Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoirs Revegetation Management Plan

Wildlife Effectiveness Monitoring of Revegetation and Wildlife Physical Works in the Arrow Lakes Reservoir

Implementation Year 5

Reference: CLBMON-11B3

Revelstoke Reach Painted Turtle Monitoring Program

Study Period: 2014

Okanagan Nation Alliance, Westbank, BC

and

LGL Limited environmental research associates,
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CLBMON-11B3 Revelstoke Reach Western Painted Turtle Monitoring Program




Monitoring Year 5 2014
FinalAnnual Report

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Cover Photographs

From left to right: Arrow Lakes Reservoir near Revelstoke; Juvenile Western Painted Turtle (*Chrysemys picta belli*); Adult Western Painted Turtle at 9 mile, Arrow Lakes Reservoir; and basking logs and Rocky Mountain Pond-lilies on Turtle Pond. Photos © Krysia Tuttle, Charlene Wood, and Virgil C. Hawkes LGL Limited environmental research associates.

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EXECUTIVE SUMMARY

This year marked the fifth year of monitoring under CLBMON-11B3, a 10-year Western Painted Turtle (*Chrysemys picta belli*) life history and habitat use monitoring study in the drawdown zone of Arrow Lakes Reservoir near Revelstoke, B.C. Initiated in 2010, this study is intended to address the relative influence 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 painted turtles occurring in habitats within Revelstoke Reach. Eight management questions are investigated in this study, with the primary objective being to provide information on how painted turtles 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 this population or the habitats in which turtles occur.

As in previous years, a variety of survey methods (radio-telemetry, hoop trapping, and visual searches) were used to document the relative abundance, distribution, productivity, and habitat use of Western Painted Turtles in three areas within the drawdown zone of Revelstoke Reach (Airport Marsh, Cartier Bay, and Montana Slough). Observations were also made at two upland reference sites (Williamson Lake and Turtle Pond) in order to assess differences between turtle habitat use and productivity between inundated and non-inundated ponds.

The primary focus of this report is on the monitoring that occurred during 2014. Particularly, we continued our assessment of overwintering habitat conditions that began in 2013. We focus on comparisons of habitat conditions at sites used by turtles in the winter compared to conditions at locations not used by turtles, as well as summer conditions. Additionally, we provide new assessments of turtle elevation distribution for all study years, sites, and months, based on interpolations from digital elevation models.

Fifty-seven observations of overwintering turtles were made during the radio-telemetry sessions between January and March 2014. Most of these detections occurred at Airport Marsh (N=25) and Montana Slough (N=19). Most turtles overwintered in the same ponds in 2013 as 2014, with the exception of one female turtle female (F091) and one male turtle (M147), both of which overwintered in Airport Marsh in 2013, but overwintered in Montana Slough in 2014. No turtles overwintered in Cartier Bay in 2013 or 2014.

In 2014, Western Painted Turtles hibernated at elevations ranging from 435.7 m and 438.3 m ASL in the drawdown zone *vs.* 442.4 m and 447.4 m ASL in upland ponds. Montana Slough and Airport Marsh appear to be the most important overwintering sites for turtles in Revelstoke Reach with "Winter Pond" in Montana Slough used disproportionately relative to other locations.

Characteristics of overwintering sites used by turtles were highly variable in terms of temperature, dissolved oxygen, and depth, suggesting tolerance to a wide range of conditions. Ponds used by Western Painted Turtles for overwintering in the drawdown zone had an average water depth of 36 cm and an average ice thickness of 39.8 cm. In the drawdown zone, turtles overwintered in locations ~ 9 cm deeper than turtles in the upland reference ponds. In winter 2014, the water surface temperatures of turtle locations were at freezing levels in all sites (mean temp: DDZ= 0.09 °C and UPL= 0.22 °C). The dissolved oxygen content at all

monitored overwintering locations did fall within anoxic levels (<2 mg/L) in the winter of 2014 (as in 2013). Dissolved oxygen levels were similar for drawdown zone and upland ponds (mean DO: drawdown zone = 5.91 mg/L; upland = 4.78 mg/L). Drawdown Zone habitats appeared to have higher concentrations of dissolved electrolyte ions than UPL turtle habitats. Surface conductivity of turtle locations in the drawdwon was almost twice that of turtle locations in upland reference ponds during the winter. The pH of turtle locations was approximately neutral during the winter and was similar between upland and drawdown ponds.

Turtle movements (distance travelled per day) were comparable between sites, though the range of variation in movements appeared to be greater in the drawdown zone at Airport Marsh and Montana Slough than in either upland reference site (Turtle Pond and Williamson Lake). Similar to 2013, turtle movements increased between the pre-inundation and inundation periods in both drawdown zone and upland sites.

Monitoring will continue in 2015 and will follow similar methods used in previous years. However, the focus in future years will be on juvenile survivorship and reproductive success rather than overwintering habitat associations.

