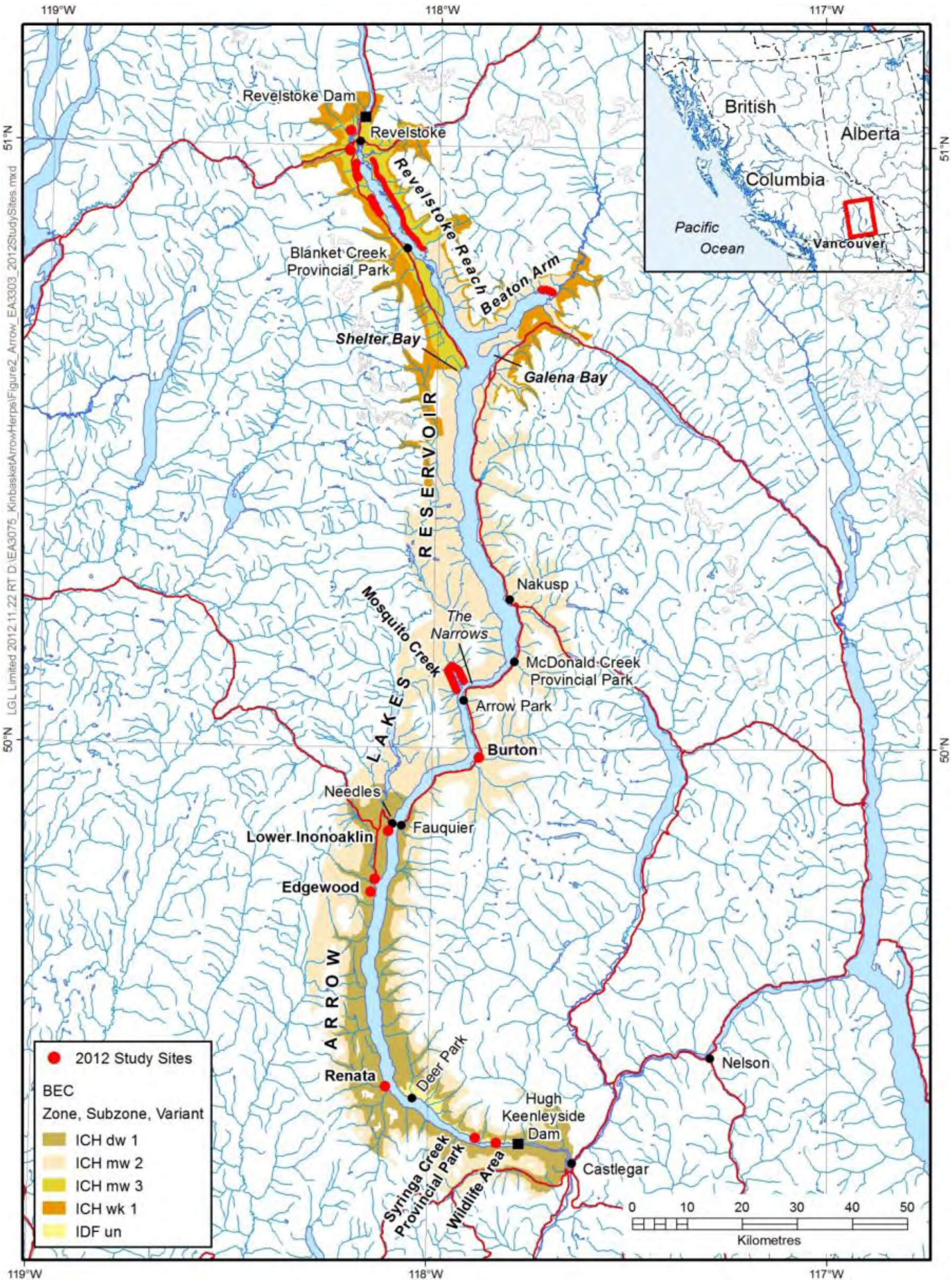

Figure 3-3: **Location of Arrow Lakes Reservoir in British Columbia, and locations sampled for CLBMON-37 in 2012.** Place names in bold are either monitoring sites or reference sites (see Table 3-2)

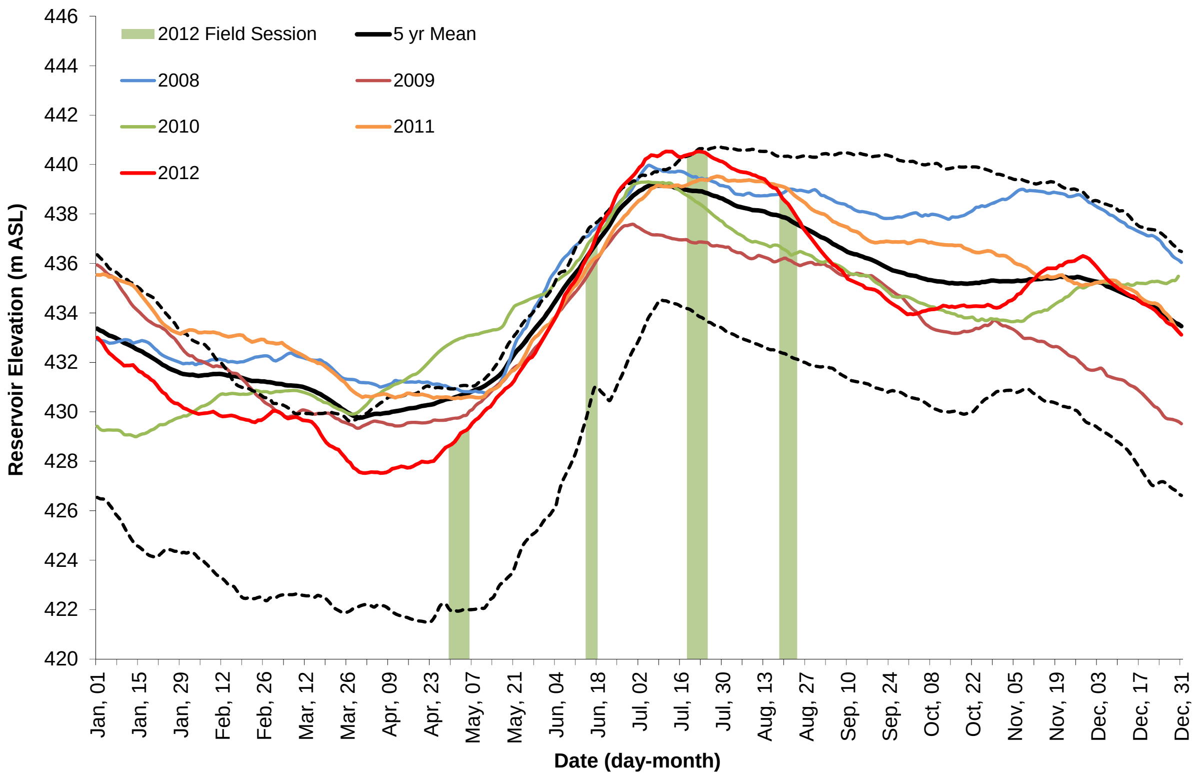

Figure 3-4: Arrow Lakes Reservoir elevations for 2008 through 2012. Green bars indicate the timing of field sessions for 2012

3.3.1 Study Locations

Seventeen sites within the DDZ of Arrow Lakes Reservoir were selected for monitoring in 2012 to document the presence or non-detection of amphibians and reptiles (Table 3-2). The site selection process follows previous years and was closely tied to a typical 10 m change in elevation (430–440 m) as well as to areas associated with the proposed physical works within Revelstoke Reach. Sites are classified as a monitoring site or reference site outside the DDZ. Monitoring sites have further been classified as primary (DDZ-P = site visited during every field session in a given year) or secondary (DDZ-S = site visited at least once a year but not during every field session). Upland ponds that are not affected by reservoir operations are considered as reference sites (REF = site visited once or more a year).

Table 3-2: Study areas and sites surveyed for amphibians and reptiles in Arrow Lakes Reservoir in 2012. Type of site was determined to be either a monitoring site in the DDZ (DDZ-P or DDZ-S) or a reference site outside the DDZ (REF)

Study Area	Site	Site Type	# Site Visits in 2012
Revelstoke Reach	Site 1 & 2	DDZ-S	1
	Big Eddy	DDZ-S	1
	Downie Marsh	DDZ-P	4
	Machete Island	DDZ-P	2
	Airport Marsh	DDZ-P	2
	Montana Slough	DDZ-P	4
	Cartier Bay	DDZ-P	4
	9 mile	DDZ-P	3
	12 mile	DDZ-P	3
Beaton Arm	Beaver Dams Marsh	DDZ-P	3
Mid Arrow	Mosquito Creek	DDZ-S	1
	Burton Creek	DDZ-P	3
	Lower Inonoaklin	DDZ-P	3
	Edgewood (North & South)	DDZ-P	3
Lower Arrow	Renata Beach	DDZ-S	1
	Syringa Creek PP	DDZ-S	1
	HK Dam Area	REF	1

4.0 METHODS

4.1 Addressing Management Questions

The methods and sampling protocols (Hawkes and Tuttle 2010b) were specifically chosen or designed to address one or more of the management questions for CLBMON-37 (see Section 2.2). Answering most management questions will require multiple years of data, and the methods used are intended to be implemented during each year of work. This will ensure that the data collected across time can be used to address each management question. Table 4-1 provides an overview of how the various work components and associated aspects and/or data collected are related to the management questions associated with CLBMON-37.

Table 4-1: Methods used for CLBMON-37 in 2012 and their application to management questions

Work Component	Related Aspects and/or Data	Management Questions: Life History & Habitat Use 1	2	3	4	Reservoir Ops 5	6	Physical Works 7	8	9
Field Sampling	Timing	■	■	■		■				
	Site selection	■	■					■		
Survey Types	Time-constrained searches	■	■	■	■	■			■	■
	Nocturnal call stations	■	■	■	■					
	Road surveys	■	■	■	■					
	Reconnaissance surveys	■	■	■	■					
	Incidental observations	■	■	■	■					
	Data acquisition	■	■	■	■	■	■	■		■
Monitoring	Timing	■		■		■	■			
	Site selection	■			■	■		■	■	
	Site occupancy	■		■	■	■	■	■	■	
General Survey Data	Survey locations	■			■	■		■		
	Species lists (for each survey location)				■	■		■		■
	Environmental data				■	■				
	Other wildlife observations					■				
Species Data	Morphometric data		■	■				■		■
	Mark-recapture data	■	■	■				■		■
	Chytrid Sampling									
	Species locations (georeferenced)	■			■	■		■	■	
	Temporal and spatial data	■	■	■	■	■				
	Habitat associations				■				■	
	Species occupancy	■		■	■	■			■	
	Species counts	■	■							■
Habitat Data	Distribution of ponds in DDZ				■	■	■			
	Microhabitat characteristics				■				■	
	Habitat Availability				■	■	■		■	
	Site-specific vegetation data				■					
	Water chemistry data				■	■				
Data Analyses	Life history & habitat Use	■	■	■	■			■		■
	Reservoir operations					■	■	■		
	Physical Works							■	■	■
Reporting	Life history & habitat use	■	■	■	■			■		■
	Reservoir operations					■	■	■		
	Physical works							■	■	■

4.2 Field Schedule

In 2012, field sampling was conducted between April and August to coincide with the active period of amphibians and reptiles (Table 4-2). Predicted water levels obtained from BC Hydro were taken into account by field scheduling to determine how much of the DDZ would be available for sampling. The 2012 field sampling schedule followed a similar timeline as that implemented in 2008–2010 to facilitate data comparison between years. Due to the large size of the study area and the differences in climatic regimes, sample sites were surveyed over five time periods (see Appendix 9-1 for the dates sites were visited during each field session).

Table 4-2: Date ranges of field surveys in Kinbasket and Arrow Lakes Reservoirs for CLBMON-37 in 2012

Session	Projects	Survey Dates	Study Areas Visited
1	CLBMON-37	April 26 – May 6	Valemount Peatland, Ptarmigan Creek, Revelstoke Reach, Beaton Arm, Burton Creek, Edgewood, L. Inonoaklin, Renata
2	CLBMON-37	May 14–18	Bush Arm – Causeway, Bear Isl., km 79
3	CLBMON-37	June 8–18	Bush Arm – Causeway, Bear Isl., km 79, Valemount Peatland, Ptarmigan Creek, Revelstoke Reach, Beaton Arm, Burton Creek, Edgewood, L. Inonoaklin
4	CLBMON-37/61 CLBMON-37/10 CLBMON-37	July 6-12 July 16-18 July 20-25	Valemount Peatland, Ptarmigan Creek, Bush Arm – Causeway, Bear Isl., km 79 Revelstoke Reach, Beaton Arm, Burton Creek, Edgewood, L. Inonoaklin
5	CLBMON-37/11B3	August 20-24	Revelstoke Reach, Beaton Arm, Burton Creek, Edgewood, L. Inonoaklin

4.3 Data Collection

4.3.1 General Survey Data

In 2012, we used a variety of techniques (egg mass surveys [EMS], larval surveys [LVS] and visual encounter surveys [VES]) to survey amphibians and reptiles in the DDZ of Kinbasket and Arrow Lakes Reservoirs. Of the methods proposed by Hawkes and Tuttle (2009b), VES surveys were determined to be the most appropriate method of sampling amphibians and reptiles of all life stages, largely because of the large geographic scale of the study and the need to sample many locations across the active 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 of 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 used at the Bush Arm Causeway in May 2012 to document the presence of amphibians moving in and out of the DDZ. Four arrays of five pitfall cans each (30 cm in depth) were installed in a row connected by 5 m of drift fence and monitored for three nights. Pitfall surveys have not been conducted in Arrow Lakes to date.

At each survey site, as much area as possible was surveyed via time-constrained searches (area size was not standardized; it was a function of how much habitat was available during each visit). Detection rates for each species (including the different life stages) and site were calculated by dividing the total number of captures made at each site by the time spent searching the site (i.e., catch per unit effort, CPUE). Aggregations of tadpoles and metamorph amphibians were treated as a single detection. The same areas are sampled each year (to the extent that they are available) to derive a metric of site occupancy (i.e., if a species occurs at a site in a given year, the site is occupied). The productivity of each occupied site was assessed using CPUE for each species as described above.

All ponds in the drawdown zone were visited, and a global positioning system (GPS) track of the perimeter of each pond was collected and mapped in a GIS to determine total area and elevation of ponds within the DDZ. Ponds were numbered at each site and were monitored across the field sessions for amphibian or reptile occupancy (provided the ponds were present during each session). Over the field season, as many ponds as possible were revisited to assess the availability of ponds to amphibians and reptiles (pond habitat availability assessment).

All amphibian and reptile observations and captures, including incidental observations, were georeferenced to identify the vegetation community (as per Hawkes et al. [2007] and Enns et al. [2007]) and elevation at which they were made.

In 2012, we continued to use a Compaq IPAQ handheld computer, which allowed for efficient data collection, storage, backup and entry into Microsoft Access databases. For each survey, two data forms were completed: (1) survey location, and (2) species location (see Hawkes and Tuttle 2010a for description). We also recorded all observations of other animals and their signs (e.g., tracks, scat, hair, nest).

4.3.2 Species Morphometric Data

In 2012, we continued to follow the Resources Inventory Standards Committee (RISC) protocols for sampling and handling of amphibians and reptiles (RISC 1998a, 1998b). All captured animals were weighed and measured, most were photographed, and UTM coordinates were noted for each observation. The sex of an animal was determined whenever possible. The marking scheme (e.g., photo identification for adult amphibians, subcaudal scute clipping in snakes) used in 2008 through 2011 was continued in 2012.

Amphibian Morphometric Data—Snout-urostyle length (SUL) and weight (g) were measured for captured amphibians. 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 amphibian stages were staged according to the Gosner (1960) or Harrison (1969) indexing standards.

Reptile Morphometric Data—Snout-vent length (SVL [mm]), tail length (TL [mm]) and weight (g) were taken for captured snakes. Sex in snakes was determined by probing for hemipenes.

For a detailed description of the methods used to sample amphibians and reptiles in 2012, refer to the CLBMON-37 Year 1 report (Hawkes and Tuttle 2009a) and revised monitoring program sampling protocols (Hawkes and Tuttle 2011).

4.3.3 Habitat Data

In 2012, habitat data were collected at all locations where species were observed as well as at sites within the DDZ where no animal observations were made. Habitat data collected included characteristics at both the macro and micro scales. The vegetation community type (from CLBMON-10 for KIN and CLBMON-33 for ARR) 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 2012, refer to the CLBMON-37 Year 1 report (Hawkes and Tuttle

2009a) 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 (Model #85) was used to measure dissolved oxygen, conductivity and temperature, and an Oakten waterproof pH Tester 30 was used to obtain pH data.

4.4 Data Analyses

Statistical analyses were performed using R (V2.12.0) and Microsoft Excel 2010 (© 1985–2011). We used a critical alpha level of 0.05 to determine significance for most statistical tests. *T*-tests were used to compare differences in water chemistry parameters for ponds with and without amphibians. To compare species richness across vegetation communities and landscape units, species richness data were standardized by correcting for detection rates (number of observations per hour). Standardized detection rates were also used to assess where amphibians and reptiles were located across the elevation gradient of the drawdown zone.

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.

5.0 RESULTS

5.1 Kinbasket Reservoir

5.1.1 Environmental Data

Environmental conditions in Kinbasket Reservoir were similar to previous years (see Hawkes and Tuttle 2012). Ambient temperature (°C), relative humidity (per cent), and precipitation (mm, in the form of rain) were well within the ranges necessary for amphibian and reptile detection (Olson 1999; Hawkes and Gregory 2012; Table 5-1). The winter snow pack was considerably higher in 2011/2012 than in 2010/2011 with a maximum of ~230 cm (Figure 5-1D), which contributed to high reservoir elevations (see Figure 3-1).

Table 5-1: Air temperature and precipitation conditions[1] for Kinbasket Reservoir during the 2012 field sessions. Precipitation values are totals by session and by month (sessions 2 through 4 only)

		Temperature (°C)				Precipitation (mm)	
Field Session	**Dates**	**Min**	**Max**	**Mean**	**Monthly Mean**	**Session**	**Monthly**
1	April 27–May 6	-1.50	15.80	7.15	--	11.10	--
2	May 14–18	-3.15	24.70	9.00	9.28	1.20	15.60
3	June 8–12	4.90	24.40	12.93	12.82	9.70	121.50
4	July 6–18	4.45	33.00	20.12	17.41	12.00	90.50

[1]Data obtained from BC Wildfire Management Branch

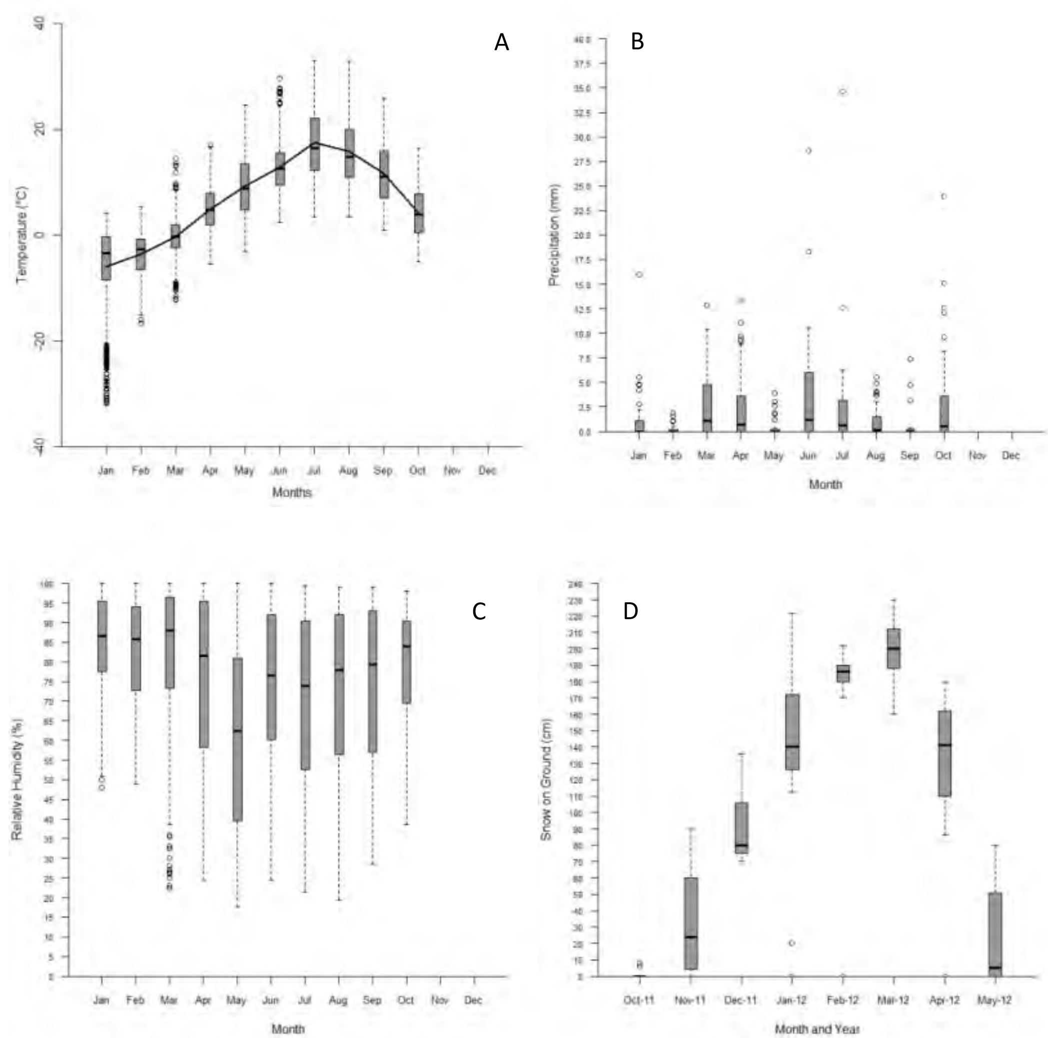

Figure 5-1: Environmental conditions for Kinbasket Reservoir in 2012 (January through October only). A: Air Temperature (°C) (with average); B: Precipitation (mm); C: Relative humidity (per cent); and D: Snow on Ground (cm). Field work for CLBMON-37 occurred between April and July. Data source = BC Wildfire Management Branch

5.1.2 Survey Data

i) Site Occupancy

Four species of amphibians and reptiles were observed in the DDZ of Kinbasket Reservoir in 2012 (Table 5-2). Only two sites supported all four species of amphibians: Valemount Peatland and Bush Arm Causeway. Western Toads and Columbia Spotted Frogs occupied most of the sites surveyed and accounted for most observations. Long-toed Salamanders were observed in only two sites: Valemount Peatland and Bush Arm at the Causeway. Neither Wood Frogs nor Pacific Chorus Frogs were documented in or adjacent to the DDZ of Kinbasket Reservoir. Out of the two species of garter snake known to occur in the DDZ of Kinbasket, only Common Garter Snakes were observed in 2012.

Table 5-2: Site occupancy of amphibians and reptiles observed in the drawdown zone of Kinbasket Reservoir in 2012. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake

Study Area	Survey Location	AMMA	ANBO	RALU	THEL	THSI
Bush Arm	Causeway (km 61)	X	X	X		X
	km 79 marshes		X	X		
	Bear Island		X	X		X
	Succour Creek					X
Canoe Reach	Ptarmigan Creek		X	X		X
	Valemount Peatland	X	X	X		X
Mica Dam	Sprague Bay		X	X		X

ii) Detection Rates

Between April and August, we spent 144 h 57 min over 29 days surveying monitoring sites within the DDZ of Kinbasket Reservoir (Table 5-3), during which we observed more than 600,000 individuals across multiple life stages (see Table 5-4 for a breakdown by life stage).

Table 5-3: Total survey time (hours:minutes) and species detections by survey location for Kinbasket Reservoir in 2012. Blanks indicate the species was not detected. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THSI = Common Garter Snake. CPUE (catch per unit effort) = the number of observations per site and per species divided by the survey time

Survey Location	Time	AMMA	ANBO	RALU	THSI	Total	CPUE
Bush Arm Bear Island	22:54		58	16	1	75	**3.28**
Bush Arm Causeway	22:30	13	60	2	2	77	**3.42**
Bush Arm km 79	7:44		23	17		40	**5.17**
Bush Arm km 79 Perched	12:22		2	26		28	**2.26**
Ptarmigan Creek	19:28		25	3	1	29	**1.49**
Sprague Bay	6:24		7	4	3	14	**2.19**
Succour Creek	1:40				1	1	**0.60**
Valemount Peatland	51:55	6	10	21	3	40	**0.77**
Totals (Time = hours:minutes; Observations = # individuals)	**144:57**	**19**	**185**	**89**	**11**	**304**	**2.10**
CPUE (# hours; obs/hr)	**144.95**	**0.13**	**1.28**	**0.61**	**0.08**	**2.10**	

Detection rates were influenced by life stage, time of day, weather conditions, habitat type, season and elevation (see section elevational distribution below). To assess species-by-site relationships, we pooled all life stages to identify sites where the detection of a given species was the highest regardless of age class. We examined the detection rates for eight areas in Kinbasket Reservoir (Figure 5-2), of which Bush Arm km 79 (marshes and perched wetland) had the most consistently high rates of detections.