The status of CLBMON-11B3 after Year 5 (2014) with respect to the management questions and management hypotheses is summarized below.

Management Questions:	**Able to Address?**	**Scope**	
		Current supporting results	Suggested modifications to methods where applicable
MQ1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?	Yes	5 years of observations on WPT use of the DDZ for most of their life history requirements	• none
MQ2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?	Partially	5 years of data on habitat characteristics of adult WPT locations Initial data collection on habitats of juvenile WPT and nesting habitats	• Continue data collection on juvenile WPT.
MQ3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?	Partially	Multiple years of live-capture data from study sites Comparison of standardized catch in each pond, season, and year Initial data collection on juvenile survivorship	• Continue data collection on juvenile WPT survival / nest success.

Management Questions:	**Able to Address?**	**Scope**	
		Current supporting results	Suggested modifications to methods where applicable
MQ4: Does the operation of the Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?	Partially	5 years of data collected on WPT in the drawdown zone of Revelstoke Reach Growth and body condition comparisons between DDZ and upland reference sites 25 documented mortalities in the DDZ	• Additional years of monitoring of various life stages, focusing particularly on juvenile WPT mortality factors and habitat availability.
MQ5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?	Partially	5 years of data collected on the occurrence and distribution of WPT in the DDZ of Revelstoke Reach	• Additional years of monitoring of various life stages and their habitat use.
MQ6: Can physical works be designed to mitigate the impacts of reservoir operations on painted turtles?	Potentially	Installation of anchored floating islands and additional basking habitat could potentially mitigate loss of available habitat due to inundation and provide refuge; enhancement of nesting habitat may improve suitability of available nesting habitat	• Implement physical works and/or habitat enhancement programs in Revelstoke Reach followed by monitoring.
MQ7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?	Not at this time	N/A	• Implement revegetation program in Revelstoke Reach followed by monitoring.
MQ8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?	Not at this time	N/A	• Implement physical works in Revelstoke Reach followed by monitoring.

Management Hypotheses:	**Able to Address?**	**Scope**	
		Current supporting results	Suggested modifications to methods where applicable
H1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir.	Partially	5 years of data documenting WPT use of the DDZ for most life history requirements	• none

Management Questions:	**Able to Address?**	**Scope**	
		Current supporting results	Suggested modifications to methods where applicable
H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity.	Partially	5 years of observations and mark-recapture data on adult WPT use of the DDZ Initial data collection on juvenile survivorship and nest success	• none
H3: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical work and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach.	Not at this time	N/A	• Implement habitat enhancement projects (revegetation and/or physical works) in Revelstoke Reach followed by monitoring.

Key Words: Western Painted Turtle, reptile, life history, habitat use, reservoir operation, drawdown zone, Arrow Lakes Reservoir

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1.0 INTRODUCTION

The Columbia River Water Use Plan (WUP; BC Hydro 2007) was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities to balance environmental values, recreation, power generation, culture/heritage, navigation, and flood control. The goal of the WUP is to accommodate these values through incremental changes on how water control facilities store and release water, or to undertake physical works in lieu of changes to reservoir operations to meet the specific interests. During the WUP, the Consultative Committee (CC) supported the implementation of physical works (revegetation and habitat enhancement) in the mid-Columbia River in lieu of changes to reservoir operations to help mitigate the impact of Arrow Lakes Reservoir operations on wildlife and wildlife habitat. In addition, the CC also recommended monitoring the effectiveness of these physical works at enhancing habitat for wildlife (BC Hydro 2005).

During the Columbia WUP, the Western Painted Turtle (*Chrysemys picta belli*) was identified as a species that may be vulnerable to fluctuating water levels resulting from operations of the Arrow Lakes Reservoir (BC Hydro 2005). It is a provincially blue-listed species and the intermountain population is listed as Special Concern under Schedule 1 of SARA (COSEWIC 2006). The population that occurs near Revelstoke, BC is one of the most northern populations and has regional importance (Schiller and Larsen 2012a and 2012b; Maltby 2000). Furthermore, the Western Painted Turtle was identified as a species that may benefit from habitat enhancement via physical works (Golder Associates 2009a and 2009b).

Western Painted Turtles are small freshwater turtles with smooth, dark carapaces with pronounced red and yellow pigmentation on the limbs and plastron. They are slow to mature sexually (8 to 10 years for males and 12 to 15 years for females) and long-lived, living to 50 years or more. They are found in the shallow water ponds, lakes, sloughs, and slow-moving streams or rivers (e.g., the Columbia River), but like many aquatic reptiles they require various habitats corresponding to their life history needs.