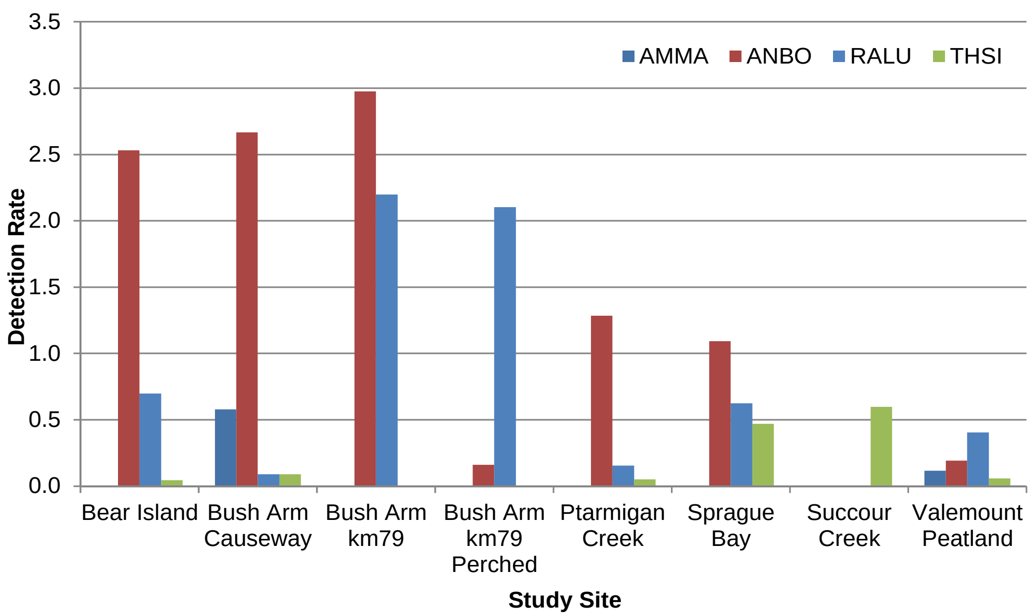

Figure 5-2: Detection rate for amphibian and reptile species in Kinbasket Reservoir in 2012. Detection rate = the number of times a species was detected (all life stages pooled)/the total time spent searching at a study site. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THSI = Common Garter Snake

The pitfall trapping surveys conducted at the Bush Arm Causeway in May 2012 yielded two species of amphibian: Western Toad (*n* = 35) and Long-toed Salamander (*n* = 7). Twenty traps were set out over three nights for a total of 60 trap nights, yielding a capture rate of 0.7 captures per night per trap. Captures were all adults assumed to be migrating between the forests and breeding ponds located in the drawdown zone. Significantly more male toads (*n* = 29) were captured in the pitfall traps than female toads (*n* = 6), potentially indicating that it was still early in the breeding period, with males arriving at the ponds early to wait for females.

iii) Seasonal and Geographic Distribution

In 2012, we documented ~200 individual (metamorph, juvenile or adult) amphibians and reptiles of four species in Kinbasket Reservoir. Approximately 218 egg masses plus ~61,000 tadpoles and larvae of the three amphibian species were observed (Table 5-4). Of the two garter snake species that could potentially occur, we only documented the presence of Common Garter Snake in the DDZ. The most abundant species were Western Toad and Columbia Spotted Frog. Amphibians and reptiles were found in all months during which surveys were conducted in 2012. Bush Arm (Causeway and km 79) and Valemount Peatland were the most productive with respect to both the number of species and the number of individuals observed. Maps of all Kinbasket Reservoir observations are provided in Appendix 9-2.

Table 5-4: Geographic and seasonal distribution of amphibians and reptiles by life stage for Kinbasket Reservoir in 2012. Blanks indicate the life stage or species was not detected. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THSI = Common Garter Snake. EM = Egg mass, T = Tadpole, Larvae = Larvae (no. of tadpoles/larvae of each species was estimated), J = Juvenile, A = Adult

Geographic Distribution												
	AMMA			**ANBO**			**RALU**				**THSI**	**Total**
Survey Location	**EM**	**L**	**A**	**EM**	**T**	**A**	**EM**	**T**	**J**	**A**	**J/A**	
Bush Arm Bear Island	5			59	73227	3	9	2102	1	5	1	75412
Bush Arm Causeway	16	2	7	51	42750	36	1	500			2	43365
Bush Arm km 79				14	1777	6	1	1	19	5		1823
Bush Arm km 79 Perched					50000	3	2	6	13	13		50037
Ptarmigan Creek					17200	47			3	3	1	17254
Sprague Bay					310301				2	2	5	310310
Succour Creek											1	1
Valemount Peatland	5	1			110502	6	60	1	9	4	3	110591
Total # of individuals	**26**	**3**	**7**	**124**	**605857**	**101**	**73**	**2610**	**47**	**32**	**13**	**608893**
Seasonal Distribution												
	AMMA			**ANBO**			**RALU**				**THSI**	**Total**
Month	**EM**	**L**	**A**	**EM**	**T**	**A**	**EM**	**T**	**J**	**A**	**J/A**	
April	5					48	60					118
May	16	2	7	124	101650	48	13	2600	5	7		104472
June					289106	3		9	25	12	8	289163
July		1			215101	2		1	16	13	5	215139
August									1			1
Total # of individuals	**26**	**3**	**7**	**124**	**605857**	**101**	**73**	**2610**	**47**	**32**	**13**	**608893**

The first field visit to Kinbasket Reservoir was timed for late April 2012 to coincide with the breeding and egg laying period for amphibians. Only Canoe Reach sites (e.g., Valemount Peatland, Ptarmigan Creek) were visited in April, as Bush Arm usually has an abundance of snow and frozen ponds at that time of year. A second field session for only Bush Arm was planned for early May due to late spring conditions and road closures in Bush Arm.

In late April and early May, adult Columbia Spotted Frogs, Western Toads and Long-toed Salamanders were documented in the drawdown zone of Kinbasket Reservoir. We recorded numerous egg masses and tadpoles of both anuran species in ponds within the DDZ, which indicated that breeding was taking place in those areas. Long-toed Salamander eggs were observed in Bush Arm at the Causeway, it was assumed that breeding was taking place at the site. Several salamander egg masses were also found in the Valemount Peatland in the same excavated pond hole at the north end, which has been used in previous years by this species. Most tadpole sightings were made in May and June, whereas juveniles and adults were frequently observed throughout the season although observations declined in July due to full inundation of the reservoir.

Species assemblages remained constant across the three main study areas as the summer progressed; however, the number of observations declined. Western Toad tadpoles grew throughout the summer, although the timing of metamorphosis was not documented for any of the sites due to inundation. In mid-July, reservoir levels at the sites were nearing the maximum height for 2012, and much of the previously available habitat was inundated. This reduced the amount of area that could be searched to zero in several locations, including most sites in Bush Arm, and we located very few animals than on previous surveys in Kinbasket Reservoir. We observed Western Toad and Columbia Spotted Frog juveniles in the perched wetland at Bush Arm km 79 in mid-summer, as this site is outside of the drawdown zone and not affected by changing reservoir levels.

iv) Elevation Distribution

Amphibians and reptiles of all species and life stages were found across a wide range of elevations in Kinbasket Reservoir in 2012 (Figure 5-3). Most observations (all life stages combined) were between 749 and 755 m ASL, a trend that was observed in 2011. As in 2011, observations of Western Toads (ANBO) spanned the largest range of elevations, while observations of Long-toed Salamanders (AMMA) spanned the smallest range. The relationship between amphibian (and reptile) distribution in the drawdown zone is likely a function of habitat availability. In the north (i.e., Canoe Reach), most pond habitat is situated above 751 m ASL and all species were documented from 745 m to 755 m ASL (Figure 5-4A). In the south (i.e., Bush Arm), the distribution of ponds spans a greater range of elevations and species observations occurred at ponds situated between 736 and 757 m ASL (Figure 5-4B).

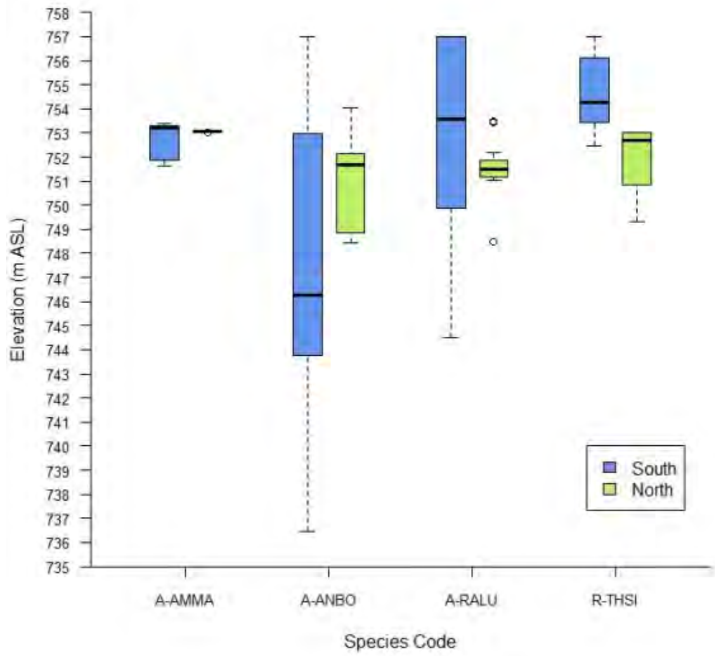

Figure 5-3: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in the northern (Canoe Reach) and southern (Bush Arm) drawdown zone regions of Kinbasket Reservoir in 2012. The boxes represent 25 per cent and 75 per cent of the ranked data (see section 4.4). The horizontal line inside the box is the median. The length of the boxes is their interquartile range. Whiskers are drawn from the top of the box to the highest observation within 1.5 interquartile range of the top, and from the bottom of the box to the lowest observation within 1.5 interquartile range of the bottom of the box. Open circles are outlier data points for box and whisker plot definitions. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-RALU = Columbia Spotted Frog, R-THSI = Common Garter Snake

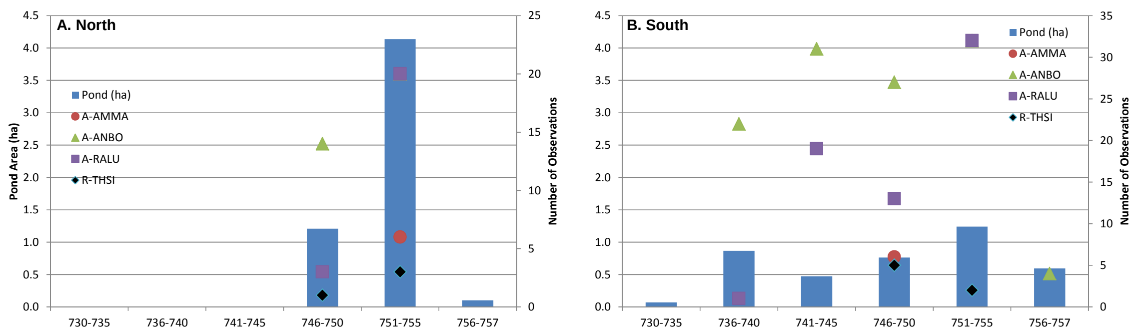

Figure 5-4: Relationship between pond area and amphibian and reptile observations in the north (A) and south (B) of Kinbasket Reservoir in 2012. Observations of all life stages of each species combined

5.1.3 Species Data

i) Western Toad (ANBO)

Approximately 150 detections of Western Toad aggregations (n = 605,857) were made in the drawdown of Kinbasket Reservoir in 2012 (Table 5-4). Aggregations were defined as small groupings of 25 or more tadpoles within a given area (3 to 5 m). We documented 101 adult toads from April to August, with most observations and captures from May to July. Adult toads ranged in snout-urostyle length from 76 to 108 mm (females) and 65 mm to 90 mm (males). As expected, adult female toads exhibited larger body size and weight than did male toads (P = 0.003, t-stat = 2.95, df = 20) (Table 5-5). Larger female size in toads is linked to increased reproductive productivity (Matsuda et al. 2006).

Table 5-5: Average body size and weight comparisons for male and female Western Toads captured in Kinbasket Reservoir in 2012. SUL = snout-urostyle length (mm); Mass (g)

Sex	Number	SUL	SD	Mass	SD
F	16	88.34	10.32	88.37	23.80
M	40	80.10	6.49	51.80	10.61
Total	56	82.48	8.54	62.25	22.63

There were 124 observations of Western Toad egg masses in 2012, all of which were in Bush Arm. It is difficult to accurately count egg masses due to breeding aggregations (several females laying strings of eggs in the same area); however, it is likely that hundreds of thousands of eggs were laid because each string can contain up to 12,000 eggs. We observed dense aggregations of tadpoles (~145,000) during May, June and July at all sites, including Ptarmigan Creek, Valemount Peatland, Sprague Bay, and Bush Arm (Bear Island, km 79 marshes and Causeway). Tadpoles were of varying sizes and stages (Gosner stage 26–40), which could have lead to variation in timing of metamorphosis between sites (Table 5-6); however this was not documented for 2012 due to reservoir inundation. No metamorphosed toads were observed in 2012 in Kinbasket Reservoir, likely due to higher than normal reservoir levels earlier in the season (Kinbasket was on average ~8 m higher in July than in previous years).

Table 5-6: Number of Western Toad egg masses, tadpoles and metamorphs observed in Kinbasket Reservoir in 2012. ? = unknown when or if toad tadpoles reached metamorphosis

	Egg Masses	Tadpoles	Metamorphs	
Study Location	Number	Number	Number	Observation Date
Bear Island	59	~75,000	0	?
Bush Arm Causeway	51	~40,000	0	?
Bush Arm km 79	14	~2,000	0	?
Bush Arm km 79 Perched	No Obs	~50,000	0	?
Ptarmigan Creek	No Obs	~17,000	0	?
Sprague Bay	No Obs	~310,000	0	?
Valemount Peatland	No Obs	~110,000	0	?

Most Western Toads life stages were captured in the DDZ in marsh areas that had an abundance of cover (e.g., peatland bog or ponds with sedge cover). Breeding ponds were shallow and mud bottomed with abundant vegetation cover (personal observation), and tadpoles were observed feeding around the edges of ponds in May and June. The one exception to this was Bear Island, where toads laid their eggs in small, shallow ponds with no vegetation.

ii) Columbia Spotted Frog (RALU)

Columbia Spotted Frog tadpoles (*n* = ~ 2,600), as well as numerous metamorph, juvenile and adult (*n* = 79) frogs were documented in 2012 (Table 5-4). Breeding, as evidenced by almost 75 egg masses, was documented at five locations. Most Columbia Spotted Frog egg masses were observed in the Valemount Peatland (*n* = 60); however, another large population of Columbia Spotted Frogs appear to occur at km 79 marshes in Bush Arm. Apparently smaller numbers occur at Sprague Bay and Bush Arm Causeway.

Juvenile and adult frogs ranged in size from 25.2 to 77.6 mm SUL (average = 44.5 ± 18.6 SD), and weighed from 1.5 to 46 g (average = 14.3 ± 14.9 SD). All spotted frogs were captured in marshes in the DDZ and perched wetlands, with the highest density occurring at the Valemount Peatland and Sprague Bay. Typical habitats were in and around shallow beaver ponds and marsh creeks with abundant submergent vegetation and sedge/horsetail vegetation around the periphery.

iii) Long-toed Salamander (AMMA)

Thirty-six observations of this species were made in 2012: 26 egg masses, 3 larvae and 7 adults (Table 5-4) in the Valemount Peatland and at Bush Arm Causeway. The seven adult salamanders were captured in pitfall traps at Bush Arm Causeway and ranged in size from 51 to 61 mm in snout-vent length (average SVL = 56.1 mm ± 3.29 SD), and weighed between 3 and 5 grams. Egg masses were found attached to vegetation or sticks in shallow ponds, located in the Valemount Peatland and at Bush Arm Causeway. Egg masses were documented from late April to mid-May, and larvae were observed in the ponds during June and July. Timing of metamorphosis for this species is unknown because no metamorphs were located in 2012.

iv) Common Garter Snake (THSI)

We observed 13 Common Garter Snakes in the drawdown of Kinbasket Reservoir in 2012: two juveniles and 11 adults (Table 5-4). We captured 10 of those snakes, and all observations and captures were made in June and July when seasonal temperatures were ideal for foraging and basking activities (e.g., 18–24 °C). Most of the snakes captured were male (*n* = 8), and snakes ranged in size from 200 to 800 mm (SVL) and 65 to 201 mm (TL). Both of the two adult females captured were gravid, weighing in at 160 g and 295 g with egg counts of 17 and 18 respectively. Common Garter Snakes were observed in marsh areas with abundant sedge or vegetation cover (e.g., horsetail, clover, ox-eye-daisy), and most captures were made in Sprague Bay, Valemount Peatland and at Bush Arm Causeway (Table 5-4). No snakes were captured at Bush Arm km 79 wetlands, which differ from previous years.

5.1.4 Habitat Data

i) Vegetation Community Associations

We used the habitat types (i.e., the 15 unique vegetation communities) described by Hawkes et al. (2007) to identify habitat associations of amphibians and reptiles in the DDZ of Kinbasket Reservoir in 2012 (Figure 5-5). In 2012, 325 amphibian and reptile observations were documented in 11 habitat types in the DDZ of Kinbasket Reservoir and one immediately adjacent to the DDZ (i.e., the FO or forest community). The most commonly used habitats (based on total observations) were swamp horsetail (SH), wool-grass–Pennsylvania buttercup (WB), and willow–sedge (WS). A substantial number of detections (*n* = 38) were made in the non-classified type (UPL) because detections were outside of the DDZ (i.e., > 754 m ASL) or mapped areas for CLBMON-10.

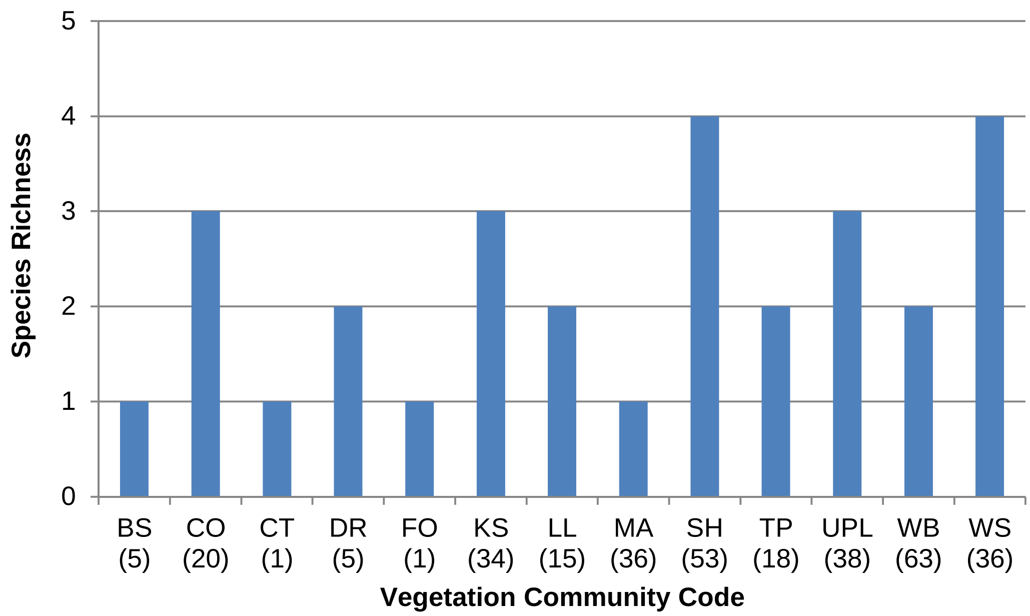

Figure 5-5: Species richness of amphibians and reptiles per habitat type in the drawdown zone of Kinbasket Reservoir in 2012. Numbers in brackets represent total observations per habitat type. BR = bluejoint reedgrass; BS = buckbean-slender sedge, CO = clover–oxeye daisy; CT = cottonwood-trifolium; DR = driftwood; FO = forest; KS = Kellogg's sedge; LL = lady's thumb-lamb's quarter; MA = marsh cudweed–annual hairgrass; SH = swamp horsetail; TP = toadrush-pond water starwort; UPL = upland, not classified; WB = wool-grass–Pennsylvania buttercup; WS = willow–sedge. See Hawkes et al. (2007) for descriptions of each habitat type

Amphibian and reptile observations made in the DDZ were independent of vegetation community type (Figure 5-6). Long-toed Salamanders were documented at Valemount Peatland and Bush Arm Causeway in wetlands in the willow-sedge and clover-oxeye daisy habitat types, respectively. Western Toads were documented from nine of the 15 described vegetation communities, plus non-classified upland habitats. Adult toads were found in both drier (e.g., clover–oxeye daisy, Kellogg's sedge) and wetter habitat types (e.g., swamp horsetail and marsh cudweed–annual hairgrass), which may relate to their variable habitat use and terrestrial nature. Columbia Spotted Frogs were closely associated with the wetland-type habitats described for the DDZ of Kinbasket Reservoir, including wool-grass–Pennsylvania buttercup, swamp horsetail and willow–sedge habitat types. These areas were typified by numerous ponds and supersaturated soils.

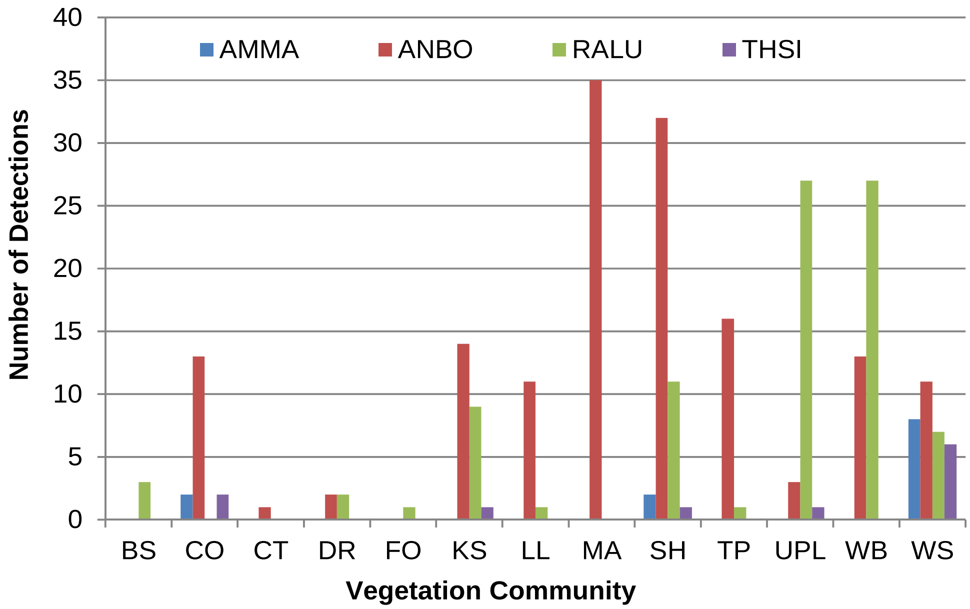

Figure 5-6: **Detections of amphibians and reptiles per habitat type in the drawdown zone of Kinbasket Reservoir in 2012.** BS = buckbean-slender sedge, CO = clover–oxeye daisy; CT = cottonwood-trifolium; DR = driftwood; FO = forest; KS = Kellogg's sedge; LL = lady's thumb-lamb's quarter; MA = marsh cudweed–annual hairgrass; SH = swamp horsetail; TP = toadrush-pond water starwort; WB = wool-grass–Pennsylvania buttercup; WS = willow–sedge; UPL = upland, not classified. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, THSI = Common Garter Snake

Amphibians laid their eggs in ponds within a variety of habitat types in the drawdown zone. Long-toed Salamander eggs are difficult to find due to their small size and inconspicuous placement on submerged vegetation and woody stems; eggs of this species were located in one pond in willow-sedge habitat in the Valemount Peatland and one pond in clover-oxeye daisy at the Bush Arm Causeway. Egg masses for Western Toads and Columbia Spotted Frogs are easier to located, and thus were found in ponds in multiple habitat types (Figure 5-7). Western Toads laid their eggs in a wider variety of habitats than did Columbia Spotted Frogs, which mainly bred in wool-grass–Pennsylvania buttercup and swamp horsetail wetted areas.