Western Painted Turtles overwinter in shallow areas, often at or near freezing temperatures. Western Painted Turtles usually hibernate at the bottom of the pond, remaining relatively stationary (Matsuda et al. 2006), but they have also been observed swimming under the ice during winter (Rollinson et al. 2008). Adapted to northern climates, the Western Painted Turtle tolerates prolonged periods of anoxia and low temperatures (Ultsch et al. 1985). While dormant, their demand for oxygen is low, and achieved by absorption of dissolved oxygen through the skin and anaerobic respiration (Dinkelacker et al. 2005).

The duration of hibernation and onset of feeding and breeding are governed by water temperature. Feeding begins at water temperatures of 15 to 18°C, with juveniles consuming tadpoles and invertebrates, gradually becoming omnivorous as they mature. Habitat during the summer active period is characterised by muddy substrates, emergent aquatic vegetation, and an abundance of basking sites. Western Painted Turtles mate underwater in warm shallow water in the spring and summer. Nesting sites are typically within 150 meters from pond margins and are composed of loose, warm, well-drained soils, often on south-facing slopes (Matsuda et al. 2006). Gravid females bury 6 to 22 eggs in a flask-shaped nest, which begin to hatch in late summer (Matsuda et al. 2006). Hatchlings remain dormant in the nest until the following spring.

Western Painted Turtles are found in all provinces in Canada except Prince Edward Island, Nova Scotia, New Brunswick and Quebec. The species range appears to be limited by the length of the turtle's active season, mean ambient temperature during egg incubation, and mean winter temperature (COSEWIC 2006). Due to low adult recruitment and delayed maturity, Western Painted Turtles are particularly susceptible to mortality of juveniles and adults (COSEWIC 2006). Factors contributing to low recruitment include road mortality (particularly of females during the nesting season), predation on dispersing turtles, and depredation of nests. Habitat degradation, loss, and fragmentation are also threats (e.g., Maltby 2000). While reservoirs have contributed to the loss of habitat during construction and fluctuating water levels have been linked to increased predation risk (COSEWIC 2006), little is known of the impacts of reservoir operations on western painted turtle populations.

During 2010 and 2011, a pilot project was conducted to collect baseline data on a population of Western Painted Turtles near Revelstoke, BC. The goal of this study was to determine the extent to which painted turtles use the reservoir, provide a preliminary assessment of the population, and develop a long-term monitoring strategy to address the concerns raised during the WUP. This two-year study used a number of techniques including visual encounter surveys (VES), nesting and hatchling emergence surveys, trapping, mark-recapture, and radio-telemetry to obtain data on painted turtles. A monitoring strategy was developed by Schiller and Larsen (2012b) who identified key information gaps and outlined how to proceed to determine the impacts of reservoir operations on Western Painted Turtles in Arrow Lakes Reservoir near Revelstoke BC and address management questions and hypotheses. Monitoring continued through 2012 (Hawkes et al. 2013), 2013 (Wood and Hawkes 2014), and 2014, providing further insights on painted turtle productivity, habitat use, and overwintering preferences.

This report summarizes work completed in 2014 for BC Hydro's Monitoring Program CLBMON-11B3: *Arrow Lakes Reservoir: Revelstoke Reach Western Painted Turtle Monitoring Program.*

2.0 STUDY OBJECTIVES

2.1 Study Design

A monitoring strategy for Western Painted Turtles in Revelstoke Reach, located at the north end of Arrow Lakes Reservoir, was developed by Schiller and Larsen (2012b) that identified key information gaps and outlined how to address the management questions and hypotheses for this project. The strategy identified several monitoring initiatives and has been adapted into the monitoring framework presented below. This monitoring strategy outlines a two-pronged approach to address the various management questions and hypotheses that can be implemented incrementally over time (Table 2-1).

First, the strategy recommended long-term tracking of population trends through mark-recapture techniques to assess the impacts of reservoir operation on the demographics parameters, requiring summer field sampling from 2012 to 2020. Since nesting locations are known in Revelstoke Reach, monitoring nest success to acquire data on recruitment was also suggested to examine productivity in this population. This initiative will address the following management questions: MQ1, MQ3, MQ4, and MQ5.

Second, a set of initiatives was proposed to address the management questions and hypotheses specific to painted turtle habitat use (Table 2-1). Initiatives 2a to 2d would involve graduate student projects over the ten year study period. With the exception of the initiative 2d, these initiatives are intended to be implemented in two-year sampling windows. Initiative 2d will require a longer sampling period than two years; however, it is likely that data for this initiative can be collected in conjunction with 2a and 2c. Collectively these initiatives will provide more information towards addressing MQ2, MQ4, MQ6, MQ7, and MQ8.

Table 2-1: Relationships between the management questions, hypotheses, and the long-term monitoring strategy for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir. Seasons are grouped into S/S (spring/summer) and F/W (fall/winter)

Initiative		Management Question Addressed	Season		Study Years
			S/S	F/W	
1	Long term tracking of turtle demographics to monitor population trends (abundance, recruitment/productivity, and mortality) and assess the impacts of reservoir operations on these parameters	MQ1, MQ3, MQ4, MQ5	X	X	2012-2020
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	MQ2, MQ4, MQ6, MQ7, MQ8	X	X	2012-2020
2a	Conduct a focused study on the fine-scale habitat use by turtles during spring and summer and investigate potential impacts of reservoir operations on summer habitat use, habitat availability, and turtle movements	MQ2, MQ4, MQ5	X		2014-2016
2b	Conduct a focused study on fine-scale habitat use by turtles during winter and investigate potential impacts of reservoir operations on winter habitat use and habitat availability	MQ2, MQ4, MQ5		X	2012-2014
2c	Conduct a focused study on turtle fine-scale nesting habitat use within and adjacent to the reservoir and identify opportunities for enhancement of nesting sites	MQ3, MQ6, MQ7, MQ8	X		2014-2018
2d	Use radio-telemetry, ground surveys, and habitat assessments to assess the effectiveness of the revegetation program (CLBWORKS 2) and wildlife physical works program (CLBWORKS 29A and 30) to enhance painted turtle habitat in Arrow Lakes Reservoir	MQ6, MQ7, MQ8	X		2012-2020

2.2 Management Questions and Hypotheses

As part of BC Hydro's long-term monitoring program CLBMON-11B3, eight management questions were developed to determine the impacts of reservoir operations on Western Painted Turtles that use habitats in the drawdown zone of Arrow Lakes Reservoir near Revelstoke Reach, B.C.:

Theme 1: Life History and Habitat Use

MQ1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?

MQ2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

MQ3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?

MQ4: Does the operation of Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

Theme 2: Mitigation – Reservoir Operations and Effects

MQ5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?

MQ6: Can physical works be design to mitigate the impacts of reservoir operations on painted turtles?

Theme 3: Effectiveness Monitoring

MQ7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?

MQ8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?

The following hypotheses were developed to address the three themes of management questions:

H1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir

H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity.

H3: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical work and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach.

These questions and hypotheses will be tested directly by this monitoring program, which is aimed at determining the life history and habitat use of Western Painted Turtles in Revelstoke Reach relative to reservoir operational regimes, including changing water levels. The monitoring program is also designed to address whether or not the physical works and/or revegetation programs will enhance habitat suitability for turtles in the drawdown zone.

2.3 Scope of Work 2014

For the period 2012 to 2014, the work is focused on Initiatives 1, 2a, and 2b of the monitoring strategy (Table 2-1). During this period, sampling and tracking of Western Painted Turtles continued to assess the impacts of reservoir operations on turtle abundance and productivity (Initiative #1), and characterise fine-scale habitat associations to assess the potential impacts of reservoir operations on habitat use, habitat availability, and turtle movements in spring, summer, and winter (Initiative #2a,b). Much of the data collected in 2013 and 2014 are also relevant to Initiatives 2c. Initiative 2d cannot be assessed until habitat enhancement works (physical works) are implemented in Revelstoke Reach.

2.4 Key Water Use Decision

The key operating decisions affected by this monitoring program are the operating regime for Arrow Lakes Reservoir and the implementation of soft constraints for Arrow Lakes Reservoir to balance the requirements of Western Painted Turtles with recreational opportunities, flood control, power generation, and other environmental objectives. Results of this monitoring program will help influence the scope of measures required to minimize or mitigate potential impacts, as well as to evaluate the efficacy of works undertaken to improve habitat for painted turtles. Information on the population demographic requirements of painted turtles will also help inform management decisions regarding the design and location of revegetation efforts and physical works projects within Arrow Lakes Reservoir. Operational changes to be considered will be limited to soft constraints that govern daily operations such as timing, magnitude and flow rate as opposed to hard constraints that include reservoir and turbine capacities, spillway rating, licensing requirements and Columbia River Treaty obligations.

2.4.1 Program Linkages

CLBMON-11B3 is directly and indirectly linked to other programs being implemented in the Arrow Lakes Reservoir. Over time (and following the implementation of physical works in Revelstoke Reach) the monitoring program developed for CLBMON-11B3 will provide an indication of the efficacy of the physical works implemented in Revelstoke Reach at enhancing wildlife habitat. In addition, data collected as part of that monitoring program are related to several long-term monitoring programs – specifically, CLBMON-37, CLBMON-40 and CLBMON-36. Additionally, the protocols for monitoring physical works implemented in Revelstoke Reach could be applied to physical works proposed for mid- and lower Arrow Lakes where wetland enhancement or creation is the objective (i.e., CLBWORKS-29B).

3.0 STUDY AREA

Arrow Lakes Reservoir is a ~230 km long section of the Columbia River drainage between Revelstoke and Castlegar, BC. It has a north-south orientation and is set in the valley between the Monashee Mountains to the west and the Selkirk Range to the east. The Hugh Keenleyside Dam, located 8 km west of Castlegar, spans the Columbia River and impounds Arrow Lakes Reservoir. The reservoir has a licensed storage volume of 7.1 million acre-feet (MAF) (BC Hydro 2007), and the normal operating range of the reservoir is between 440.1 m and 418.64 m ASL. The reservoir is largely operated for downstream power generation and flood control in the United States.