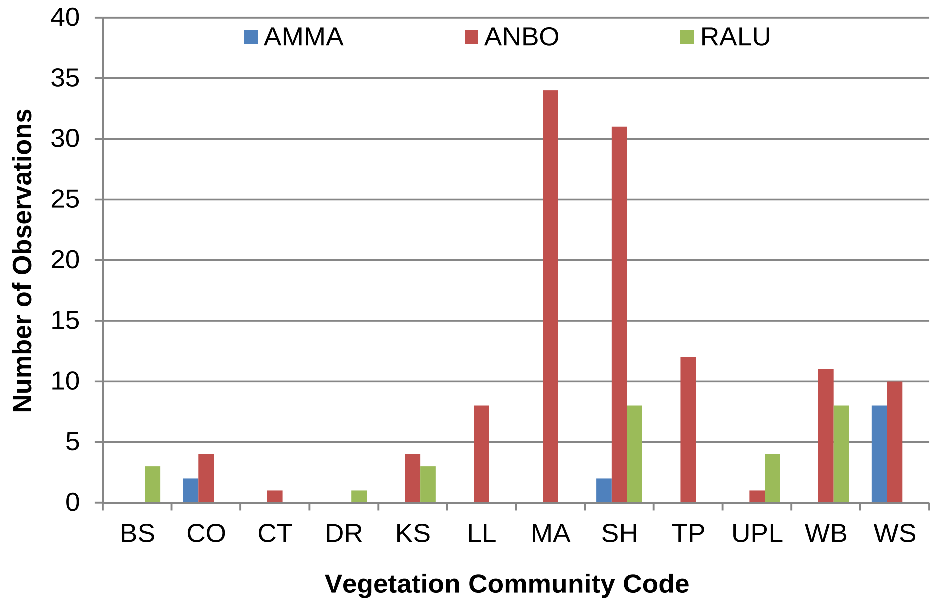

Figure 5-7: **Detections (number of observations) of amphibian breeding locations (egg masses and tadpoles) per habitat type in the drawdown zone of Kinbasket Reservoir in 2012.** BS = buckbean-slender sedge, CO = clover–oxeye daisy; CT = cottonwood-trifolium; DR = driftwood; KS = Kellogg's sedge; LL = lady's thumb-lamb's quarter; MA = marsh cudweed–annual hairgrass; SH = swamp horsetail; TP = toadrush-pond water starwort; WB = wool-grass–Pennsylvania buttercup; WET = unmapped wetland or reservoir in DDZ; WS = willow–sedge. ANBO = Western Toad, RALU = Columbia Spotted Frog

Common Garter Snakes (THSI) were documented in four of the 15 vegetation communities described for the DDZ of Kinbasket Reservoir, occurring in both drier (e.g., clover–oxeye daisy) and wetter habitat types (e.g., swamp horsetail) (Figure 5-6). This species was frequently encountered close to ponds or wetlands within the DDZ, presumably because of foraging opportunities on Western Toad tadpoles and metamorphs, and the structural complexity of these sites provided ample cover habitat.

Vegetation cover (per cent of bare to vegetative ground cover) was common in many of the aquatic and terrestrial habitats in which amphibians and reptiles were observed, presumably because it provided cover from predators or shade for thermoregulation. Common types of emergent vegetation associated with habitats in which amphibians and reptiles were observed included various species of sedge (e.g., *Carex aquatilis*, *C. lenticularis*, *Scirpus* spp.) and horsetail (e.g., *Equisetum arvense*, *E. fluviatile*, *E. palustre*), and an abundance of other species such as common mare's tail (*Hippuris vulgaris*), small yellow pond-lily (*Nuphar luteum*), marsh cinquefoil (*Comarum palustre*), and buckbean (*Menyanthes trifoliata*). Submergent vegetation was typically absent from amphibian breeding ponds but when it did occur included various species of algae and bladderworts, *Potamogeton* spp. (grass-leaved pondweed) and whorled water-milfoil (*Myriophyllum verticillatum*). Common types of terrestrial vegetation growing at sites where species were observed included a wide variety of grasses (e.g., *Phalaris arundinacea*), herbaceous species (fireweed, Douglas water-hemlock, tufted loosestrife, ox-eye daisy), shrubs (hardhack, *Salix* spp.) and poplar trees (*Populus trichocarpa*).

ii) Amphibian Breeding Ponds in the Drawdown Zone

Between 2008 and 2012, 95 ponds were identified in or near the drawdown zone of Kinbasket Reservoir. Most of those ponds were in the Valemount Peatland (n = 39) and Bush Arm (n = 41) (Table 5-7). Five monitoring locations, with 1 to 39 ponds per location, supported breeding populations of amphibians. In 2012, surveys were conducted in spring and early summer when the reservoir was between ~722.65 and ~752.60 m ASL. All ponds within the drawdown zone were inundated by mid-July, and higher than normal reservoir elevations (> 753 m ASL) occurred for the remainder of the summer.

Table 5-7: Number of pond-breeding amphibian ponds in or near the drawdown zone of Kinbasket Reservoir, based on data from Years 1 to 4 of CLBMON-37 and Year 1 of CLBMON-58

Study Location	Number of Ponds		Elevation Range of Ponds (m ASL)	Amphibians Present in 2012
	DDZ	Upland		
Valemount Peatland	39	2	750–756	Western Toads Columbia Spotted Frogs Long-toed Salamanders
Ptarmigan Creek	1	–	749	Western Toads
Bear Island	14	–	734–749	Western Toads Columbia Spotted Frogs
Bush Arm km79	21	1	744–752	Western Toads Columbia Spotted Frogs
Bush Arm Causeway	6	–	751–753	Western Toads Columbia Spotted Frogs Long-toed Salamanders
Sprague Bay	–	11	753–755	Western Toads Columbia Spotted Frogs

Amphibian use of ponds for breeding in the drawdown zone of Kinbasket Reservoir varied by species, pond size and study location. In areas where only one or a few ponds were available (i.e., pond habitat was a limiting factor), Western Toad and Columbia Spotted Frog egg masses were often found in the same ponds. For example, egg masses of both species were found in two of the main wetland ponds in the drawdown zone at Bush Arm Causeway. In other locations, such as Bush Arm km 79 ponds, Bear Island and the Valemount Peatland, where there were more ponds and a greater variety of pond types (e.g., shallow, mud-bottomed vs. deeper vegetated ponds) there was some evidence of pond partitioning between the species. At Bear Island and Bush Arm km 79, Western Toad egg masses were documented in mud-bottomed ponds (with little vegetation) at lower elevations, whereas Columbia Spotted Frogs tended to lay their eggs in ponds with more vegetation and at higher elevations.

iii) Water Physicochemistry

We collected water physicochemistry point data (water temperature, dissolved oxygen, pH and conductivity) from 265 locations within the DDZ of Kinbasket Reservoir in 2012. Of these, 203 were taken from ponds, marshes or the edges of the reservoir where species were either captured or observed, and 62 were taken from areas in which no animal observations were made (Table 5-8). Most amphibians were found in ponds that had dissolved oxygen levels of about 8.37 mg/L; however, Western Toads were typically found in pond areas with higher levels of dissolved oxygen. Water temperature varied greatly across ponds in which amphibian observations were made, from 10.3°C in the spring to 33.1°C in the summer; however, most animals were found in water around 18°C to 23°C.

Table 5-8: Water physicochemistry characteristics of ponds with amphibians in the drawdown zone of Kinbasket Reservoir in 2012. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog

Species	# ponds sampled	Dissolved Oxygen (mg/L)		Conductivity (µS/cm)		pH		Temperature (°C)	
		Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
AMMA	12	7.45	2.08	201.33	148.14	7.63	0.58	17.13	3.61
ANBO	127	8.80	2.65	150.46	109.67	7.77	0.64	18.19	4.43
RALU	64	7.68	3.27	117.62	68.96	7.55	0.44	17.27	5.50
Overall	203	8.37	2.88	143.11	103.06	7.68	0.58	17.84	4.76

Pond characteristics varied between aquatic areas associated with amphibian larval observations and those that were not (Table 5-9). In general, larvae tended to be found in ponds with higher dissolved oxygen levels, slightly higher pH levels, higher conductivity levels, and higher water temperatures.

Table 5-9: Comparisons of water physicochemistry characteristics (mean ± SD) in ponds with or without larval amphibian observations in Kinbasket Reservoir in 2012.

Water Physicochemistry Characteristic	Larvae Observed	No Larvae Observed	*t*-test with unequal variances		
	N = 61	*N* = 107	*t*-stat	df	*P*
Dissolved oxygen (mg/L)	8.72 ± 2.84	7.78 ± 2.07	-2.46	158	**0.0007**
Conductivity (µS/cm)	130.30 ± 92.28	80.13 ± 70.12	-3.93	152	**< 0.001**
pH	7.70 ± 0.61	7.43 ± 0.71	-3.24	147	**0.0007**
Temperature (°C)	18.69 ± 4.83	15.46 ± 4.03	-4.86	136	**< 0.001**

5.1.5 Reservoir Relationships

i) Reservoir Operations

Reservoir operations affect habitat availability and the degree to which specific areas in the drawdown zone are affected depends on the differences in reservoir elevations in any given year, which varies between and among months (Figure 3-1). These differences directly affect spatial and temporal habitat availability in the drawdown zone, which has implications for amphibians and reptiles using those habitats. In 2012, amphibian and reptile sampling was conducted when the reservoir was between ~722.65 m ASL (Field Session 1) and 752.60 m ASL (Field Session 4) (Table 5-10). The elevations of the reservoir increased steadily between May and mid-July and reached a maximum for the summer of 754.68 m (Figure 5-8) on July 20, 2012, approximately one month earlier than 2011.

Table 5-10: Kinbasket Reservoir elevations for each of the field sessions in 2012. m ASL = metres above sea level

Field Session	Dates	Reservoir Elevation (m ASL)		
		Min	Max	Mean
1	April 26–28	722.65	723.14	722.90
2	May 15–19	725.50	726.41	726.01
3	June 7–13	732.19	734.95	733.55
4	July 6–17	766.99	740.04	749.90

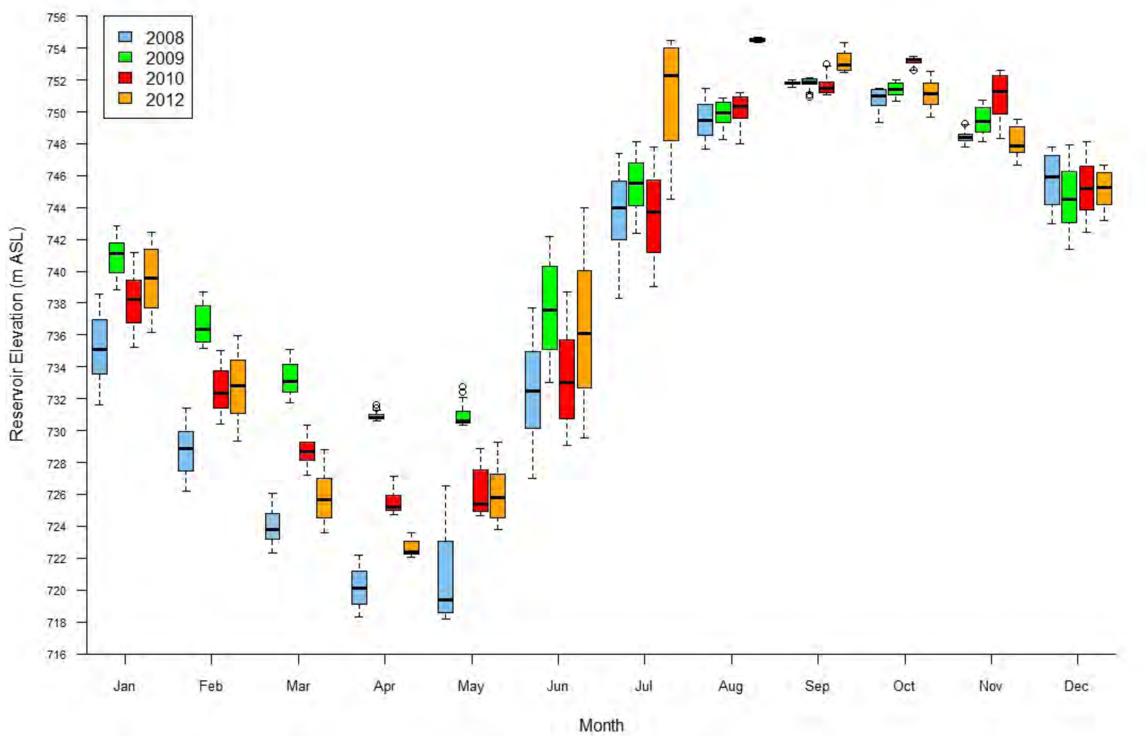

Figure 5-8: Monthly reservoir elevations recorded for Kinbasket Reservoir in 2008, 2009, 2010 and 2012

ii) Reservoir Effects

The operation of Kinbasket Reservoir influences the spatial and temporal availability of habitat for amphibians and reptiles. In 2012, Kinbasket Reservoir was filled beyond the normal operational maximum for the first time in 16 years; the reservoir also reached the highest elevation since creation (Figure 5-9). The frequency at which Kinbasket Reservoir has exceeded full pool is approximately once every 7.4 years, which likely has immediate effects on amphibian populations. The longer-term, and potential population, impacts will be assessed more thoroughly in the 5-yr interim report and as part of CLBMON-58.

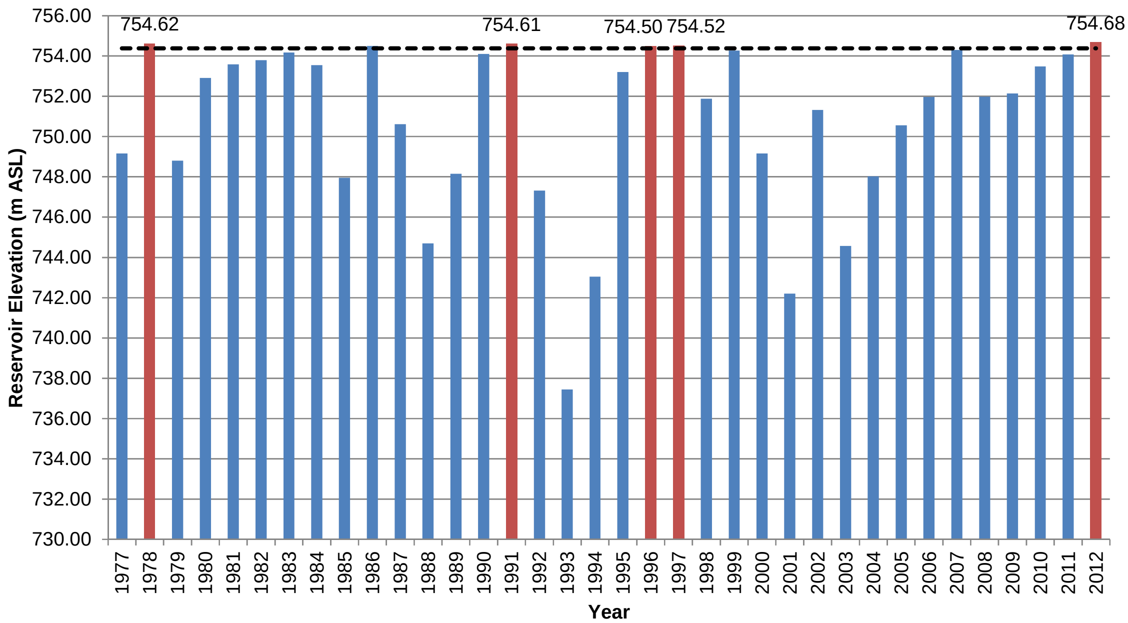

Figure 5-9: Maximum reservoir elevations recorded for Kinbasket Reservoir for the period 1977 through 2012. Numbers above years indicate years during which the reservoir exceeded the normal operation maximum

Kinbasket Reservoir filled more rapidly and reached full pool approximately one month earlier in 2012 than in previous implementation years (2008, 2009 and 2010; Figure 5-10). The relationship between reservoir elevation and habitat availability (i.e., the total area available to amphibians and reptiles during the active season) needs to be assessed relative to the time of year and duration of inundation. This will be assessed in the next implementation year (2013), which will provide an indication of the short-term effects of exceeding the normal operational maximum and in the 5-yr interim report. The latter will assess trends (or the lack thereof) between reservoir operations and habitat availability.

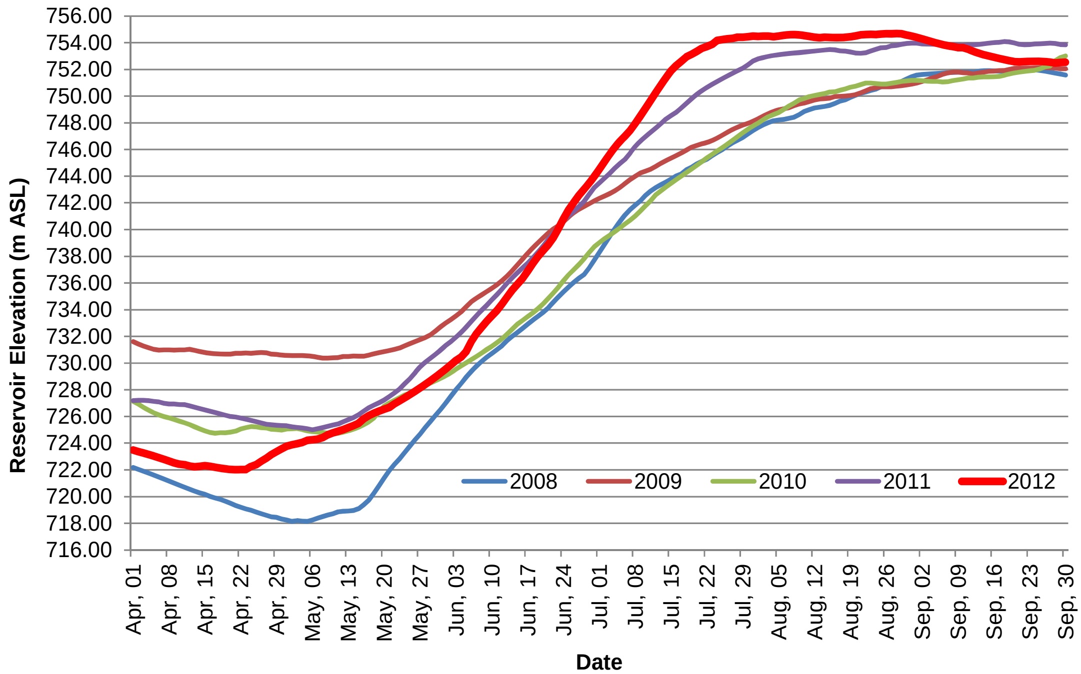

Figure 5-10: Kinbasket Reservoir elevations between April 1 and September 30 in all CLBMON-37 implementation years. 2011 is provided for continuity and because amphibian surveys occurred in that year

5.2 Arrow Lakes Reservoir

5.2.1 Environmental Data

Environmental conditions in Arrow Lake Reservoir were well within the ranges necessary for amphibian and reptile detection (Olson 1999; Hawkes and Gregory 2012; Table 5-11).

Table 5-11: Air temperature and precipitation conditions[1] for Arrow Lakes Reservoir during the 2012 field sessions. Precipitation values are totals by session and by month (session 2 through 4 only)

Field Session	Dates	Temperature (°C)				Precipitation (mm)	
		Min	Max	Mean	Monthly Mean	Session	Monthly
1	April 26–May 6	-1.40	15.30	6.79	9.20	19.60	47.80
2	Jun 14–18	4.40	21.00	11.11	12.35	67.60	192.40
3	Jul 18–25	9.30	32.20	16.90	18.05	41.20	73.80
4	Aug 18–24	7.00	33.80	17.40	17.76	21.00	53.60

[1]Data obtained from BC Wildfire Management Branch

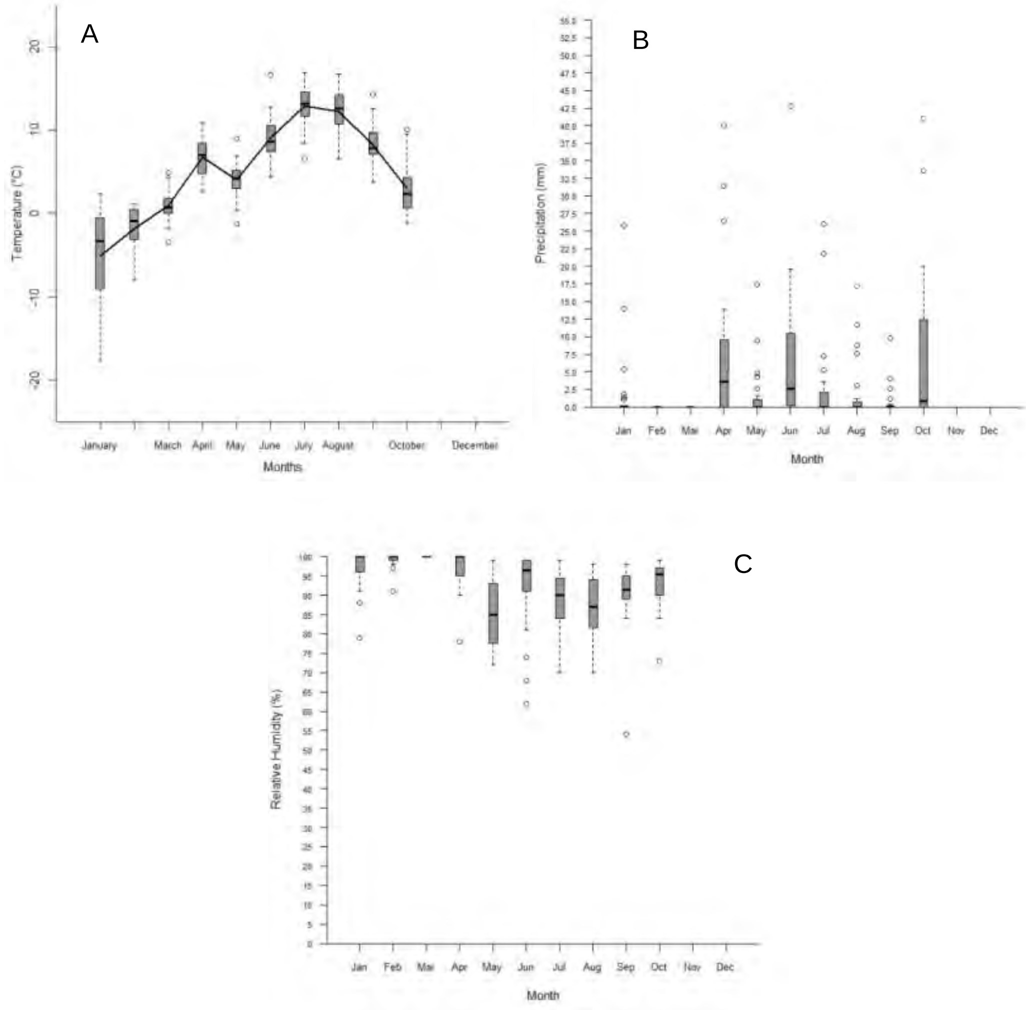

Figure 5-11: Environmental conditions for Kinbasket Reservoir in 2012 (January through October only). A: Air Temperature (°C) (with average); B: Precipitation (mm); and C: Relative humidity (per cent). Field work for CLBMON-37 occurred between April and August. Data source = BC Wildfire Management Branch

5.2.2 Survey Data

i) Site Occupancy

Four species of amphibians and four species of reptiles were observed in the DDZ of Arrow Lakes Reservoir in 2012 (Table 5-12). Montana Slough, and Revelstoke Reach in general, had the highest species diversity and site occupancy. Western Toads and Pacific Chorus Frogs occupied most of the sites surveyed and accounted for most of the observations. Long-toed Salamander egg masses and adults were observed in Cartier Bay, Revelstoke Reach. Painted turtles were studied in Revelstoke Reach as part of CLBMON-11B3 and location data are provided in this report (see section 5.2.3v). Northern Alligator Lizards and both species of garter snake occurred in the DDZ of Arrow Lakes

Reservoirs in 2012; however, Western Skink and Rubber Boa were notably absent this year.

Table 5-12: Site occupancy of amphibians and reptiles observed in the drawdown zone of Arrow Lakes Reservoir in 2012. AMMA = Long-toed Salamander, ANBO = Western Toad, PSRE = Pacific Chorus Frog, RALU = Columbia Spotted Frog, CHPI = Painted Turtle; ELCO = Northern Alligator Lizard, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake

Study Area	Survey Location	AMMA	ANBO	PSRE	RALU	CHPI	ELCO	THEL	THSI
Revelstoke	12 mile		X	X				X	X
Reach	9 mile		X	X					X
	Airport Marsh		X	X		X			
	Cartier Bay	X	X	X		X			
	Downie Marsh		X					X	X
	Machete Island			X					
	Montana Slough		X	X	X	X	X	X	X
Mid Arrow	Beaton Arm		X	X	X				
	Burton Creek		X	X	X			X	
Lower Arrow	Edgewood North		X	X				X	
	Edgewood South						X		
	Lower Inonoaklin			X	X			X	
	HK Dam Area			X					

ii) Detection Rates

Between April and August there were 182 observations of amphibians and reptiles within the DDZ of Arrow Lakes Reservoir (Table 5-13; 151 h 36 min over 36 days) for a total of more than 360,000 individuals across multiple life stages (see Table 5-4 for a breakdown by life stage).