The typical hydrological regime of Arrow Lakes Reservoir is characterized by rapid infill between May through early July followed by a drop in reservoir levels through August. Reservoir levels may continue to decline though the fall but they may also be elevated to near maximum levels to accommodate fall storage. Reservoir levels decline throughout the winter reaching their lowest levels in the late winter/early spring. While levels of Arrow Lakes Reservoir can fluctuate dramatically (upwards of 60 meters) over the course of a year, there are several water bodies that retain water year round, providing possible refuge for the population of Western Painted Turtles near Revelstoke, B.C.

Two biogeoclimatic zones occur at the lower elevations surrounding Arrow Lakes Reservoir: the Interior Cedar Hemlock (ICH) and the Interior Douglas-fir (IDF). Most of the reservoir area occurs within the ICH, with three subzones and four variants represented. The IDF is restricted to the southernmost portion of the area and consists of a single subzone (IDFun); this area is outside of the study area of this project. The subzones are a reflection of increasing precipitation from the dry southern slope of Deer Park to the wet forests near Revelstoke (Enns et al. 2008). The Arrow Lakes Reservoir is situated primarily within the Arrow Boundary Forest District, with a small portion of its northerly area occuring in the Columbia Forest District. Western Painted Turtles are known to occur in Revelstoke Reach, at the northern extent of the Arrow Lakes Reservoir. The study area for CLBMON-11B3 is restricted to Revelstoke Reach, with all work focused on the east side of the reach. The area hosts several large wetland complexes, large open sedge/grass habitats and several willow-shrub complexes.

3.1 Study Sites

Monitoring occurred at main sites determined to be used by Western Painted Turtles in early monitoring years. Survey locations were consistent with previous study years (Wood and Hawkes 2014; Hawkes et al. 2013; Schiller and Larsen 2012b). Three sites were located within the drawdown zone of Revelstoke Reach (DDZ: Airport Marsh, Cartier Bay, and Montana Slough) and two sites were located upland, adjacent to the reservoir (UPL: Turtle Pond and Williamson Lake) (Figure 3-1). Upland ponds are unaffected by reservoir operations and can potentially serve as reference sites (i.e., controls) to compare with DDZ sites.

Vegetation varied considerably between the study locations where turtles were observed. Airport Marsh vegetation is dominated by bulrushes (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*), pondweed (*Potamogeton spp.*), and reed canary grass (*Phalaris arundinacea*). The dominant vegetation in Montana Slough is moss (*Sphagnum spp.*), willow (*Salix spp.*), and reed canary grass (*Phalaris arundinacea*). Outside of the drawdown zone, Turtle pond is mainly comprised of Rocky Mountain pond lily (*Nuphar polysepalum*) and Williamson Lake has combination of bulrushes (*Schoenoplectus tabernaemontani*), common cattail (*Typha latifolia*), pondweed (*Potamogeton spp.*), and skunk cabbage (*Lysichiton americanus*). Common to all areas of turtle observations was the frequent use of basking logs by turtles, some fixed and some floating, often multiple individuals using the same log. More detail regarding the vegetation of each site within Revelstoke Reach can be found in Fenneman and Hawkes (2012) and Miller and Hawkes (2013).

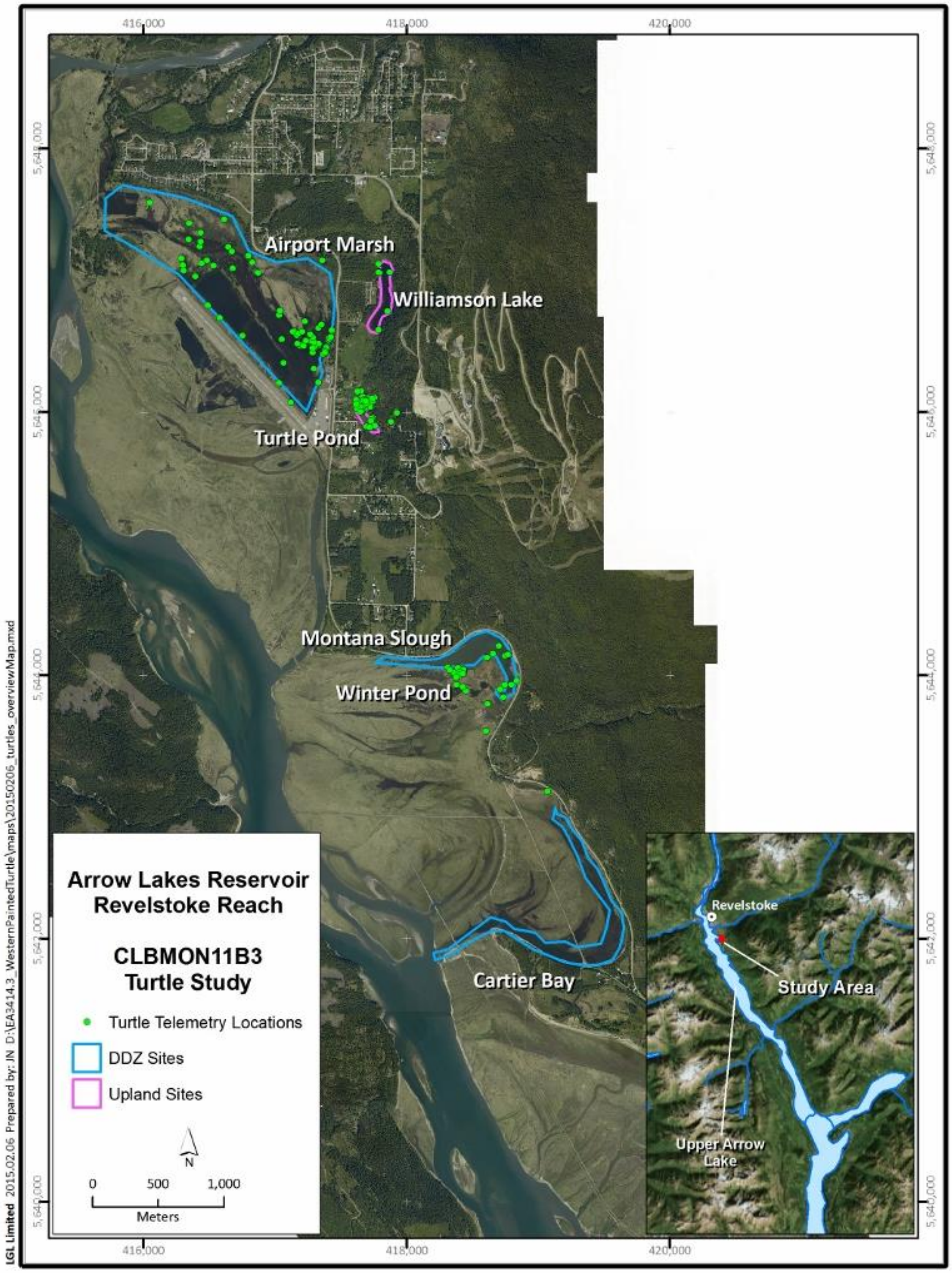

Figure 3-1: **Location of Western Painted Turtle study sites in the drawdown zone (DDZ) and upland areas of Revelstoke Reach of Arrow Lakes Reservoir.** Turtle locations detected in telemetry surveys are shown

4.0 METHODS

As outlined in section 2.1, most management questions necessitate analyses of long-term trends in turtle abundance, productivity, and habitat use/availability. Therefore, the methods and sampling protocols were specifically designed to address the management questions for CLBMON-11B3, and are intended to be comparable in during each year of work. The protocols for 2013 were consistent with previous years and are briefly summarized (see Hawkes et al. 2013).

4.1 Monitoring Methodology

Determining the status of long-lived animal populations such as chelonians is problematic and long-term studies are required to assess population trends (Whitfield et al 2000). As such, it is important to continue to monitor population parameters over time. Monitoring in 2014 followed the methods described by Schiller and Larsen (2012a) and RISC (1998a,b,c), and occurred every three to four weeks in most months of the year, depending on the survey type. Several sampling methods were used to collect field data including: 1) radio-telemetry, 2) live trapping, 3) visual encounter surveys (VES), and 4) mark/recapture techniques. These methods were used to monitor population trends (abundance, recruitment/productivity, and mortality) and to assess the impact of reservoir operations on these parameters. These data will contribute to addressing management questions: Q1, Q3, Q4, and Q5 over the 10 year study period.

4.1.1 Radio-telemetry

Radio-telemetry surveys were conducted every month, from January to December in 2014. Radio-telemetry provides detailed information on habitat use and selection, home range, mortality and survivorship, migration, dispersal, travel routes, and critical habitat (RISC1998b; Millspaugh and Marzluff 2001). To track turtles, a VHF transmitter was affixed to the carapace of a turtle and a VHF radio receiver was used for the direct location of each animal or an approximate location was obtained through triangulation methods (as in Schiller and Larsen 2012a, b; Hawkes et al. 2013). Transmitters did not exceed 5% of the turtle's body weight (Millspaugh and Marzluff 2001). The life expectancy of transmitters ranged from 10 to 36 months depending on the size of the unit.