Table 5-13: Total survey time (hours:minutes) and species detections by survey location for Arrow Lakes Reservoir in 2012. Blanks indicate the species was not detected. AMMA = Long-toed Salamander, ANBO = Western Toad, PSRE = Pacific Chorus Frog, RALU = Columbia Spotted Frog, CHPI = Painted Turtle, ELCO = Northern Alligator Lizard, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake. CPUE (catch per unit effort) = the number of detections per site and per species divided by the survey time

Survey Location	Time	AMMA	ANBO	PSRE	RALU	CHPI	ELCO	THEL	THSI	Total	CPUE
Beaton Arm	16:40		9	2	5					16	0.96
Burton Creek	12:30		1	1	4			1		7	0.56
Edgewood	11:28			1	3	1		3		8	0.70
HK Dam	3:30			3						3	0.86
Lower Inonoaklin	5:40		5	1						6	1.06
Mosquito Creek	2:10										0.00
Revelstoke Reach	99:38	2	81	15	1	6	2	6	29	141	1.42
Totals	**151:36**	**2**	**96**	**23**	**13**	**7**	**2**	**10**	**29**	**182**	**1.20**
CPUE (# hours)	**151.6**	**0.01**	**0.63**	**0.15**	**0.09**	**0.05**	**0.01**	**0.07**	**0.19**	**1.20**	

Detection rates (number of detections per hour) varied across sites: rates were influenced by a number of factors, including life stage, time of day, weather conditions, habitat type, season and elevation. To assess site-by-species relationships, we pooled all life stages to identify sites where the detection of a given species was the highest regardless of age class (Figure 5-12). Revelstoke Reach and Beaton Arm had relatively consistently high rates of detection for amphibians and reptiles.

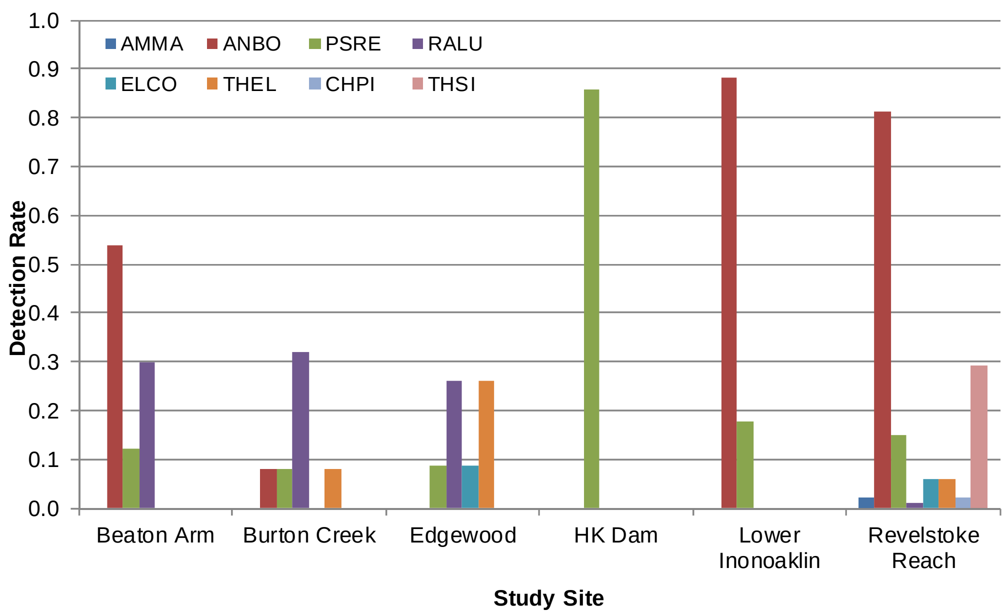

Figure 5-12: Detection rates for amphibian and reptile species in Arrow Lakes Reservoir in 2012. Detection rate = the number of times a species was detected (all life stages pooled)/the total time spent searching at a study site. AMMA = Long-toed Salamander, ANBO = Western Toad, PSRE = Pacific Chorus Frog, RALU = Columbia Spotted Frog, CHPI = Painted Turtle, ELCO = Northern Alligator Lizard, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake

iii) Seasonal and Geographic Distribution

In 2012, we documented more than 10,000 individual (metamorph, juvenile or adult) amphibians and reptiles of eight species in Arrow Lakes Reservoir. Over a hundred egg masses and approximately 350,000 (90 per cent of which were Western Toads at two sites) tadpoles and larvae of the three amphibian species were observed (Table 5-14). Adults of all four amphibian species were also documented during the breeding season; however, Western Toads were by far the most abundant species in this life history stage. We documented the presence of four reptile species, with Common Garter Snake the most encountered species in the drawdown zone. The most abundant species were Western Toad, Pacific Chorus Frog and Common Garter Snake. Amphibians and reptiles were found in all months during which surveys were conducted in 2012. Revelstoke Reach, Beaton Arm and Burton Creek were the most productive sites with respect to both the number of species and the number of individuals observed. Maps of all Arrow Lakes Reservoir animal observations are provided in Appendix 9-2.

The first field visit to Arrow Lakes Reservoir was timed for early May 2012 to coincide with the breeding and egg laying period for amphibians. No snow remained on the ground and all of the ponds had thawed; however there was little to no vegetation growing in the drawdown zone. In early May, we recorded numerous egg masses and tadpoles of Western Toads in ponds within the DDZ, which indicated that breeding was taking place in those areas. Long-toed Salamanders were only observed in Revelstoke Reach, with over 100 salamander egg masses found in the large eastern pond at Cartier Bay, thus indicating that quite a few individuals were breeding in the area. Most Western Toad tadpole sightings were made from May and July, whereas most adults were observed during road surveys in May and were largely absent in the drawdown zone for the remainder of the season. Both species of snakes were observed and captured in the spring and summer months, although our ability to detect snakes likely declined as vegetation height increased throughout the summer.

The number of observations declined throughout the summer for most species. It is likely that tadpole metamorphosis occurred for most sites in July. Numerous newly emerged Western Toad metamorphs were observed at Cartier Bay and Beaton Arm, but absent from the remainder of sites. Northern Alligator Lizards were surveyed in July; several individuals were documented basking in the riprap boulders that line the reservoir edge near Montana Slough and Cartier Bay.

In late June, reservoir levels at the sites were nearing the maximum height for 2012, and the entire previously available habitat was inundated; this timing is was much earlier for full pool than in previous years. This reduced the amount of area that could be searched to zero in several locations, including most sites in Revelstoke Reach, Burton and Edgewood, and we located very few animals than on previous surveys in Arrow Lakes Reservoir. Water levels dropped by the August field session, however very few animals were documented from the drying drawdown zone areas. We made quite a few turtle observations in September as part of CLBMON-11B3, but few other animals were noted during that time span.

Table 5-14: Geographic and seasonal distribution of amphibians and reptiles by life stage for Arrow Lakes Reservoir in 2012. Blanks indicate the life stage or species was not detected. AMMA = Long-toed Salamander, ANBO = Western Toad, PSRE = Pacific Chorus Frog, RALU = Columbia Spotted Frog, CHPI = Painted Turtle, ELCO = Northern Alligator Lizard, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake. EM = Egg mass, T = Tadpole (no. of tadpoles of each species was estimated), M = Metamorph, J = Juvenile, A = Adults

Geographic Distribution																	
	AMMA		ANBO				PSRE			RALU			ELCO	CHPI	THEL	THSI	
Survey Location	**EM**	**A**	**EM**	**T**	**M**	**J/A**	**EM**	**T**	**A**	**EM**	**T**	**J/A**	**A**	**J/A**	**J/A**	**J/A**	**Total**
RR_12 mile						1			2						2	9	14
RR_9 mile			59	50000		8			1					10		4	50082
RR_Airport Marsh						2											2
RR_Cartier Bay	100	1	11	200202		28	3		2					1			200348
RR_Downie Marsh			1	2000											3	14	2018
RR_Machete Island									6								6
RR_Montana Slough			2	510	3	2		1	3			1	6	11	1	2	542
Revelstoke Reach						21			3					45			69
Beaton Arm			20		10050	43			2	5		2					10122
Burton Creek				500					1	2		3			1		507
Edgewood								25		2	25	1	1		3		57
Lower Inonoaklin									3								3
HK Dam Area			2	100000		3			1								100006
Total # individuals	100	1	95	353212	10053	108	3	26	24	9	25	7	7	67	10	29	363776
Seasonal Distribution																	
April	100	1	1			30			8								140
May			94	300500	50	70	3	1	10	9		4		1		5	300747
June				2500		8		25	3		25	3		3	7	22	2596
July				50212	10002								6	15	2	14	60236
August					1								1	15	1	1	4
September						1								33			1
Total # individuals	100	1	95	353212	10053	108	3	26	24	9	25	7	7	67	10	29	363776

iv) Elevation Distribution

Amphibians and reptiles of all species and life stages were found across a wide range of elevations in Arrow Lakes Reservoir in 2012 (Figure 5-15). Most observations (all life stages combined) were between 436 and 444 m ASL. Observations of Western Toads (ANBO) and Pacific Chorus Frogs (PSRE) spanned the largest range of elevations, while observations of Long-toed Salamanders (AMMA) spanned the smallest range (occurring at only one location in 2012). Northern Alligator Lizards (ELCO) occurred mainly in the rip rap armouring the highway adjacent to Revelstoke Reach, but were also observed in the drawdown zone at Cartier Bay, Lower Inonoaklin Road, and Edgewood South. Western Painted Turtles (CHPI) were observed in several locations within Revelstoke Reach, primarily Airport Marsh and Montana Slough and occupied a narrow range of elevations. Both species of garter snake were caught in and adjacent to the drawdown zone of Arrow Lakes Reservoir and occurred over a similar range of elevations.

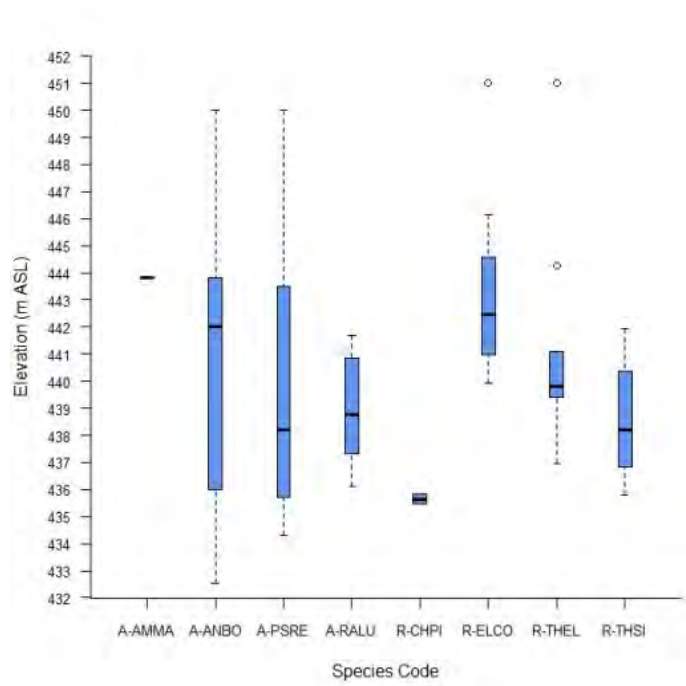

Figure 5-13: Elevation distribution of amphibians and reptiles (number of observations, all life stages combined) documented in the drawdown zone regions of Arrow Lakes Reservoir in 2012. The boxes represent 25 per cent and 75 per cent of the ranked data (see section 4.4). The horizontal line inside the box is the median. The length of the boxes is their interquartile range. Whiskers are drawn from the top of the box to the highest observation within 1.5 interquartile range of the top, and from the bottom of the box to the lowest observation within 1.5 interquartile range of the bottom of the box. Open circles are outlier data points for box and whisker plot definitions. A-AMMA = Long-toed Salamander, A-ANBO = Western Toad, A-PSRE = Pacific Chorus Frog; A-RALU = Columbia Spotted Frog, R-CHPI = Western Painted Turtle; R-ELCO = Northern Alligator Lizard; R-THEL = Western Terrestrial Garter Snake; R-THSI = Common Garter Snake

5.2.3 Species Data

i) Western Toad (ANBO)

Nearly 100 observations of Western Toads were made in the drawdown of Arrow Lakes Reservoir in 2012. In addition to the 76 egg masses, thousands of tadpoles (*n* = ~300,000) and metamorphs (I = ~10,000) documented from several dense aggregations, we observed three juvenile and 85 adult toads through a combination of time-constrained and nocturnal searches. The survey sites with significant Western Toad activity were Revelstoke Reach (Montana Slough, Cartier Bay and 9 mile), Beaton Arm and Burton Creek. Adult Western Toads averaged 84.7 ± 8.6 SD mm SUL (range = 69–112 mm SUL) and weighed 72.4 ± 29.9 SD g. Adult females were significantly larger than males in both body length and weight (Table 5-15).

Table 5-15: Average body size (SUL) and weight (Mass) comparisons for male and female Western Toads captured in Arrow Lakes Reservoir in 2012. SUL = snout-urostyle length (mm), Mass (g), SD = standard deviation

Sex	Number	SUL	SD	Mass	SD
F	12	99.2	8.6	120.1	23.1
M	45	80.9	6.9	59.1	13.3
Total	57	84.7	10.4	72.4	29.9

The spring survey period overlapped with the prime migration and breeding time for Western Toads depending on the location. We observed breeding individuals (amplexus pairs ~43, plus single males) and egg laying (strings of eggs), with more than 51 dense clusters of string egg masses found in early May at Beaton Arm, as well as in smaller numbers at Lower Inonoaklin and in Revelstoke Reach. Twenty-seven adults were documented during nocturnal road surveys in Revelstoke Reach along Airport Road. Road traffic was documented for the timing of surveys and four road mortalities were recorded during those times. Breeding areas in Revelstoke Reach can be characterized as shallow, muddy bottomed ponds with very little submergent vegetation, usually in reed canarygrass landscapes within the DDZ; however, the largest number of egg masses observed in 2012 was in the pond lily wetland with abundant vegetation in Beaton Arm. Western Toads also used the shallow, mud-bottomed pond at Lower Inonoaklin and the human-altered gravel ponds at Burton Creek.

Inundation of breeding ponds occurred in late May, and toad tadpoles (Gosner stage 25–30) were observed along the sheltered edges of the reservoir, hidden in the vegetation. The most productive sites for egg mass and toad activity in 2012 were Beaton Arm and Cartier Bay (Revelstoke Reach; Table 5-16). In late July, thousands of toad tadpoles (Gosner stage 36–43) were observed at the same time as some newly emerged metamorphs (Gosner stage 44–46) in Cartier Bay, indicating asynchrony of breeding, hatching, development/growth or metamorphosis.

Table 5-16: Western Toad observations by life stage in Arrow Lakes Reservoir in 2012

	Life Stage Numbers		
Location	**Egg Masses**	**Tadpoles**	**Metamorphs**
9 mile	69	~50,000	No obs
Cartier Bay	11	~200,000	~5,000
Downie Marsh	1	~2,000	No obs
Montana Slough	2	~500	3
Beaton Arm	20	~50,000	~10,000
Burton Creek	No obs	~500	No obs
Lower Inonoaklin	2	~100,000	No obs

Toads were typically observed in or near shallow, muddy ponds, in dense shoreline vegetation, under logs and other forms of woody debris on land near the reservoir edge, and on dirt or paved roads around the reservoir. Metamorphs were typically found by the thousands near the edges of the reservoir (Cartier Bay), either in the water amongst the vegetation (e.g., reed canarygrass) or immediately adjacent to the water on shore in the grass duff layer or sedge vegetation.

ii) Columbia Spotted Frog (RALU)

Columbia Spotted Frogs (*n* = 51) were not documented as frequently in Arrow Lakes as in Kinbasket Reservoir in 2012. Most observations of this species were either egg masses (*n* = 9), tadpoles (*n* = 25), or juveniles (*n* = 3). Spotted frog egg masses were observed at Beaton Arm (*n* = 5), Burton Creek (*n* = 2) and Edgewood south (*n* = 2), and tadpoles (Gosner stage = 31) were observed at Edgewood south. No Columbia Spotted Frogs were captured and only one adult was observed at Burton Creek. Most Columbia Spotted Frogs were documented in or near water, including the upper pond at Beaton Arm, the small cobble bottomed pond at Edgewood, and the wetland stream at Burton Creek. Typical habitat included shallow marsh areas with abundant emergent sedge vegetation around the periphery of small open patches of water.

iii) Pacific Chorus Frog (PSRE)

Pacific Chorus Frogs were rarely visually observed in the DDZ of Arrow Lakes Reservoir in 2012; however, diurnal and nocturnal auditory records were made for several sites including at nocturnal call stations. In late April and early May, we recorded calling males from seven of the nine established nocturnal call stations in Revelstoke Reach (Table 5-17). At some locations, the number of calling individuals could be easily counted (i.e., < 10 males per location), whereas at other sites, choruses of more than 100 individuals were documented. Egg masses were only found at Cartier Bay (*n* = 3); however tadpoles were observed in Montana Slough (*n* = 10) and in the small pond at Edgewood South (*n* = ~25).

Table 5-17: Amphibian nocturnal call station records for Revelstoke Reach in Arrow Lakes Reservoir in 2012. Wisconsin Calling Index: 0 = no calls, 1 = individual calls can be counted, 2 = calls are overlapping but still distinguishable, and 3 = full chorus where individuals cannot be distinguished

Call Station	Survey Site	UTM Coordinates Zone	Easting	Northing	Wisconsin Index	# males
1	Site 1 & 2	11	413849	5651107	0	0
2	Big Eddy	11	414547	5650171	1	1
3	Downie Marsh	11	415250	5648974	1	1
4	Machete Island	11	415689	5648099	3	> 100
5	Airport Marsh	11	417346	5645647	3	25–50
6	Montana Slough	11	418830	5644166	3	~ 100
7	Cartier Bay	11	418863	5643200	2	10–20
8	9 mile	11	420696	5639278	0	0
9	12 mile	11	422681	5635573	3	50–100

During nocturnal road surveys and visual encounter surveys, we captured eight adult males ranging in size from 33.2 to 45.2 mm SUL. Most Pacific Chorus Frogs were documented in reed canarygrass habitats that often contained various willow species.

iv) Long-toed Salamander (AMMA)

Two main observations of this species were made in 2012: approximately 100 egg masses and one adult. The single adult (116 mm total length) was found moving away from the drawdown zone on Airport Road, near Cartier Bay in Revelstoke Reach. This is the same location where this species had been observed in previous years; however, significantly more individuals were noted in other years. The numerous small egg masses were found in the main pond of Cartier Bay, along the eastern shoreline, attached to small pieces of submergent vegetation. This was the first observation of this species in the actual drawdown zone of Arrow Lakes.

v) Painted Turtle (CHPI)

We observed over 60 Painted Turtles within the DDZ of Revelstoke Reach during 2012 (n = 66), most of which were documented as part of CLBMON-11B3. Twenty one were documented in the drawdown zone in Airport Marsh, Montana Slough or Cartier Bay, and 45 were observed in either Williamson Lake or Turtle Pond, both of which are outside of the drawdown zone. Most observations were adult individuals (n = 58); however a few juveniles were spotted in Turtle Pond (n = 8), and one nest was located at Williamson Lake. Nesting surveys were not conducted in 2012 for the known nesting site on Red Devil Hill. Most of the turtles were observed in July, when the reservoir levels and ambient temperatures were high. Turtles were frequently seen using basking logs near the edges of the reservoir, most notably in the willow vegetation near the mouth of Montana Creek.

vi) Northern Alligator Lizard (ELCO)

We observed seven Northern Alligator Lizards in 2012. Captured lizards (n = 2) ranged in size from 121 to 157 mm total length; one of which was an obviously gravid female who weighed 11 g. Most lizards were observed in the rocky slope areas ~5–20 m from the DDZ in Revelstoke Reach (Cartier Bay) or under cover in the rocky slope near the DDZ at Edgewood North.

vii) Common Garter Snake (THSI)

Twenty-four observations of Common Garter Snakes were made in or near the drawdown of Arrow Lakes Reservoir in 2012, a much lower number than in previous years. We captured 5 juveniles and 13 adults from May to August, with most of the observations and captures being made in the spring. Common Garter Snakes were observed in marsh areas with abundant grass or vegetation cover (e.g., horsetail, willows); all captures were made in Revelstoke Reach (Table 5-14).

Captured snakes ranged in size from 245 to 745 mm snout vent length. Juveniles were on average 293 mm SVL and adults 558 mm SVL, with females larger than males. All of the females captured were gravid, and egg counts ranged from four to ten eggs. Three snakes that were captured had food in their stomachs.

viii) Western Terrestrial Garter Snake (THEL)

Western Terrestrial Garter Snakes (*n* = 10) were observed on several occasions (Table 5-14), mostly outside of the DDZ in Arrow Lakes Reservoir. Seven captures were made including several life stages: two neonates (165 to 215 mm snout-vent length); one juvenile (290 mm SVL); and four adults (average 448 mm SVL). Both adult female snakes were gravid with 6 to 7 eggs. None of the captured snakes had food in their stomachs. Most snakes were observed basking at the edge of the road or near vegetation cover.

5.2.4 Habitat Data

i) Vegetation Community Associations

We used the habitat types described by Enns et al. (2007) to describe the habitat associations of amphibians and reptiles documented in the drawdown zone of Arrow Lakes Reservoir. A substantial number of observations were made in the non-classified type (UPL) outside the DDZ or mapped areas (> 440 m ASL). In 2012, a total of four amphibian species and four reptile species were documented in 11 habitat types in the drawdown zone of Arrow Lakes Reservoir. The most commonly used habitats were reed canarygrass-lenticular sedge mesic habitat type (PC), reed canarygrass-redtop upland (PA) and non-classified habitat (NC) which included the spring road survey data (Figure 5-14).

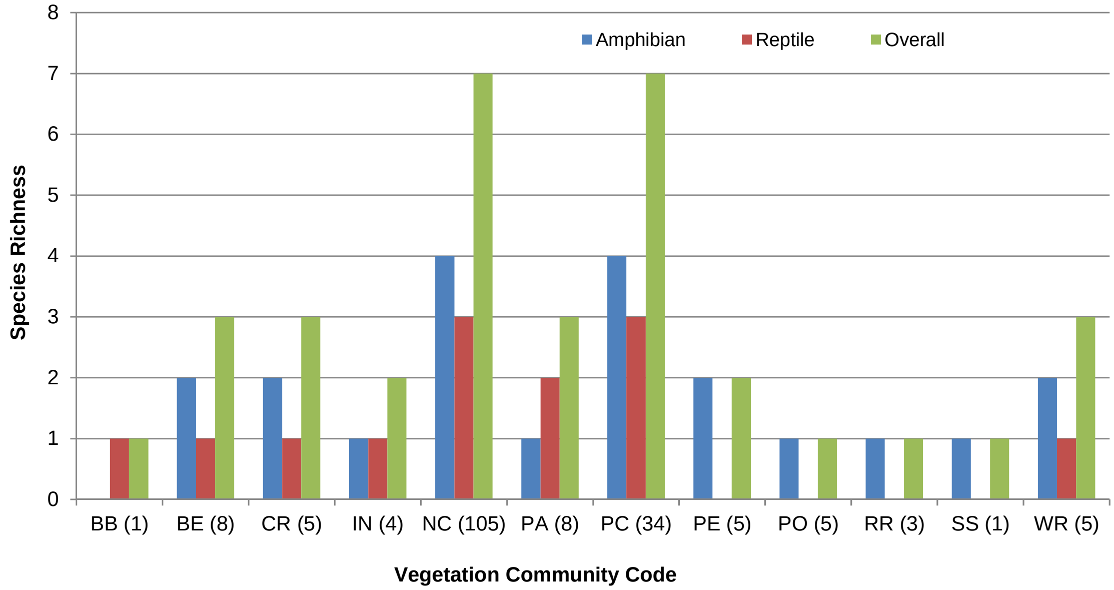

Figure 5-14: Species richness of amphibian and reptile documented in the drawdown zone of Arrow Lakes Reservoir in 2012. BB = Non-vegetated boulders, steep; BE = non- to sparsely vegetated sands or gravels; CR = cottonwood-riparian; IN = Industrial/Recreational/Residential; NC = not classified; PA = reed canarygrass-redtop upland; PC = reed-canarygrass-lenticular sedge mesic; PE = reed canarygrass-horsetail middle to lower slope; PO = waterlily-potamogeton open water; RR = rush wet sites / seepage / rill ; RS = willow–red-osier dogwood stream entry; SS = non-vegetated sand and/or gravels; WR = willow-silverberry river. Numbers in brackets represent total observations per habitat type

Different species assemblages were documented across the different habitat types (Figure 5-15). Western Toads were documented from eight of the 14 described vegetation communities, plus non-classified upland habitats. Adult toads were found in both drier (e.g., sparsely vegetated sands or gravels) and wetter habitat types (e.g., waterlily-potamogeton open water and wetlands within reed-canarygrass-lenticular sedge), which may relate to their variable habitat use and terrestrial nature. Columbia Spotted Frogs were closely associated with the wetland-type habitats of Arrow Lakes Reservoir, including rush wet sites / seepage / rill and willow–silverberry river habitat types. Pacific Chorus Frogs were also associated with both drier and wetter habitat types, but they were most common in the reed canarygrass flats in Revelstoke Reach.