4.1.2 Live-Trapping

Two rounds of trapping were conducted in 2014. The first occurred in the spring (May 11-17) and the second occurred in the fall (September 8-14). Hoop traps (Memphis Net and Twine Co., Inc.) were set in drawdown zone (Airport Marsh and Montana Slough) and upland reference sites of Revelstoke Reach (Turtle Pond and Williamson Lake). The traps were partially submerged in the water and were baited with sardines to attract turtles (bait was refreshed every few days). Baited traps were set and then checked every 12 hours (Gamble 2006). Morphometric data was collected on captured turtles and transmitters were affixed. Efforts were made to minimize stress to the animals, by immediately releasing turtles at the site of capture and equipping handlers with gloves (RISC 1998c).

4.1.3 Visual Searching and Hand Capture

Hand capture (i.e., net trapping) was used less often for surveying turtles in 2014 than in previous years. However, the locations of all turtles encountered by visual searches or caught by hand were recorded. Hand capture involved the use of a long-handled dip net while walking, wading or canoeing along the shoreline of a pond or wetland. Searches were conducted when turtles were most likely to be basking (i.e., mid-morning to early evening on either sunny or overcast, but warm days). In shallow water, searches followed a zigzag course parallel to the shoreline. Hand captures were also performed from boat if a turtle was encountered while paddling between locations.

4.1.4 Mark Recapture

Mark-recapture techniques have been used extensively throughout this study and enable the monitoring of individual turtles over time. Mark-recapture techniques involve the capturing, marking, releasing, and recapturing of individuals through repeated sampling (Krebs 1999). Recapturing of individuals was conducted opportunistically during nesting, VES surveys, hoop trapping, and radio-tracking under CLBMON-11B3 and VES under CLBMON-37. Individuals were marked by notching the carapace following the marking technique developed by Cagle (1939) and recommended by the RISC (1998a). Neonates and most juveniles were not notched, as their shells have not fully ossified and are soft. The notching scheme for this project was recorded as per Schiller and Larsen (2012b). Through the use of this marking technique, captured turtles were given unique identifiers in order to track individual turtles for the duration of CLBMON-11B3.

4.2 Additional Data

Additional data were collected during monitoring surveys to determine turtle habitat associations. These include: date, time, position of turtles, elevation, water depth, ice depth, pH, conductivity, dissolved oxygen content, water temperature, air temperature, precipitation, wind speed, humidity, and cloud cover. Turtle positions (UTM coordinates) were acquired using a Garmin® GPSmap60CSx unit. Elevation was interpolated from turtle positions based on the available digital elevation model (DEM) for Arrow Lakes Reservoir. Water and ice depth were measured using a tape measure, recorded to the nearest centimeter. During the winter, an auger was used to drill through the ice at the position of the turtle (or random location) to allow for measurements. The pH of the water was measured using an Oakton waterproof pH Tester 30. A YSI 85 multi-function metre was used to measure dissolved oxygen, conductivity, and temperature (taken approximately 10 cm from the surface of the water). A Kestrel® 4000 pocket weather meter was used to measure air temperature, wind speed, and relative humidity. Surveyors also recorded categories of precipitation (none, light, rain, snow) and estimated percent cloud cover.

To determine habitat use relative to habitat availability, these parameters were also measured within each water body at randomly selected locations with similar microhabitat characteristics. Comparisons were also be made between inundated ponds in the drawdown zone of Revelstoke Reach (Airport Marsh, Montana Slough, and Cartier Bay) to upland reference ponds (Williamson Lake and Turtle Pond).

4.3 Data Analyses

All analyses were performed in R version 3.1.2 (R core team 2014) and Microsoft Excel (Microsoft 2013). For determining statistical significance, we set α at 0.10. Box-and-whisker plots were used for interpretation of variance. 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.

Kruskal-Wallis rank sum tests (Hollander and Wolfe 1973) were performed with the ‘agricolae’ package in R (de Mendiburu 2013) in order to detect differences across turtle locations and between years. This analysis is a non-parametric alternative to analysis of variance, allowing for comparison of data that does not meet assumptions of normality. Most of the turtle data was highly skewed and thus, testing of mean ranks was an appropriate choice. The critical level of alpha was set to 0.1 and post-hoc comparisons were Bonferroni corrected.

4.3.1 Site Occupancy and Detection Rates

Turtle occurrence patterns were assessed with turtle presence (and non-detection) data for each study site and monitoring year. To examine turtle habitat-associations, trap catches, observations and detections were expressed in terms of catch per unit effort (CPUE). For CPUE standardizations, effort related to the number of traps, number of surveys, trap time (hours traps operated), and/or survey time (hours of telemetry or VES).

4.3.2 Elevation Distribution

Using the currently available digital elevation model (DEM) for Arrow Lakes Reservoir, we interpolated turtle elevations from turtle positions (UTM coordinates) recorded during all monitoring years (2010 to 2014). The interpolated elevations were generally much less variable than the recorded GPS elevations, reinforcing the use of DEM interpolations rather than readily available GPS elevations. For example the average difference between interpolated elevations and GPS elevations in 2013 data was 7.31 m (min = 0.15 m, max = 104.61 m).