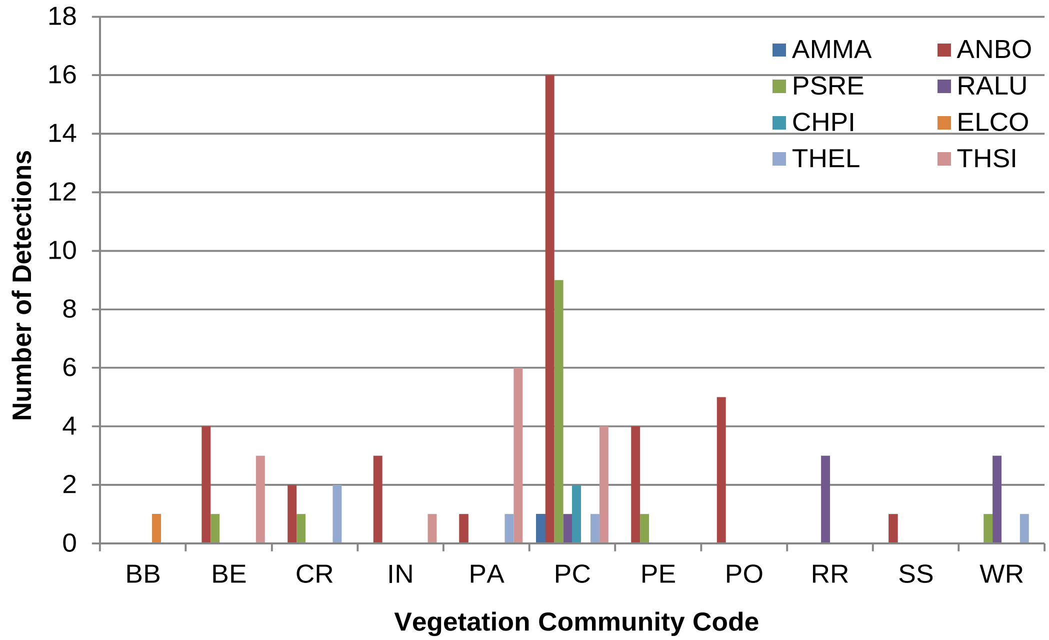

Figure 5-15: Detections of amphibians and reptiles per habitat type in the drawdown zone of Arrow Lakes Reservoir in 2012. BB = Non-vegetated boulders, steep; BE = non- to sparsely vegetated sands or gravels; CR = cottonwood-riparian; IN = Industrial/Recreational/Residential; PA = reed canarygrass-redtop upland; PC = reed-canarygrass-lenticular sedge mesic; PE = reed canarygrass-horsetail middle to lower slope; PO = waterlily-potamogeton open water; RR = rush wet sites / seepage / rill; SS = non-vegetated sand and/or gravels; WR = willow-silverberry river. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog, PSRE = Pacific Chorus Frog, CHPI = Painted Turtle, ELCO = Northern Alligator Lizard, THEL = Western Terrestrial Garter Snake, THSI = Common Garter Snake

Long-toed Salamander eggs were difficult to find due to their small size and inconspicuous placement on submerged vegetation and woody stems; eggs of this species were located in one pond in reed canarygrass-lenticular sedge habitat in Cartier Bay. Similarly, egg masses for Pacific Chorus Frogs are also small and inconspicuous, and we made only a couple of observations of grape-sized egg masses attached to reed canarygrass in Cartier Bay. Egg masses for Western Toads and Columbia Spotted Frogs were easier to located, and thus were found in ponds in multiple habitat types.

Common (THSI) and Western Terrestrial (THEL) Garter Snakes were documented in six of the vegetation communities described for Arrow Lakes Reservoir, occurring in both drier (e.g., sparsely vegetated sands or gravels) and wetter habitat types (e.g., wetlands within reed-canarygrass-lenticular sedge). Common Garter Snakes were usually encountered close to ponds or wetlands, presumably because it could forage on Western Toad tadpoles and metamorphs, and the structural complexity of these sites provided ample escape habitat. Western Terrestrial Garter Snakes were found further from water and the drawdown zone, as this species is considered more of an upland species.

Vegetation cover (per cent of bare to vegetative ground cover) was common in many of the aquatic and terrestrial habitats in which amphibians and reptiles were observed, presumably because it provided cover from predators or shade for thermoregulation. Common types of emergent vegetation associated with habitats in which amphibians and reptiles were observed included various species of sedge (e.g., *Carex aquatilis*, *C. lenticularis*, *Scirpus* spp.) and horsetail (e.g., *Equisetum arvense*, *E. fluviatile*, *E. palustre*), and an abundance of other species such as small yellow pond-lily (*Nuphar luteum*), marsh cinquefoil (*Comarum palustre*), and water smartweed (*Polygonum amphibium*). Submergent vegetation was typically absent from amphibian breeding ponds but when it did occur included various species of algae and bladderworts, *Potamogeton* spp. (grass-leaved pondweed) and whorled water-milfoil (*Myriophyllum verticillatum*). Common types of terrestrial vegetation growing at sites where species were observed included a wide variety of grasses (e.g., *Phalaris arundinacea*, *Calamagrostis canadensis*), herbaceous species (knapweed, hawkweed, vetches and clovers, ox-eye daisy), shrubs (*Spirea alba*, *Salix* spp., Thimbleberry) and poplar trees (*Populus trichocarpa*).

ii) Water Physicochemistry

In 2012, we collected water physicochemistry point data (water temperature, dissolved oxygen, pH and conductivity) from 102 locations within the DDZ of Arrow Lakes Reservoir. Of these, 64 water measurements were taken from ponds, marshes or the edges of the reservoir where species were either captured or observed, and 39 measurements were taken from areas in which no animal observations were made (Table 5-18). Most amphibians were found in ponds that had dissolved oxygen levels of about 8.16 mg/L; however, Western Toads were typically found in pond areas with higher levels of dissolved oxygen. Water temperature varied greatly across ponds in which amphibian observations were made (9.8°C to 23.7°C); however, most of the observations of amphibians were made in the spring resulting in a lower average water temperature than expected.

Table 5-18: Water physicochemistry characteristics of ponds in the drawdown zone of Arrow Lakes Reservoir in 2012. AMMA = Long-toed Salamander, ANBO = Western Toad, RALU = Columbia Spotted Frog

Species	# ponds sampled	Dissolved Oxygen (mg/L)		Conductivity (µS/cm)		pH		Temperature (°C)	
		Mean	±SD	Mean	±SD	Mean	±SD	Mean	±SD
AMMA	1	10.67	N/A	59.00	N/A	9.80	N/A	18.60	N/A
ANBO	34	8.43	1.55	88.76	61.52	8.09	0.63	17.22	3.92
PSRE	16	8.21	1.39	79.50	36.30	7.87	0.42	15.28	3.08
RALU	13	7.40	0.62	86.92	35.77	8.17	1.41	13.68	2.48
Overall	64	8.16	1.41	86.03	50.96	8.05	0.81	16.00	3.71

Pond characteristics varied between aquatic areas that were associated with amphibian larval observations and those that were not (Table 5-19). In 2012, there was a significant difference only in conductivity between water bodies with or without amphibian larval species.

Table 5-19: Comparisons of water physicochemistry characteristics (mean ± standard deviation) in ponds with or without larval amphibian observations in Arrow Lakes Reservoir in 2012. *P* values in bold indicate a significant difference based on an alpha rejection criterion of 0.05

Water Physicochemistry Characteristic	Larvae Observed	No Larvae Observed	*t*-test with unequal variances		
	N = 41	*N* = 39	*t*-stat	df	*P*
Dissolved oxygen (mg/L)	8.33 ± 1.55	7.95 ± 3.23	0.67	54	0.251
Conductivity (µS/cm)	92.49 ± 58.49	127.95 ± 122.03	-1.64	54	**0.050**
pH	8.02 ± 0.65	8.11 ± 0.50	-0.73	76	0.235
Temperature (^{o}C)	16.43 ± 3.66	16.14 ± 4.88	0.29	70	0.383

5.2.5 Reservoir Relationships

i) Reservoir Operations

Reservoir operations affect habitat availability and the degree to which specific areas in the drawdown zone are affected depends on the differences in reservoir elevations in any given year and month (Figure 3-4). The variable manner in which Arrow lakes Reservoir has been operated since the inception of this monitoring program will likely make it difficult to assess the relationship between reservoir operations and habitat availability. These differences directly affect spatial and temporal habitat availability in the drawdown zone, which has implications for amphibians and reptiles using those habitats. In 2012, amphibian and reptile sampling was conducted when the reservoir was between ~428.62 m ASL (Field Session 1) and 440.41 m ASL (Field Session 3; Table 5-20). The elevations of the reservoir increased steadily between April and early-July and reached a maximum for the summer of 440.53 m (Figure 5-16) on July 11, 2012, approximately one month earlier than in 2011.

Table 5-20: Arrow Lakes Reservoir elevations for each of the field sessions in 2012. m ASL = metres above sea level

Field Session	Dates	Reservoir Elevation (m ASL)		
		Min	Max	Mean
1	April 29–May 6	428.62	429.38	429.00
2	Jun 14–18	436.14	437.26	436.66
3	Jul 18–25	440.38	440.41	440.66
4	Aug 18–24	437.85	438.85	438.86

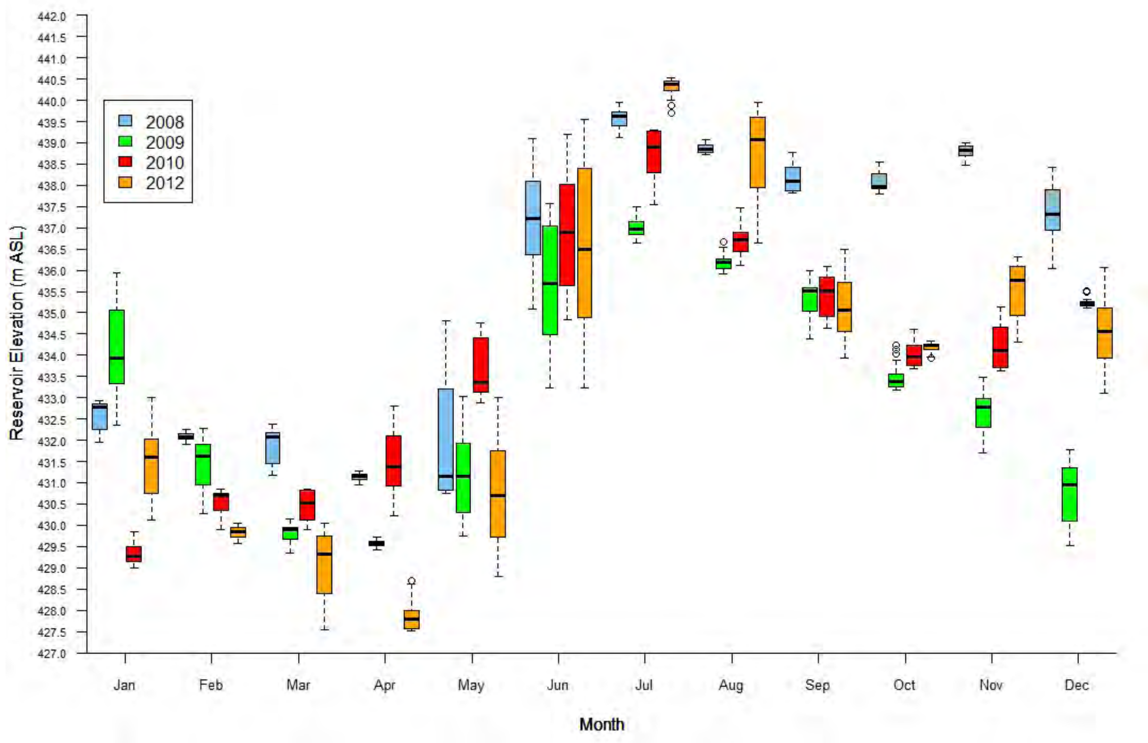

Figure 5-16: Monthly reservoir elevations recorded for Arrow Lakes Reservoir in 2008, 2009, 2010 and 2012

ii) Reservoir Effects

The operation of Arrow Lakes Reservoir influences the spatial and temporal availability of habitat for amphibians and reptiles. Arrow Lakes Reservoir has been operated above full pool 14 times since reservoir creation (Figure 5-17). In 2012, Arrow Lakes Reservoir was filled beyond the normal operational maximum for the first time in 21 years (Figure 5-17). The longer-term and potential population impacts will be assessed more thoroughly in the 5-yr interim report in 2013.

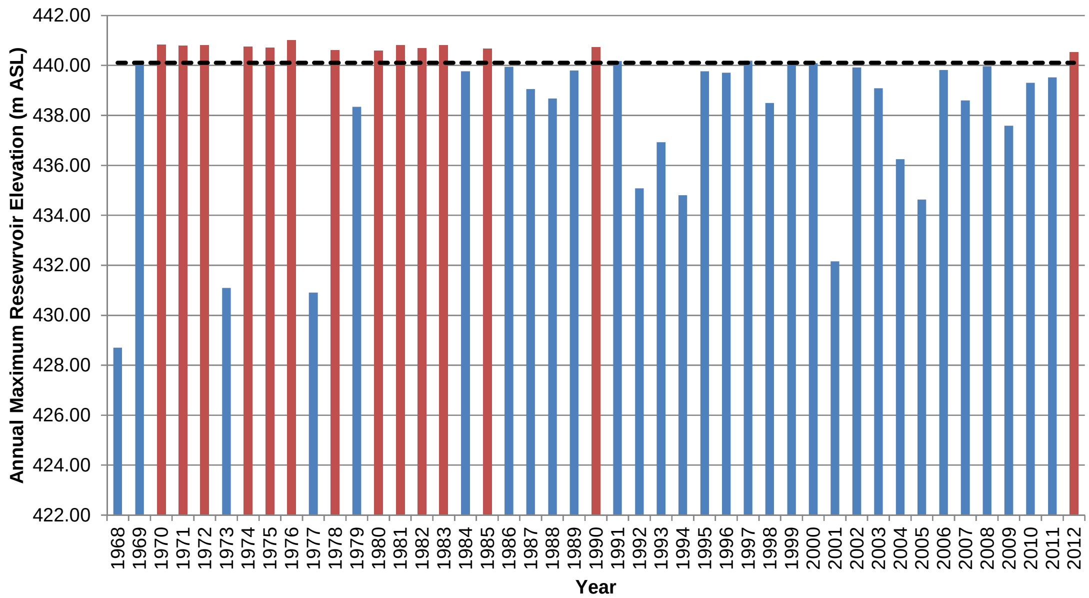

Figure 5-17: Maximum reservoir elevations recorded for Kinbasket Reservoir for the period 1968 through 2012. The years during which the reservoir exceeded the normal operation maximum are coloured red. The normal maximum reservoir elevation is depicted by the dashed line

Arrow Lakes Reservoir reached and exceeded full pool for the first time since project implementation in 2008 (Figure 5-18). The relationship between reservoir elevation and habitat availability needs to be assessed relative to the time of year and duration of inundation, and this will be investigated in the 5-yr interim report in 2013.

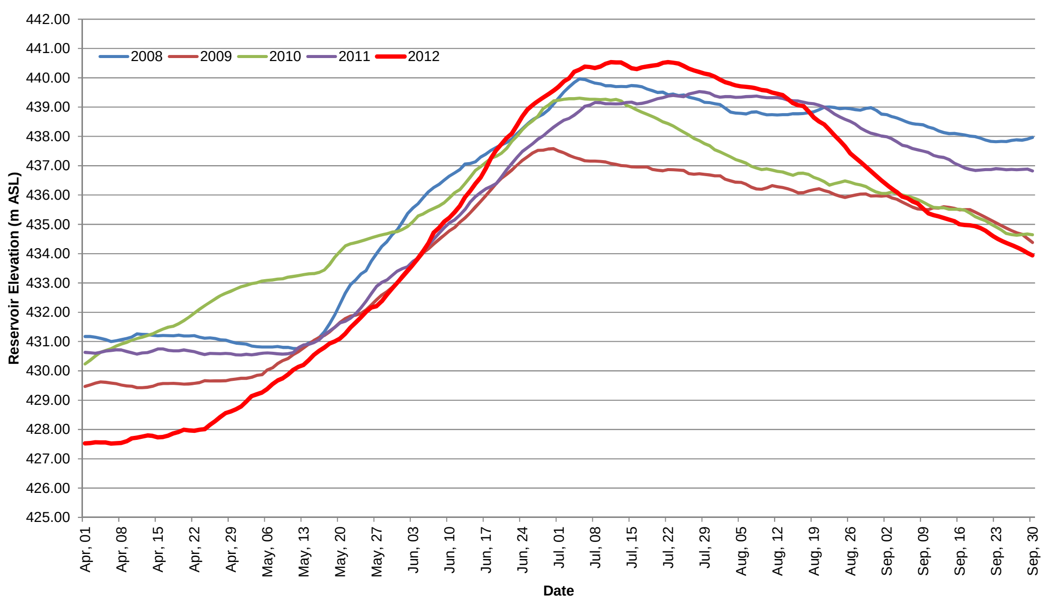

Figure 5-18: Arrow Lakes Reservoir elevations between April 1 and September 30 in all CLBMON-37 implementation years. 2011 is provided for continuity

6.0 DISCUSSION

The distribution of amphibians and reptiles in the drawdown zone of Kinbasket and Arrow Lakes Reservoirs has been studied since 2008. This study focuses primarily on the life history and habitat use of amphibian and reptile populations in the drawdown zone, on how reservoir operations affect those populations and the habitats they use, and whether physical works can be implemented to mitigate any potentially adverse effects of reservoir operations on those populations or habitats. Monitoring populations of amphibians and reptiles in the drawdown zone over a ten year period will provide the necessary information to address the management questions outlined in the terms of reference for CLBMON-37.

6.1 Management Questions and Hypotheses

Amphibian and reptile life history and habitat use of the drawdown zone relative to the 10 hypotheses listed in Section 2.2 are best discussed within the context of the broad themes associated with the management questions for this project. Several management questions strive to address how reservoir operations (including changes associated with Mica Units 5 and 6 operations – CLBMON-58) affect the use of the drawdown zone by amphibians and reptiles, as measured by indices of habitat use and life history characteristics. Concurrent with the assessment of the life history of amphibians and reptiles and habitat suitability and use, certain components seek to determine whether various revegetation techniques or future physical works projects could affect habitat quality or use by amphibians and reptiles in the drawdown zone. Our ability to address each of the management questions within the broad themes is discussed below. For the most part, the methods we have used appear to have been appropriate for collecting adequate data that can be used to address the questions; however, time series are required before hypotheses linked to broader management questions can be addressed (Table 6-1).

Hypothesis testing will continue in 2013 (under CLBMON-58) and 2014 (under CLBMON-37) using time series that span the 2008–2013 (or 2014) period. In some cases (e.g., MQ1), we currently have sufficient data to address the management question. In others (e.g., portions of MQs 2 and 4), alternative approaches may be required. For example, to assess the productivity of amphibians, studies that focus on the reproductive success of amphibians at various elevations of the drawdown zone will be required (this also relates to MQ4). This work is being undertaken in Kinbasket Reservoir as CLBMON-58, which will assess the survivorship of amphibians at various elevations of the drawdown zone. Egg mass surveys are currently the main method that is used to assess productivity. Assessing the productivity of most reptile species, such as garter snakes, is likely beyond the scope of this monitoring program, as it would require a telemetry study targeting females of reproductive size.

Table 6-1: Relationships between Hypotheses, Management Questions (MQs), Methods, Study Components, and Time Frame of Project CLBMON-37

Themes and Hypotheses	**MQs**										**Methods**	**Study Component***	**Able to Address MQ?**	**Time Frame**
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	Suggested modifications to methods where applicable	(Data to Test Hypotheses)		
Life History and Habitat Use	**X**	**X**	**X**	**X**						X		SM, RA, MR, RT, LH, HU, SO, TS	Yes	**Time-series: ≥ 5 yrs**
H_{1A}	X	X	X							X	Pond numbering, pitfall trapping	SM, RA, MR, RT, LH, HU, SO, TS	Yes	Time-series: ≥ 5 yrs
H_{1B}		X	X							X	Pitfall trapping	RA, MR, LH, TS	Yes	Time-series: ≥ 5 yrs
H_{1C}	X	X		X						X		RA, MR, LH, TS	Yes	Time-series: ≥ 5 yrs
H_{1D}	X	X	X							X	Standardized study locations	SM, MR, HU, SO, TS	Yes	Time-series: ≥ 3 yrs
H_{1E}	X			X						X		RA, MR, LH, TS	Yes	Time-series: ≥ 5 yrs
Reservoir Operations Influence on Habitat Use					**X**	**X**				X		SM, RA, MR, RT, LH, HU, SO, TS	Yes	**Time-series: ≥ 5 yrs**
H_{1A}					X	X				X		SM, RA, MR, RT, LH, HU, SO, TS	Yes	Time-series: ≥ 5 yrs
H_{1B}					X	X				X		RA, MR, LH, TS	Yes	Time-series: ≥ 5 yrs
H_{1C}					X	X				X		RA, MR, LH, TS	Yes	Time-series: ≥ 5 yrs
H_{1D}					X	X				X		SM, MR, HU, SO, TS	Yes	Time-series: ≥ 5 yrs
H_{1E}					X	X				X		RA, MR, LH, TS	Yes	Time-series: ≥ 5 yrs
Physical Works' Effects on Habitat Use							**X**	**X**	**X**	X		SM, RA, LH, HU, SO, TS	Yes	**Depends when and how physical works are implemented**
H_{2A}	X	X					X	X	X			SM, RA, HU, SO, TS	Yes	Time-series: ≥ 5 yrs
H_{2B}		X	X				X	X	X			SM, RA, LH, HU, SO, TS	Yes	Time-series: ≥ 5 yrs
H_{2C}				X			X	X				SM, RA, LH, HU, SO, TS	Yes	Time-series: ≥ 5 yrs

***Study Component:** SM = Site Monitoring; RA = Relative Abundance Estimation; MR = Mark-recapture; RT = Radiotelemetry; LH = Life History Data; HU = Habitat Use Data; SO = Site Occupancy; TS = Time-series Analysis

6.1.1 Theme 1: Life History and Habitat Use

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

Site occupancy followed a somewhat similar pattern to that of previous years of the CLBMON-37 study (2008 to 2010); however, species diversity across sites was generally lower in 2012. Four species of amphibians and four species of reptiles used the DDZs of Kinbasket and Arrow Lakes Reservoirs (Table 6-2). The most commonly occurring species were Western Toad, Columbia Spotted Frog and Common Garter Snake. These species are widespread across B.C. (Matsuda et al. 2006) and are locally abundant at most monitoring locations. The monitoring locations in Kinbasket Reservoir with the highest productivity are Bush Arm km 79 marshes, Valemount Peatland and Ptarmigan Creek, and Revelstoke Reach, Beaton Arm and Burton Creek in Arrow Lakes Reservoir.

Table 6-2: Species of amphibians and reptiles that occurred within the drawdown zone of Kinbasket and Arrow Lakes Reservoirs in 2012. PC = Ptarmigan Creek, VP = Valemount Peatland, BA = Bush Arm sites, SB = Sprague Bay, RR = Revelstoke Reach, BeA = Beaton Arm, BC = Burton Creek, LW = Lower Inonoaklin, EW = Edgewood

Species	Arrow Lakes Sites	Kinbasket Sites
Columbia Spotted Frog	RR, BeA, BC, EW	PC, VP, BA, SB
Western Toad	RR, BeA, BC, LI, EW	PC, VP, BA, SB
Pacific Chorus Frog	RR, LI, EW	
Long-toed Salamander	RR	VP, BA
Painted Turtle	RR	
Northern Alligator Lizard	RR, EW	
Western Terrestrial Garter Snake	RR, BC, EW	PC, VP, BA
Common Garter Snake	RR, BC	PC, VP, BA, SP

Inconspicuous species are generally difficult to locate; however, multiple years of surveys across seasons should provide an understanding of species diversity across all sites. For example, Long-toed Salamanders 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). Long-toed Salamanders egg masses were detected in Cartier Bay which was a new record for Arrow Lakes. Hawkes and Tuttle (2009a) recommended the use of pitfall to determine the distribution of species such as Long-toed Salamanders in the drawdown zone. This method was implemented in 2011 and 2012 in Bush Arm and proved to be very successful for the detection of both inconspicuous and conspicuous species. As such, we do not currently have sufficient data to assess the abundance, distribution or productivity of the Long-toed Salamanders in the drawdown zone of either reservoir. The continuation of pitfall trapping will also provide abundance data for the other amphibian species in the area.

As part of the ongoing Painted Turtle studies in Revelstoke Reach, LGL Limited and ONA spent several days tracking and documenting use of the DDZ and upland habitat by turtles in 2012. Detailed information for this project will be available in the CLBMON-11B3/4 report in 2013; however, this additional location data for Painted Turtles' use of the drawdown zone (e.g., Airport Marsh, Montana Slough and Cartier Bay) gave us a better understanding of the site occupancy for this species in Revelstoke Reach.

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?

Differences in species diversity were measured across time using a simple site occupancy approach, and the data to date indicate that the species of amphibians and reptiles that use specific sites in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs are relatively consistent over time. We suspect that site occupancy for each site is nearing its maximum value; however, with additional years of sampling, the species lists for some sites may be expanded and further increase our understanding of the distribution of amphibians and reptiles in the drawdown zone. For example, it is likely that additional Long-toed Salamander observations will be recorded over time, as this species requires a greater search effort than more conspicuous species.

Currently, we have sufficient data to describe species-specific trends in the abundance of Western Toads, Columbia Spotted Frogs and Common Garter Snakes; however, we do not have adequate life history data for most other species (e.g., Long-toed Salamanders, Western Terrestrial Garter Snakes, Northern Alligator Lizards, etc.). Western Toads appear to be particularly abundant in the DDZ, as evidenced by large spring breeding aggregations (across years), egg mass counts in 2012, numerous tadpole clusters, and emerging metamorphs at a few key sites; therefore, this species will likely be highlighted as an indicator amphibian species in future years. Columbia Spotted Frogs are moderately abundant in Bush Arm and Burton Creek, and they use permanent wetlands in the DDZ to fulfill their life requisites. The presence of amphibians of all life stages attracts predators such as Common and Western Terrestrial Garter Snakes to the DDZ. Current data show Common Garter Snakes as the more abundant snake species in the DDZ. This supports the literature that states that Western Terrestrial Garter Snakes typically inhabit upland areas (Matsuda et al. 2006; L. Isaac, Nupqu, pers. comm. 2010).

We currently know which species use the DDZ in each reservoir for reproduction. Egg mass surveys, larval surveys and the documentation of metamorphosis will provide data on amphibian abundance and use of the drawdown zone for reproduction from 2008 to 2018. However, data thus far collected to date may not be adequate for assessing the productivity of some species, no matter how long the sites are monitored (e.g., Long-toed Salamander). 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, and additional methods may be required (e.g., larval enclosures). 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 zones.

Although we can measure abundance and species occurrence of reptiles in the DDZs of Kinbasket and Arrow Lakes Reservoirs, we can't assess productivity at this time. This is largely because reptile productivity is not linked to the presence or absence of water. Reproduction in snakes (mating and fertilization) likely occurs near overwintering sites (Garstka et al. 1982; Kromher 2004), but these sites have not been located because they are likely outside of the DDZ and would likely require telemetry to locate. While snakes still use the DDZ for basking and foraging, the presence of ponds and the subsequent inundation of ponds likely do not affect reptiles in the same way as they affect amphibians. 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). More data are required to determine if a correlation between amphibian and reptile abundance, diversity and reproduction exists. This will be explored fully in Year 2 of CLBMON-58 (2013) and Year 6 of CLBMON-37 (2014).

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 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, garter snakes, painted turtles) appear to use the DDZ to fulfill specific stages (Table 6-3). This information is based on five years of data. At this point, we have a good sense of when and how Western Toads and Columbia Spotted Frogs are using the DDZ; however, we do not have enough data for Long-toed Salamanders or both species of garter snake to determine how they are using the DDZ.

Table 6-3: Observed life history activity of amphibian and reptile species in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs, 2008 to 2012

Species	Life History Activity			
	Reproduction	Growth	Foraging	Overwintering
Columbia Spotted Frog	Yes	Yes	Yes	Unknown
Western Toad	Yes	Yes	Yes	Unlikely
Pacific Chorus Frog	Yes	Yes	Likely	Unlikely
Long-toed Salamander	Yes	Yes	Likely	Unlikely
Painted Turtles	No	Yes	Yes	Yes
Northern Alligator Lizards	Unlikely	Unlikely	Likely	Unlikely
Western Terrestrial Garter Snake	Unknown	Yes	Yes	Unlikely
Common Garter Snake	Unknown	Yes	Yes	Unlikely

Since 2008, we have collected spatial data on pond locations and sizes, and the documentation of amphibian reproduction within these ponds continued in 2012. Over time, we believe we can develop a correlation between pond elevation, size and characteristics (e.g., vegetation type, water chemistry) and amphibian use for both reproduction and foraging within each reservoir. Detailed data collection in Kinbasket Reservoir under CLBMON-58 will supplement the life history and productivity data for most anuran species over the 10 year period. Data loggers were installed in several ponds as part of CLBMON-61 to obtain a range of water temperature data, which will be compared to point data collected at amphibian capture locations. These data will be collected in early 2013 and used to supplement the life history growth and development data for Western Toads and Columbia Spotted Frogs.

At this point, we have sufficient data for Western Toad to show the species' use of the drawdown zones by its multiple life stages, particularly at certain times of the year. In all five years of study, we have documented adult toads breeding at the same locations (e.g., Bush Arm km 79, Valemount Peatland, Ptarmigan Creek, Revelstoke Reach, Beaton Arm and Burton Creek) and individuals migrating to and from certain ponds from late April to late June (Bush Arm Causeway, Ptarmigan Creek, Cartier Bay, Burton Creek). Metamorph toadlets have also been documented emerging from the same drawdown zone locations (e.g., Valemount Peatland, Cartier Bay, Beaton Arm) 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. A similar pattern is unfolding for Columbia Spotted Frog. With a more focused effort on certain species (mainly Long-toed Salamanders and garter snakes), we are confident that we can address this management question for the three most common species (Western Toad, Columbia Spotted Frog, Common Garter Snake) over the 10 year study period.

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 history requisites (Duellman and Trueb 1986; Duellman 2007; Wells 2007). Painted Turtles use aquatic habitats in the DDZ for foraging, basking, and overwintering. Other reptiles, such as garter snakes, use habitats in the DDZ mainly for foraging because amphibians are their primary prey.

Small, isolated wetlands can be critical to the persistence of amphibians with complex life cycles (Hopkins 2007). These habitat features (i.e., small, isolated wetlands) are common in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs and are affected on an annual basis to varying degrees by reservoir operations depending on the elevation at which they are situated. We correlated species presence with vegetation communities mapped in the drawdown zone (using vegetation communities classified under CLBMON-10 and CLBMON-33), and measured the water chemistry of ponds with and without amphibians. Most species in Kinbasket were found in the wetland habitat types (willow-sedge, wool-grass–Pennsylvania buttercup, and swamp horsetail) and reed-canarygrass habitats for Arrow (Table 6-4). Each species was most often associated with certain elevation bands. For example, Common Garter Snakes were observed over a narrower range of elevations (750 to 757 m ASL) than amphibians (736 to 757 m ASL) (Table 6-4). Western Toads used a wider range of elevations (736 to 757 m ASL) than Columbia Spotted Frogs (748 to 754 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. However, in general, amphibian breeding ponds tend to be small, shallow and warm, and often have high levels of dissolved oxygen and abundant vegetation cover, with the exception of several ponds in Bush Arm Bear Island and the lower elevation ponds used by Western Toads at km79 marshes, which were devoid of vegetation.

Table 6-4: Habitats and elevation bands commonly used by amphibians and reptiles in Kinbasket and Arrow Lakes Reservoirs in 2012

Species	Elevation Band (m ASL)	Most Commonly Used Habitat
Kinbasket Reservoir		
Columbia Spotted Frog	748–754	wool-grass–Pennsylvania buttercup; swamp horsetail
Western Toad	736–757	marsh cudweed–annual hairgrass; swamp horsetail
Long-toed Salamander	752–754	willow-sedge; swamp horsetail
Common Garter Snake	750–757	willow-sedge
Arrow Lakes Reservoir		
Columbia Spotted Frog	436–442	rush wet sites / seepage / rill; willow-silverberry river
Western Toad	433–450	reed-canarygrass-lenticular sedge
Pacific Chorus Frog	434–450	reed-canarygrass-lenticular sedge
Long-toed Salamander	444	reed-canarygrass-lenticular sedge
Painted Turtle	435–436	
Northern Alligator Lizard	440–444	non-vegetated boulders
Western Terrestrial Garter Snake	437–441	cottonwood-riparian
Common Garter Snake	436–442	reed canarygrass-redtop upland

More data are required to determine if the amphibian and reptile habitat associations and use trends persist across time and if they are affected by reservoir operations. Despite conducting surveys over the same general time frames each year, environmental conditions vary between years, often due to changing reservoir levels on an annual basis (especially in Kinbasket Reservoir), so we expect to see some variability in seasonal habitat use over the years. Habitat relationships will be further reported on in the comprehensive report for this project in July 2013.

6.1.2 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?

Habitat change is assessed in terms of changes in vegetation community and habitat availability. Assessing direct or indirect effects (Table 6-5) of habitat 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 or CLBMON-33. For example, 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. These changes, particularly at the lower elevations of the DDZ of Kinbasket Reservoir, have led to an increase in vegetation species richness and per cent cover. These changes are believed to be related to reservoir operations (Hawkes et al. 2010), but it is not clear how they might affect reptile and amphibian populations over time.

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Table 6-5: Anticipated effects of reservoir operations on amphibians and reptiles found in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs in 2012

Species	Description of Anticipated Effect	Severity of Effect	Direction of Effect
Columbia Spotted Frog	Inundation of cold water - slows development	Low	Direct
Western Toad	Inundation – changes tadpole habitat use	High	Direct
Pacific Chorus Frog	Inundation of cold water - slows development	Low	Direct
Long-toed Salamander	Inundation of cold water - slows development	Moderate	Direct
Painted Turtle	Changes to basking and foraging habitat	Moderate	Direct
Northern Alligator Lizard	Inundation of cold water may decreases availability of basking and foraging habitat	Low	Direct & Indirect
Western Terrestrial Garter Snake	Possible changes to food availability	Low	Indirect
Common Garter Snake	Possible changes to food availability	Low	Indirect

Habitat availability is a function of reservoir elevation throughout the year. From five years of data, it is apparent that reservoir operations influence amphibians and reptiles in the DDZ, both directly and indirectly. Habitat availability mapping in 2009 showed a decrease in available habitat with increasing reservoir levels (Hawkes and Tuttle 2010a), and as water levels increased, amphibian and reptile observations were concentrated around the water's edge. In 2012 reservoir elevations in Kinbasket Reservoir increased more rapidly than previous years, reaching full pool ~ one month earlier (Figure 3-1). There was an observed immediate effect on habitat availability and because of the timing associated with reservoir filling, it is likely that the fecundity of amphibians (all species) will be affected. Although assessing the direct effects of reservoir operations on amphibian populations has proven difficult, there is evidence to suggest that increasing reservoir elevations will contribute to breeding failure, particularly in ponds situated lower in the drawdown zone (Hawkes and Tuttle 2012).

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. From a seasonal perspective, animals were found throughout the DDZ in the early spring and around the periphery of the reservoir later in the year as reservoir elevations increased.

Using pond elevation and size, we can:

- determine the timing, frequency and duration of inundation and assess how reservoir inundation affects productivity directly (e.g., are fewer larval amphibians documented when reservoir elevations are higher?);
- assess mortality through the determination of breeding failure (because ponds are inundated too early in the developmental cycle of pond-breeding amphibians); and
- determine whether reservoir operations affect site occupancy and habitat quality.

Because we have just completed the collection of the spatial data required to complete these analyses in 2011, we will begin to address these questions in 2013 and 2014 after more years of data collection.

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

This management question is related to H_{1A} through H_{1E} (and MQs 1-5), and the discussion associated with these hypotheses relates to MQs 5, 6, and 10 (for CLBMON-58). Several additional years of documenting breeding and larval development and amphibian and reptile habitat use in the DDZ will help determine how the timing of reservoir inundation affects these species. Based on these data, we will be able to provide recommendations on managing reservoir elevations to benefit amphibian and reptile populations that use the drawdown zones of Kinbasket and Arrow Lakes Reservoirs.

Currently, we know that the rapid inundation of breeding ponds with cold water can significantly slow tadpole development and change tadpole behaviour, which can delay metamorphosis, decrease survival and reduce reproductive output (Ultsch et al. 1999; Bury 2008). As indicated under MQ5, we will correlate pond elevation and timing of larval development with reservoir elevations and habitat use by amphibians to determine how reservoir elevations affect breeding populations of amphibians. The results of this assessment will be used to address this management question by determining the elevations at which breeding ponds are impacted and whether recommendations for altering reservoir operations can be made to mitigate for those impacts.

6.1.3 Theme 3: Physical Works

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

Several wildlife physical works have been proposed for implementation in select areas of mid- and lower Arrow Lakes Reservoir (Hawkes and Howard 2012). These physical works have been designed to specifically address the loss of shallow valley bottom and wetland habitat, which would have been flooded when Arrow Lakes Reservoir was created. The creation or enhancement of habitats in the drawdown zone of Arrow Lakes Reservoir is intended to improve habitat suitability for several species groups including pond-breeding amphibians and reptiles. The physical works have yet to be implemented; however, evidence from other similar programs suggests that these projects will have a high degree of success (Hawkes and Fenneman 2010; Tuttle 2012).

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 spring and summer months. The construction of dykes (for example) could be used to protect habitats at Bear Island and km79 from inundation, and habitat for amphibians and reptiles could either be created or improved in specific areas of the drawdown zone.

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

The relationship between revegetated areas of the drawdown zone and improvements in habitat suitability is contingent upon the efficacy of the revegetation program. As demonstrated in Fenneman and Hawkes (2012), the revegetation program in Kinbasket Reservoir did not increase the total area of vegetated habitat in the drawdown zone. Furthermore, the survivorship of plants used in the revegetation program (CLBWORKS-1) was low, and showed a downward trend across all years assessed. Because of this, it is unlikely that the revegetation efforts in the drawdown zone will affect the availability and use of the habitats in the drawdown zone by amphibians and reptiles.

Some of the revegetation efforts in Arrow Lakes Reservoir (CLBWORKS-2) were successful and have increased the total cover of plants, particularly sedges, near certain wetlands (e.g., Lower Inonoaklin Road). However, these areas were not completely devoid of vegetation to begin with; the availability and use of these habitats by amphibians and reptiles is not likely to be a function of the revegetation efforts. By continuing to sample in areas where revegetation prescriptions have been applied (particularly in Arrow Lakes Reservoir), we should be able to determine the extent to which successful revegetation of the DDZ contributes to changes in habitat use by amphibians and reptiles. Our ability to answer this question will likely be better in the final comprehensive report at the end of the 10 year study and we will explore this in more detail in the 5-year interim report.

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

Physical works in Arrow Lakes Reservoir have been in the planning process for several years. The data collected for this study over the past five years will provide some baseline data against which post-monitoring of any physical works can be compared. We will not be able to address this management question until physical works are constructed and a monitoring program developed and implemented. However, as indicated above, with proper planning and construction, there is a high likelihood of success. There are elements of the physical habitat that could be included with the physical works to further increase the suitability of the sites for amphibians and reptiles when physical works are constructed. For example, loafing logs and floating islands could be used to improve habitat suitability for Western Painted Turtles in Revelstoke Reach.

The data collected at the permanent monitoring locations in the drawdown zone of Kinbasket Reservoir since 2008 (CLBMON-9) provide an excellent baseline data set against which future data can be compared. Current monitoring of sites where future physical works are to be implemented (e.g., additional revegetation efforts) will determine if those physical works contribute to increased reptile or amphibian abundance, diversity or productivity. If physical works were designed and implemented to increase the amount of shallow wetland habitat in the drawdown zone, it is likely that the abundance, diversity and productivity of amphibians will increase, with which could be associated an increase in abundance, diversity and productivity of reptiles. This assumption is supported by Hawkes and Fenneman (2010), which indicate that building physical works in the drawdown zone of a hydroelectric reservoir can lead to increased abundance, diversity and productivity of amphibians. Given garter snakes' reliance on amphibians, it is assumed that changes in snake productivity would be correlated with changes in amphibian populations. It is unlikely that there would be changes in snake diversity in Kinbasket Reservoir given that all species expected to occur there have already been documented. This assumption cannot be tested until such physical works are designed for the drawdown zone of Kinbasket Reservoir.

6.1.4 Recommendations

The objective of CLBMON-37 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, determine their habitat use, and assess the impacts of any revegetation and physical works on species that use habitats within the drawdown zones of Kinbasket and Arrow Lakes Reservoir.

We will continue to monitor amphibian and reptile populations in the DDZ using the methods applied in previous years in 2013 (CLBMON-58) and 2014 (CLBMON-37). Additional recommendations for consideration in future years include the following:

1. Continue with annual sampling in both Arrow Lakes and Kinbasket Reservoirs to increase the time series of data, combining data from CLBMON-37 and CLBMON-58. This will help determine if and how reservoir operations affect amphibian and reptile communities (e.g., site occupancy, productivity).
2. Surveys should be conducted at similar times each year whenever possible. Continue to start field surveys early in the year (late April), particularly in the Valemount Peatland and Bush Arm, to capture early pond-breeding amphibians, such as Long-toed Salamanders. The actual timing of early spring surveys will depend on the amount of snow on the ground.
3. Establish pitfall trapping sites at additional monitoring locations (e.g., Bush Arm km 79 marshes, Valemount Peatland, Ptarmigan Creek) to determine site occupancy of inconspicuous species of amphibians that migrate to and from breeding ponds. Furthermore, individuals captured in pitfall traps will provide additional morphometric data to the life history component of this study. Pitfall trapping sessions should be scheduled for early May (to examine breeding amphibian migrations and habitat use near DDZ ponds) and mid-summer (to examine use of DDZ edges by metamorph amphibians).
4. Conduct more intensive surveys to assess the direction and magnitude of impacts of reservoir operations on amphibian and reptiles populations. Primary monitoring locations will require increased survey effort (more frequent visits and surveys at the same location for several days in a row) to effectively address some management questions (especially in regards to reservoir effects on larval amphibian development). Work associated with CLBMON-37 is suitable for determining the presence and distribution of amphibians and reptiles in the drawdown zones, but is not well suited to assess population-level impacts of reservoir operations on amphibians and reptiles because the frequency of site visits is too low, as is the level of effort during each visit. Therefore, to accurately assess how reservoir operations affect amphibian and reptile populations, it is recommended that more

intensive surveys be conducted in key areas and for specific species (e.g., Western Toad and Columbia Spotted Frog in Bush Arm and the Valemount Peatland). The increased level of effort and frequency of surveys will help to estimate amphibian population size, characterize age and size structure of the populations in the drawdown zone, and assess the impacts of reservoir operations on amphibians, most likely through an analysis of survivorship. Reservoir effects can be examined by studying breeding habitats used by pond-breeding amphibians and the changes to those habitats that result from inundation.

5. Compare anuran larval development rates and size at metamorphosis among Kinbasket and Arrow Lakes Reservoirs monitoring locations, unregulated habitats and lower elevation areas to determine whether the operation of the reservoirs affect developmental rates, which, in turn, could affect survivorship and reproductive success. Data collected in Arrow Lakes Reservoir for CLBMON-37 could be used to compare developmental rates and size at metamorphosis among habitats at different elevations, and data could be collected in the Columbia wetlands and Summit Lake to determine if developmental rates and size at metamorphosis differ between regulated and unregulated systems. There are wetlands (mainly beaver ponds) immediately above the drawdown zone in Bush Arm that could function as unregulated reference sites in Kinbasket Reservoir. This would provide the data necessary to determine if developmental rates of anurans are different from what would be expected (based on comparisons with unregulated habitats at similar elevations) and if they differ from those at lower elevation sites. If there is no difference, then the question about potential impacts of Mica 5 and 6 on anuran productivity could be addressed from a habitat perspective. However, due to the lack of pre-impoundment data, it would not be possible to determine if the amphibian populations that use the drawdown zone of Kinbasket Reservoir are suppressed (i.e., persisting below carrying capacity). If there is a difference in developmental rates, the effect of reservoir operations on development and habitat availability could be assessed.

6. Consider the continued involvement of graduate students on CLBMON-37 (and 58) to research amphibian and reptile productivity in the drawdown zone of Kinbasket Reservoir. The intensive nature of associated with amphibian and reptile productivity studies or use vs. non-use studies would be best facilitated with the involvement of graduate students. For example, in 2010 and 2011, amphibian and reptile surveys in Canoe Reach of Kinbasket Reservoir were greatly enhanced by the research conducted by LGL-funded graduate student Kelly Boyle. She was able to document the presence of amphibians and reptiles in multiple habitats associated with the Valemount Peatland and Ptarmigan Creek. Consistent with results from 2008 and 2009, she found Western Toads, Columbia Spotted Frogs and Common Garter Snakes in the DDZ at both sites in 2010 and 2011. Her studies complement this project and lend support to the utility of graduate student involvement in long-term BC Hydro projects.

7.0 ADDITIONAL REPORTING REQUIREMENTS

7.1 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-37 or to fulfill the requirements of the wildlife sundry permit provided to LGL Limited for CLMON-37:

1.	Draft technical report	Submitted December 17, 2012
2.	300 word abstract	Submitted February 2013
3.	Copies of notes, maps, photos	Submitted February 2013
4.	Digital appendix (data)	Submitted February 2013

7.1.1 Data Provided to BC Hydro

An MS Access database containing all 2008 through 2012 data will be provided to BC Hydro in February 2013. This database conforms to the standards established by the B.C. Ministry of Environment for wildlife species inventories.

7.1.2 Data Provided to the Ministry of Environment

Data collected under CLBMON-37 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. This task will be conducted in December 2012.

7.2 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 currently (as of October 2010) a COSEWIC status report candidate species. The status of this species remains not assessed and populations are considered to be stable throughout its range.

One species of reptile with federal conservation status was documented in 2012 (Painted Turtle), either in or near the DDZ of Arrow Lakes Reservoir. Two other listed species have been documented in the past as part of CLBMON-37 and are included here only as references. The Intermountain–Rocky Mountain Population of the western Painted Turtle (*Chrysemys picta*) is blue-listed in British Columbia and is a SARA Schedule 1 species of Special Concern. This species was documented in 2012 using the drawdown zone of Arrow Lakes Reservoir in Revelstoke Reach from Airport Marsh south to Cartier Bay. The Western Skink (*Plestiodon skiltonianus*) is blue-listed in British Columbia and is a SARA Schedule 1 species of Special Concern. This species was documented in the drawdown zone of Arrow Lakes Reservoir near Deer Park and at Edgewood in the west-central portion of the reservoir in 2010. The Rubber Boa (*Charina bottae*) is yellow-listed in British Columbia, and is a SARA Schedule 1 species of Special Concern. This species was documented just outside the drawdown zone of Arrow Lakes Reservoir at Edgewood North in the west-central portion of the reservoir in 2010.

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9.0 APPENDICES

Appendix 9-1: Work schedule 2012

LGL's work schedule was developed around the milestones presented in the Terms of Reference for CLBMON-37. Progress reports were submitted monthly. Details of each field session for CLBMON-37 are as follows:

Site Visits for CLBMON-37

Field Session 1: April 26–May 6, 2012

Krysia Tuttle, Doug Adama, Janean Sharkey

April 26, 2012	Travel from Sidney (KT, JS) or Golden (DA) to Valemount
April 27, 2012	Ptarmigan Creek, Valemount Peatland
April 28, 2012	Ptarmigan Creek, Valemount Peatland
April 29, 2012	Drive to Revelstoke (KT, JS, DA)
April 30, 2012	Revelstoke Reach: 12 mile, 9 mile, Cartier
May 1, 2012	Revelstoke Reach: Montana, Airport, Site ½
May 2, 2012	Revelstoke Reach: Machete Island, Downie, Big Eddy
May 3, 2012	Drive to Golden (DA), Beaton Arm/Mosquito Creek (KT/JS)
May 4, 2012	Burton Creek, Edgewood, Lower Inonoaklin
May 5, 2012	Drive to Syringa, HK Dam, Boat to Renata
May 6, 2012	Travel from Castlegar to Sidney (KT/JS)

Field Session 2: May 15–19, 2012

Doug Adama, Jeremy Gatten

May 15, 2012	Travel from Sidney to Golden (JG)
May 16, 2012	Bush Arm: Causeway/ km 79
May 17, 2012	Bush Arm: Causeway/ Bear Island
May 18, 2012	Bush Arm: Causeway/km 79 perched
May 19, 2012	Travel from Golden to Sidney (JG)

Field Session 3: June 7–18, 2012

Krysia Tuttle, Janean Sharkey

June 7, 2012	Travel from Sidney to Valemount
June 8, 2012	Valemount Peatland
June 9, 2012	Ptarmigan Creek, Valemount Peatland
June 10, 2012	Drive to Golden
June 11, 2012	Bush Arm: Bear Island/Causeway
June 12, 2012	Bush Arm: km 79/Causeway; Drive to Revelstoke
June 13, 2012	Sprague Bay, Mica Dam
June 14, 2012	Revelstoke Reach: 12 mile, 9 mile, Cartier, Downie
June 15, 2012	Revelstoke Reach: Montana, Airport, Machete Island
June 16, 2012	Beaton Arm, Burton Creek
June 17, 2012	Edgewood, Lower Inonoaklin
June 18, 2012	Travel from Nakusp to Sidney

Field Session 4: July 6–25, 2012

Krysia Tuttle, Doug Adama, Natasha Audy, Janean Sharkey

July 6, 2012	Travel from Sidney (KT) or Golden (DA) to Valemount
July 7-11, 2012	CLBMON-61/37 Valemount Peatland, Ptarmigan
July 12, 2012	Travel from Valemount to Sidney (KT) or Golden (DA)
July 15, 2012	Drive to Golden (KT)

July 16, 2012	Bush Arm: Bear Island (KT, JG, JF)
July 17, 2012	Bush Arm: km79, Causeway (KT, VH, DA, JF, JG, GM)
July 18-19, 2012	CLBMON-37/11B3 Revelstoke Reach (KT, NA)
July 20, 2012	Fly to Kamloops (JS), Travel to Revelstoke (KT)
July 21, 2012	Revelstoke Reach: 12 mile, 9 mile, Cartier, Downie
July 22, 2012	Revelstoke Reach: Montana, Airport, Machete Island
July 23, 2012	Beaton Arm, Burton Creek
July 24, 2012	Edgewood, Lower Inonoaklin
July 25, 2012	Travel from Nakusp to Sidney (KT, JS)

Field Session 5: August 18–24, 2012

Krysia Tuttle, Alexis Friesen

August 18, 2012	Travel from Sidney (KT) or Penticton (AF) to Revelstoke
August 19, 2012	CLBMON-37/11B3 Revelstoke Reach
August 20, 2012	CLBMON-37/11B3 Revelstoke Reach
August 21, 2012	CLBMON-37 Revelstoke Reach
August 22, 2012	Edgewood, Lower Inonoaklin, Burton Creek
August 23, 2012	Beaton Arm, travel to Revelstoke
August 24, 2012	Travel from Nakusp to Victoria (KT), Penticton (AF)

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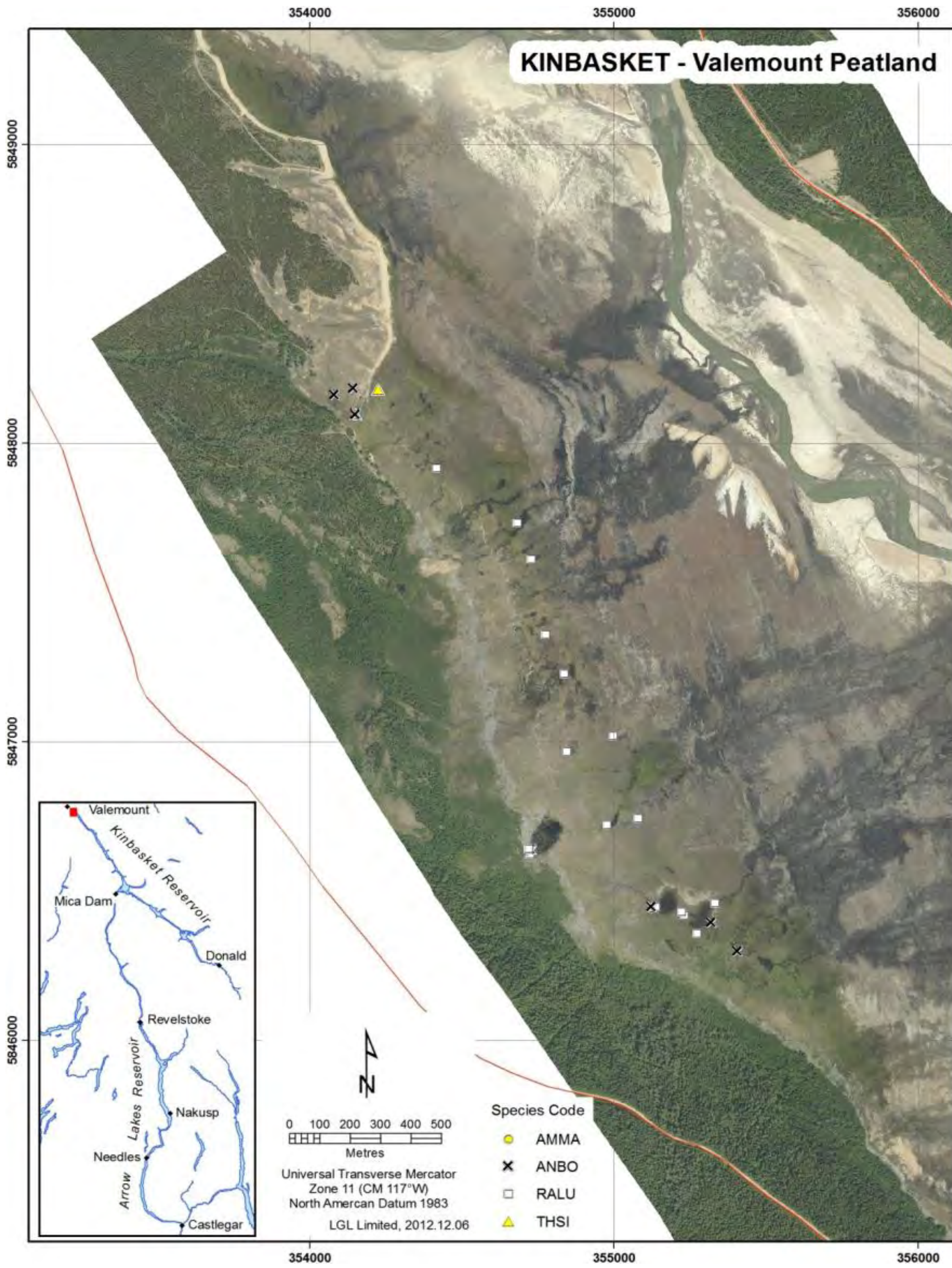
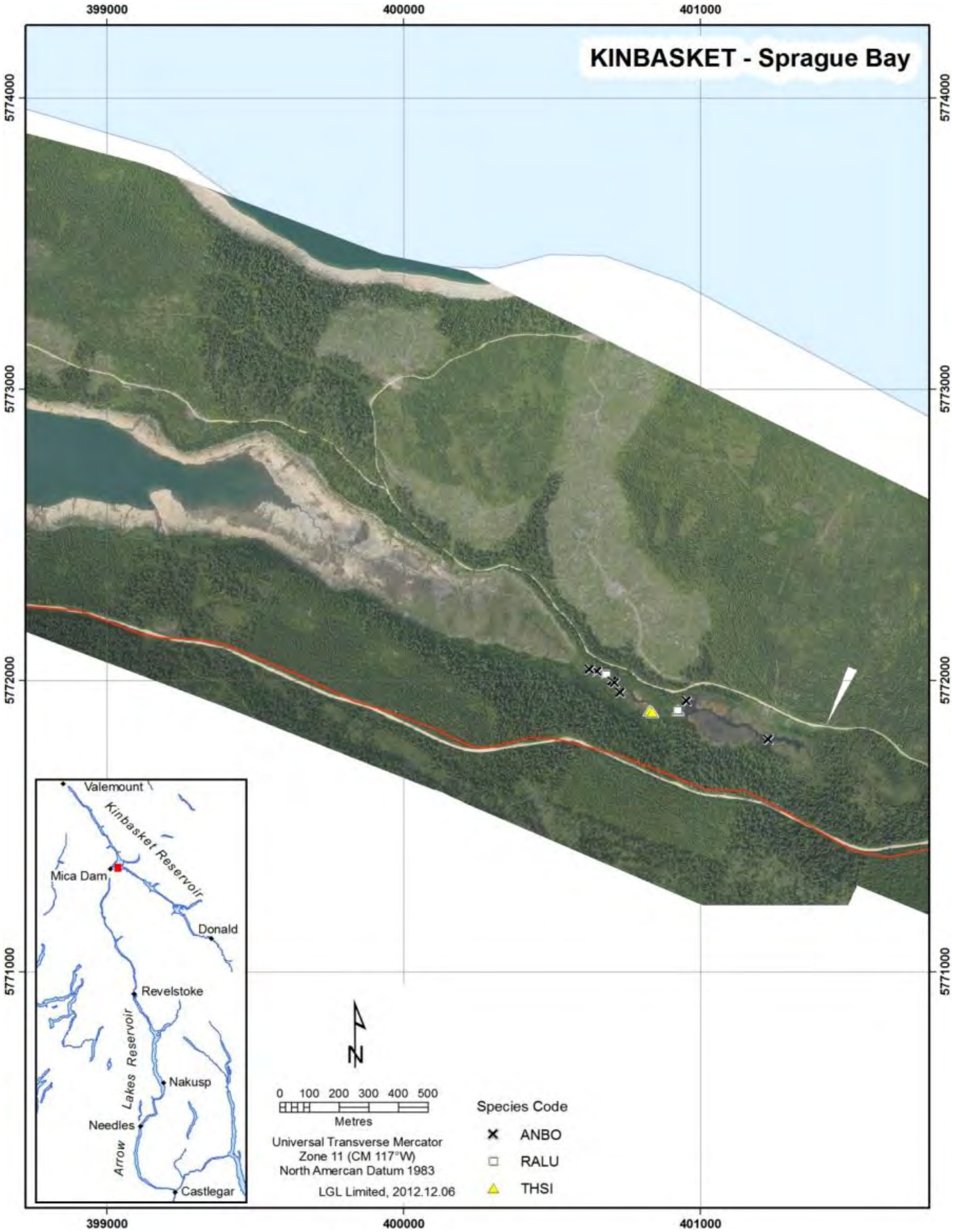
Appendix 9-2: Survey locations and amphibian and reptile captures made during the 2012 life history and habitat monitoring surveys in Kinbasket and Arrow Lakes Reservoirs

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

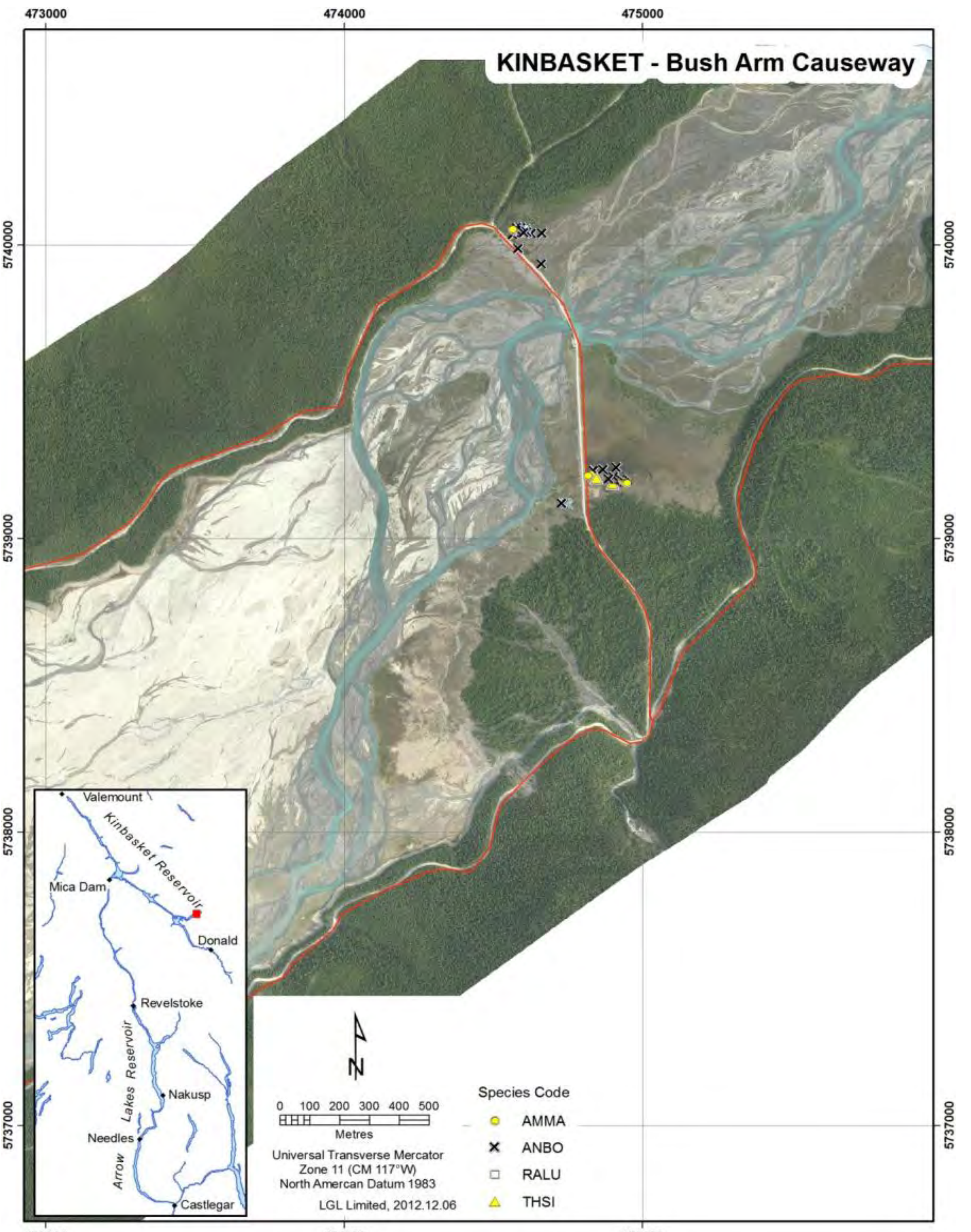


Map 9-1: **Species documented in the Valemount Peatland, Kinbasket Reservoir.** Species codes can be found in Table 1-1

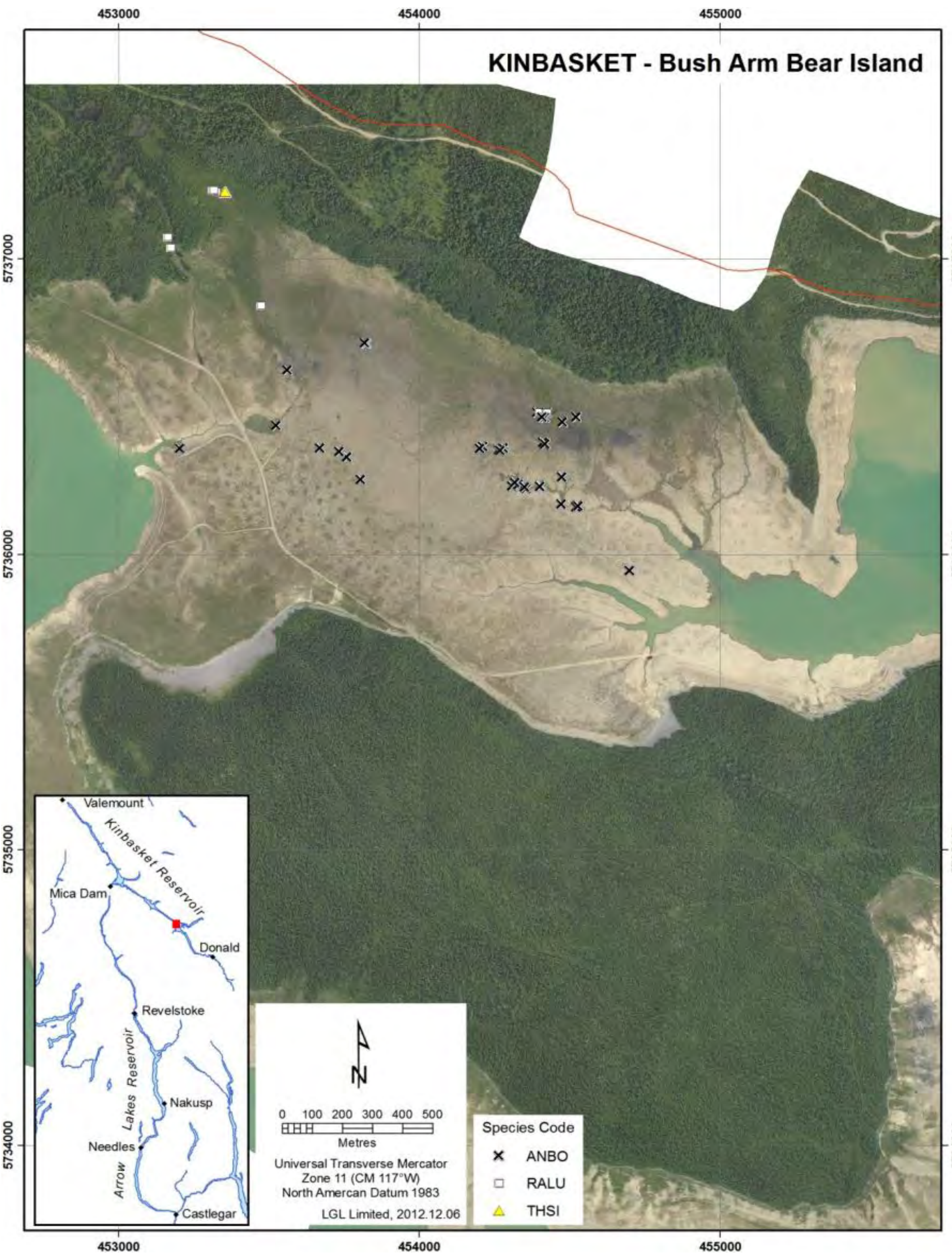
Map 9-2: **Species documented at Ptarmigan Creek, Kinbasket Reservoir.** Species codes can be found in Table 1-1



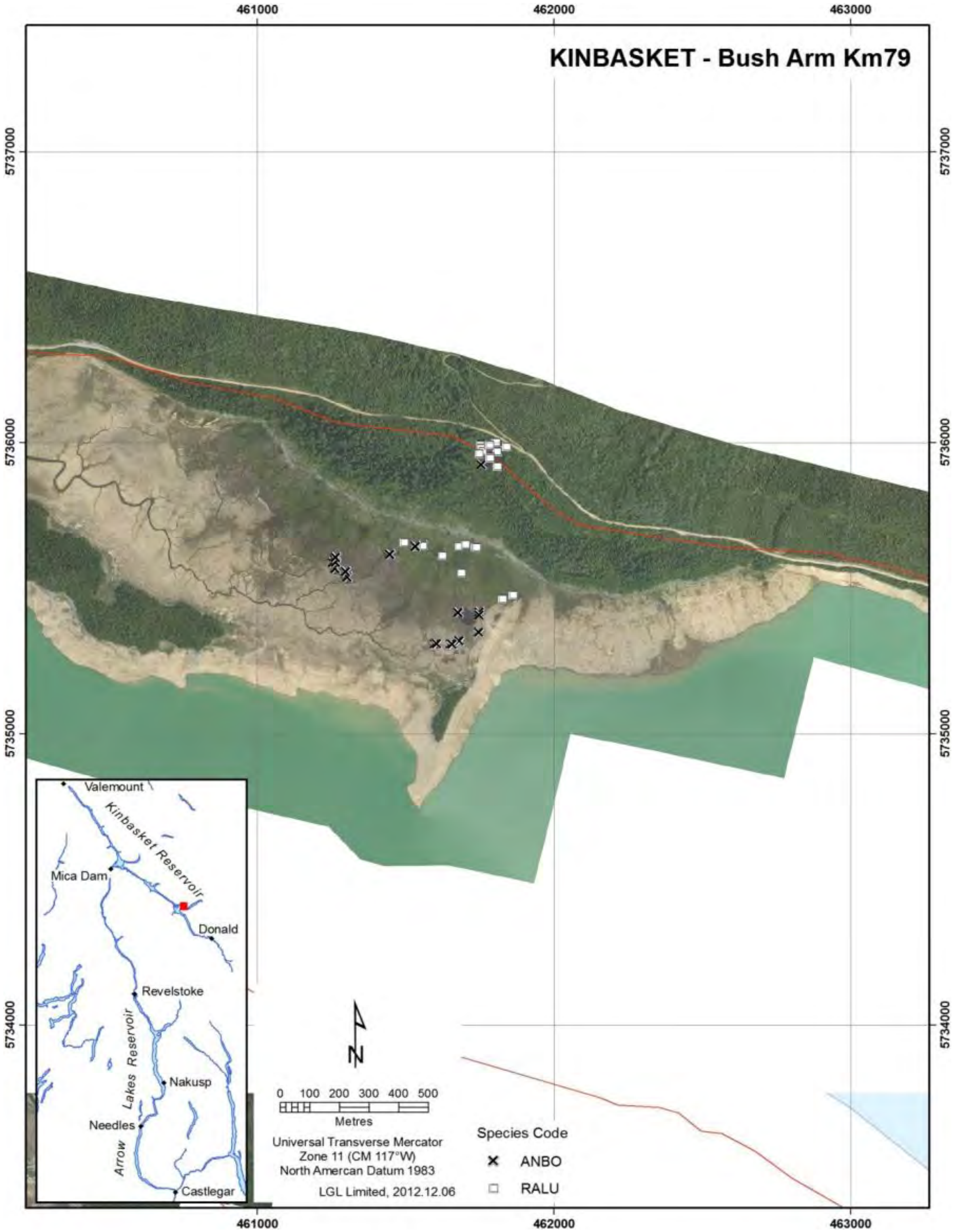
Map 9-3: Species documented at Sprague Bay, Kinbasket Reservoir. Species codes can be found in Table 1-1



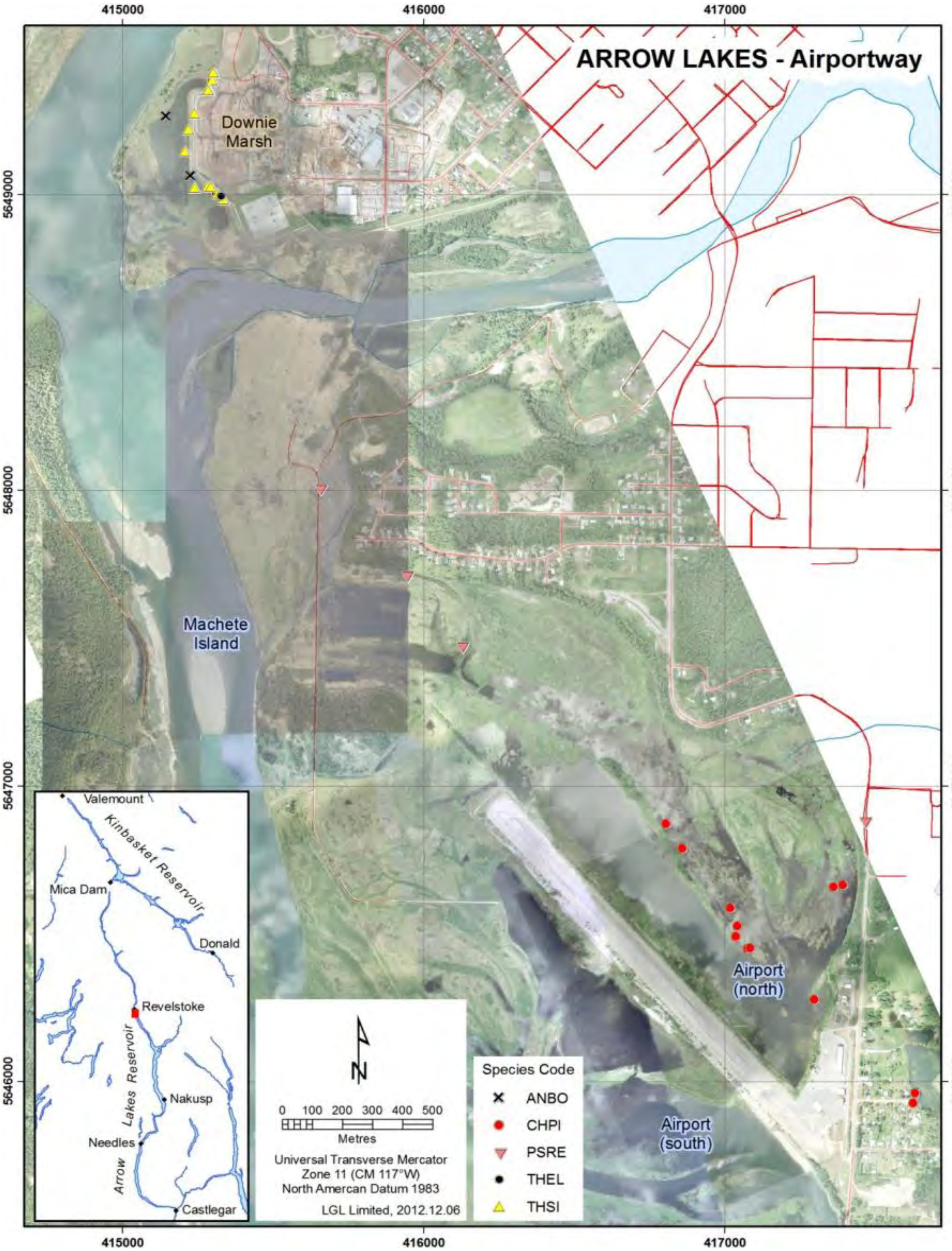
Map 9-4: **Species documented at Bush Arm (Causeway), Kinbasket Reservoir.** Species codes can be found in Table 1-1



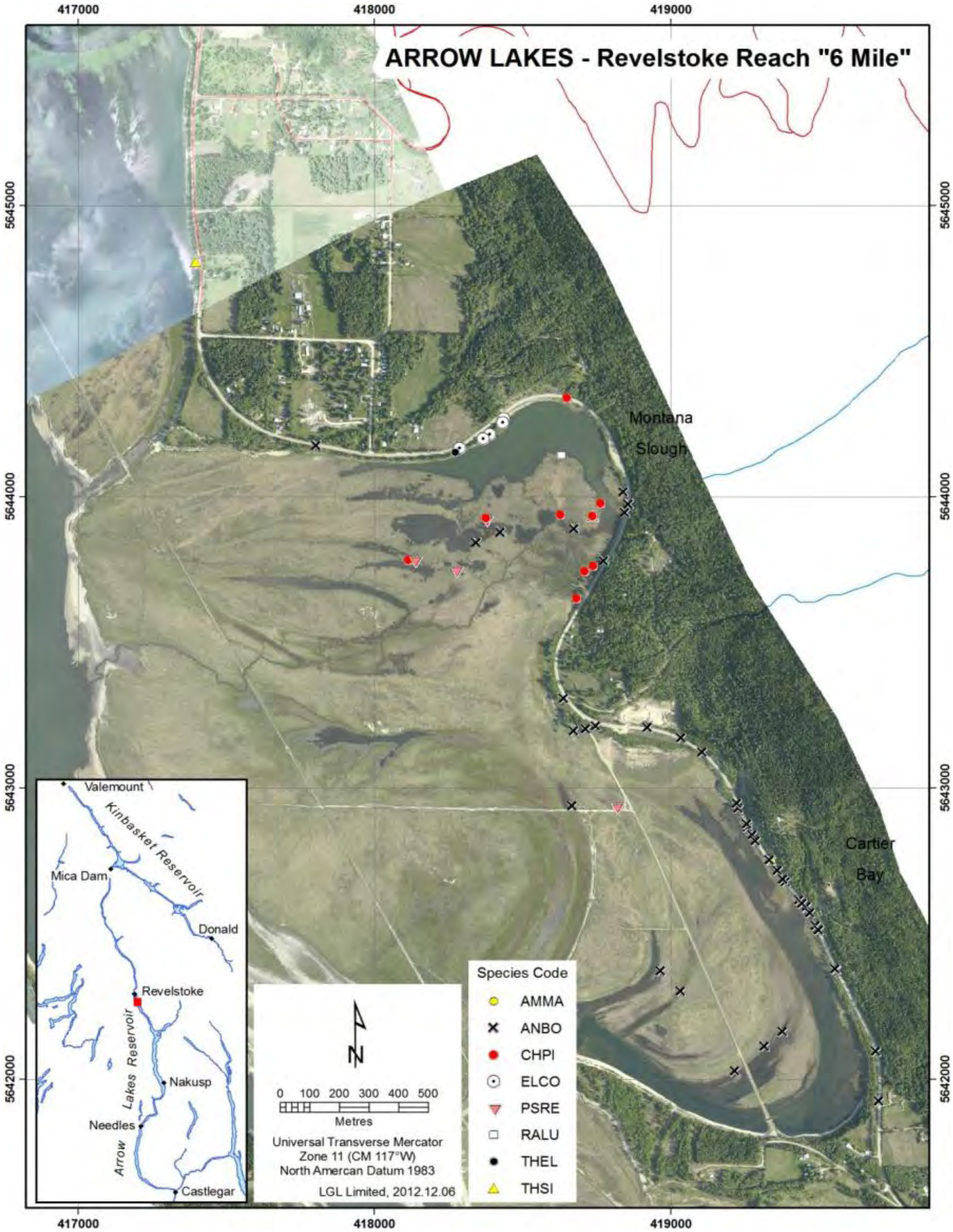
Map 9-5: **Species documented at Bear Island in Bush Arm, Kinbasket Reservoir.** Species codes can be found in Table 1-1



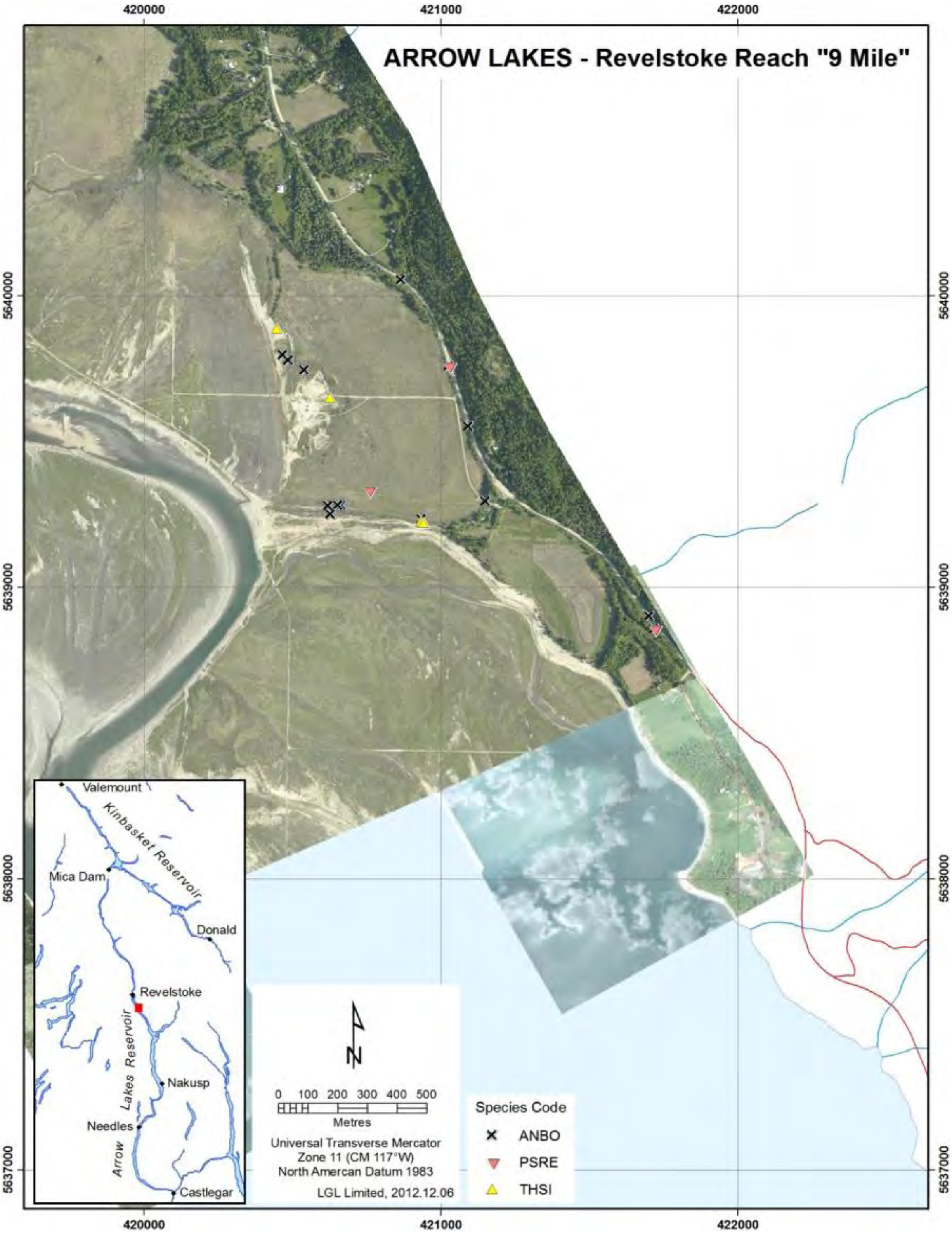
Map 9-6: **Species documented at km 79 marshes Bush Arm, Kinbasket Reservoir.** Species codes can be found in Table 1-1



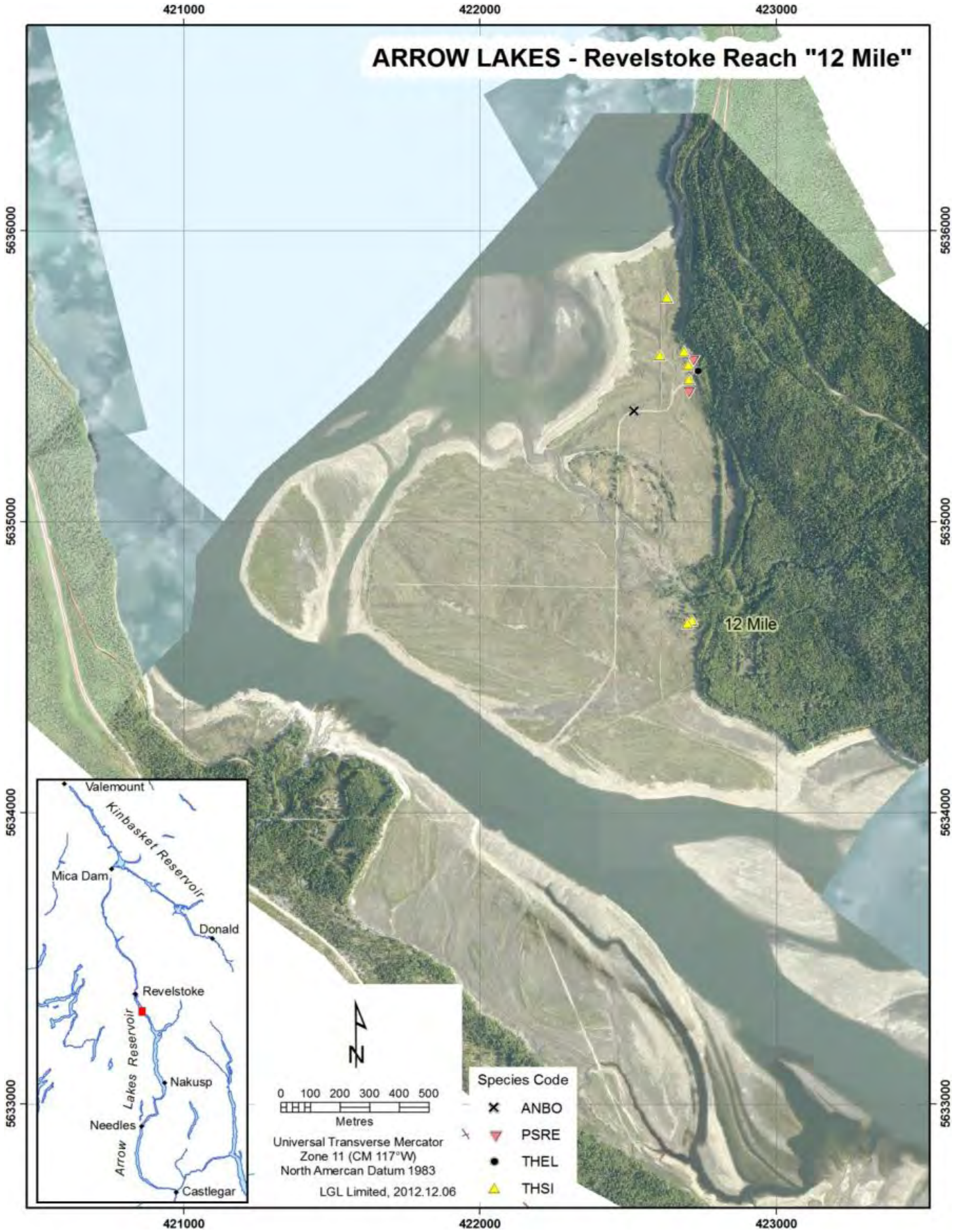
Map 9-7: Species documented at Airport Marsh, Arrow Lakes Reservoir. Species codes can be found in Table 1-1



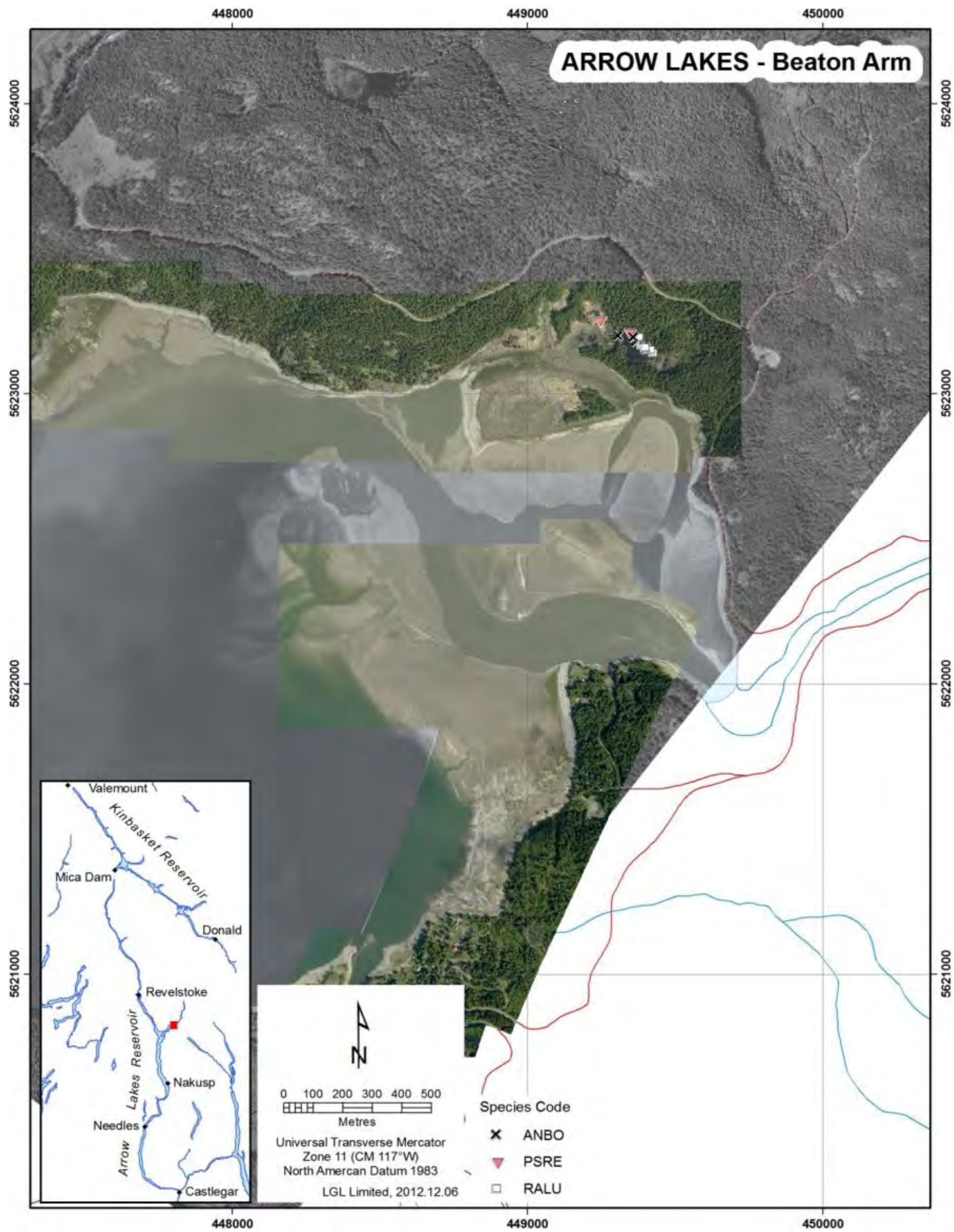
Map 9-8: **Species documented at "6 Mile", Arrow Lakes Reservoir.** Species codes can be found in Table 1-1



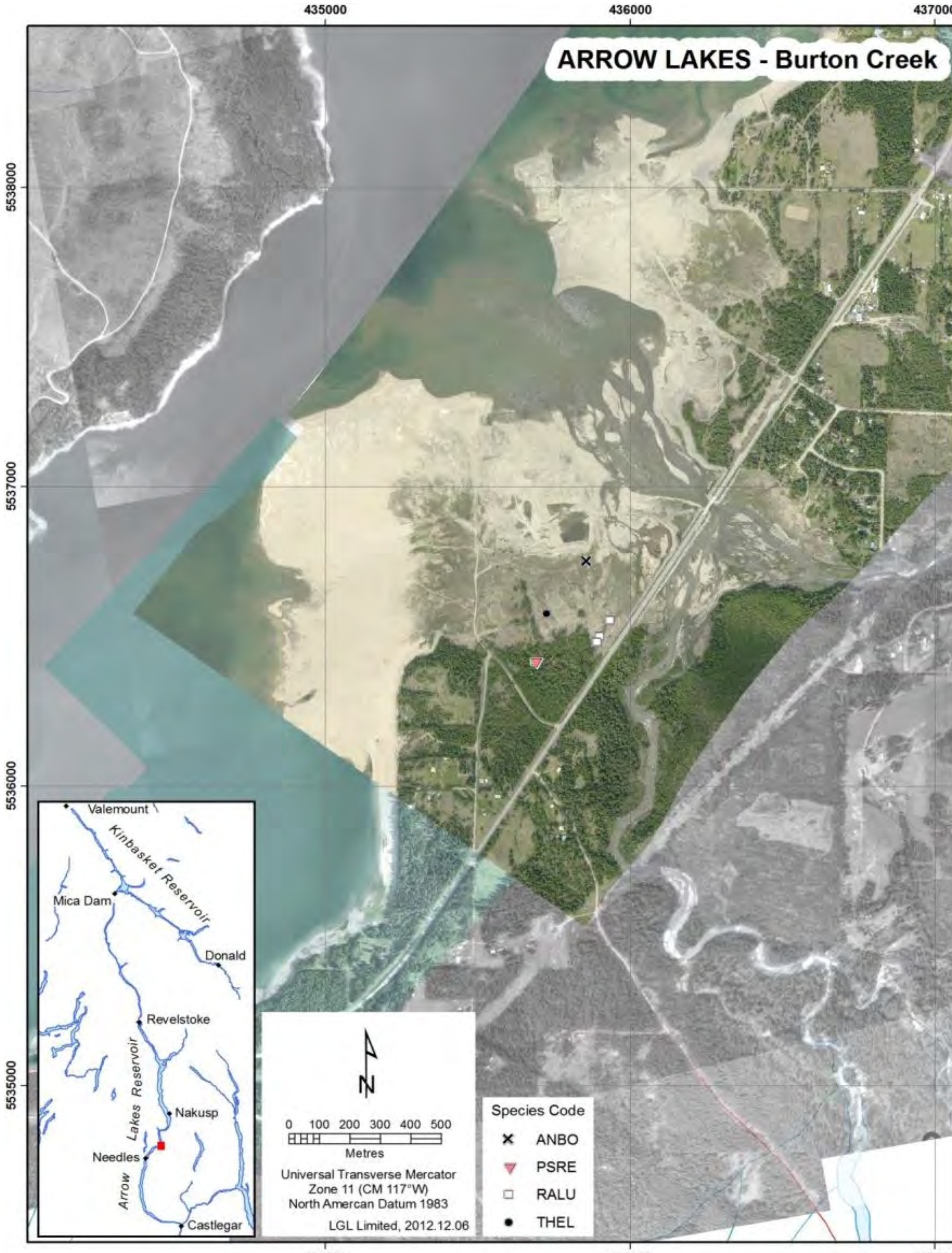
Map 9-9: **Species documented at "9 Mile", Arrow Lakes Reservoir.** Species codes can be found in Table 1-1



Map 9-10: Species documented at "12 Mile", Arrow Lakes Reservoir. Species codes can be found in Table 1-1

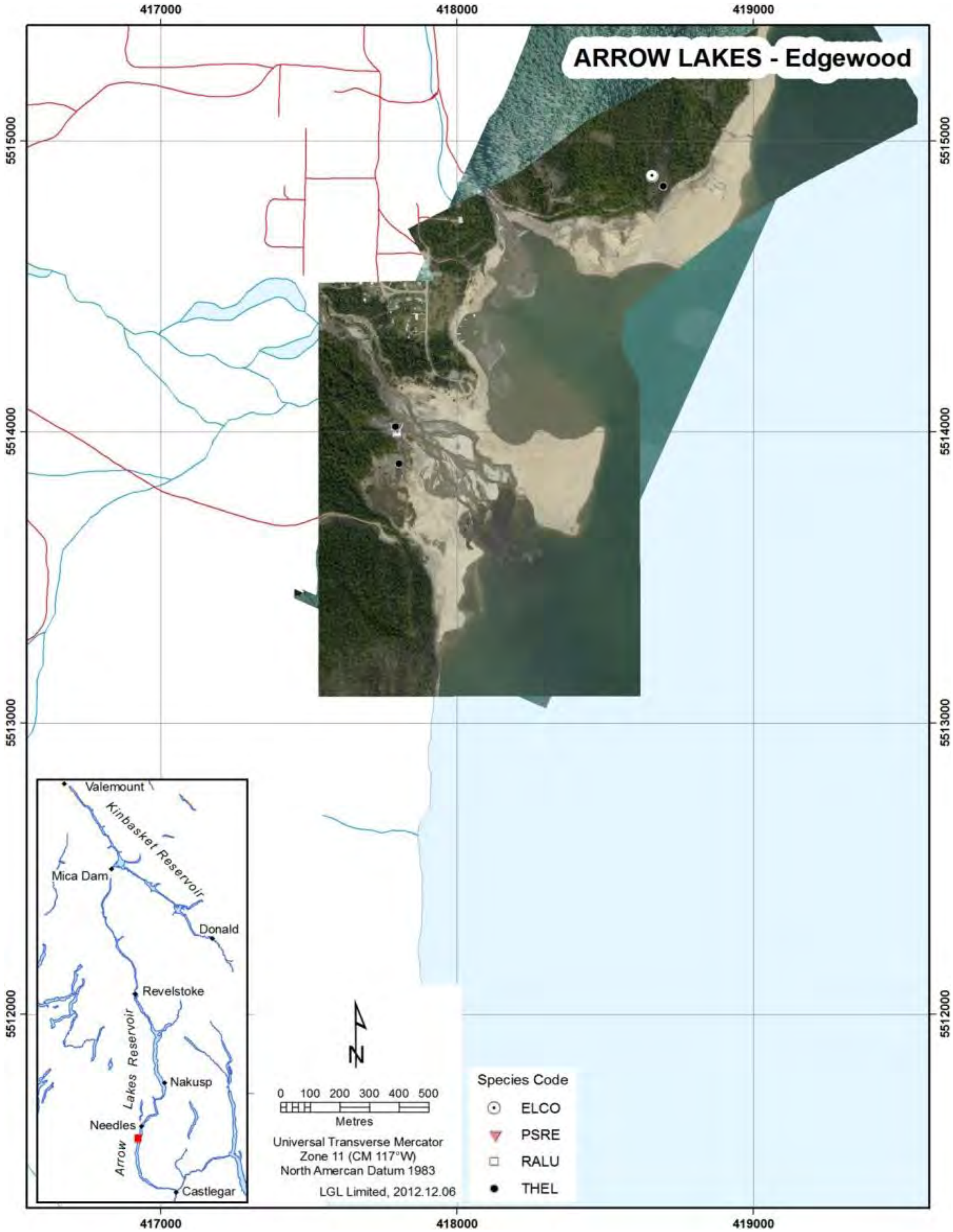


Map 9-11: Species documented at Beaton Arm, Arrow Lakes Reservoir. Species codes can be found in Table 1-1



Map 9-12: **Species documented at Burton Creek, Arrow Lakes Reservoir.** Species codes can be found in Table 1-1

Map 9-13: Species documented at Lower Inonoaklin Road, Arrow Lakes Reservoir. Species codes can be found in Table 1-1



Map 9-14: Species documented at Edgewood, Arrow Lakes Reservoir. Species codes can be found in Table 1-1