The elevation of radio-tagged turtles was compared across all years (2010–2014), sites, and months to identify differences in relation to reservoir elevation and inundation period. We also examined the elevation distribution of turtles by sex to assess if male and female turtles were located at similar elevations at different times of year in the drawdown zone and upland reference ponds.

4.3.3 Water Depth and Water Quality

Turtles are known to use a wide range of water depths, however, shallow habitat may be preferred during certain life-history periods. For instance, during the active foraging period, shallow waters are generally warmer and more productive and can thus enhance foraging and growth rates. Turtle age has also been correlated to use of different pond depths. Congdon et al. (1992) found that younger turtles primarily occupy the shallow portions of a pond and move to increased water depth with increasing size and age through to sexual maturity. For these reasons, we assessed turtle associations with water depth at different times of year (winter and non-winter) and compared overwintering turtle locations with non-used winter locations. Ice thickness was likewise examined.

Water quality characteristics could be important determinants of turtle distribution and site occupancy patterns, particularly during the overwintering period. Therefore, we compared the water conditions (temperature, dissolved oxygen, and conductivity) associated with radio-transmitter tagged turtles during different periods (overwintering and non-overwintering) at each study site. A suite of water quality characteristics were also summarized for winter locations where turtles were not present in 2014 (as in Hawkes et al. 2013; Wood and Hawkes 2014).

Inter-annual comparisons in overwintering site conditions are strongly cautioned. Water physicochemistry measurements were taken during different months in the winters of 2013 and 2014 and replication is inadequate for statistical comparisons

4.3.4 Pond Size and Habitat Availability

The location, elevation, and number of ponds available in the drawdown zone were mapped for Cartier Bay and Montana Slough in Revelstoke Reach as per the CLBMON-37 Arrow Lakes Monitoring Program (Hawkes and Tuttle 2013). The relationship between habitat availability (in terms of pond area) and reservoir elevations was examined for various years (2008 to 2012).

4.3.5 Movement Patterns

Similar to the methods used for the 2013 monitoring year, we examined the relationship between the daily movements of radio transmitter-tagged turtles by year, month, and site in Arrow Lakes Reservoir. Turtle movement was expressed as the linear distance (in metres) between subsequent telemetry detections of each uniquely identified turtle. Linear distance was calculated using the Pythagorean Theorem and UTM position of turtle locations. The time between observations (recorded to the nearest minute) was used to generate measures of distance traveled (m) per day between each telemetry detection. Detections that were not within 100 days of the previous known turtle location were excluded to avoid increased bias in the results. Differences between years, months, and sites in terms of turtle movement were tested with Kruskal-Wallis rank sum tests, due to the non-normality of movement data.

4.3.6 Mass and Body Condition

The mass and body condition of turtles was examined consistent with Wood and Hawkes (20104). Animals in good condition are generally found to be heavier because of increased fat and protein stores or because they are structurally larger (Dobson 1992). We compared the mass of juvenile, adult male, and adult female turtles from each study site using boxplots to see if turtle weight was similar regardless of reservoir activity (comparison between drawdown zone and upland reference sites). Further, we examined the relationship between turtle mass and size for adult male and female turtles at each site with scatterplots and regression analyses. We used a common method to measure body condition that involves regressing body mass on a linear measure of body size (in this case straight-line carapace length; Schulte-Hostedde et al. 2005; Welsh et al. 2008). We log transformed mass and straight carapace length to achieve a linear fit prior to performing ordinary least squares regression for female and male turtles separately. Data included all captures from 2012 to 2014, amounting to 57 female and 68 male turtles. The proportion of positive versus negative standard residuals were used to assess the body condition of turtles in drawdown zone and upland reference sites. A positive residual indicates better body condition than a negative residual (Jakob et al. 1996), since individuals with positive residuals weigh more than predicted based on their size.

5.0 RESULTS

5.1 Environmental Data

Weather conditions are known to affect the growth rates and activity of turtles and other reptiles. Warm, sunny summer days are particularly important to turtles for thermoregulation via basking behaviour, and painted turtles are more conspicuous in surveys corresponding to optimal climatic conditions (RISC 1998a). Thus, weather data were obtained from Environment Canada's "Revelstoke Airport" weather station (11U 414147 m E, 5647151 m N; 444.70 m ASL) to evaluate the influence of weather conditions on species detectability and measures of relative abundance among years.

Consistent with previous monitoring years, mean daily temperature varied by month and between years, which is to be expected (Figure 5-1). Similarly, total precipitation varied on a monthly basis and between years (Figure 5-1). Environmental conditions were similar to previous monitoring years and were well within the ranges necessary for Western Painted Turtle detection (i.e., spring and summer, temperatures above freezing; RISC 1998a).

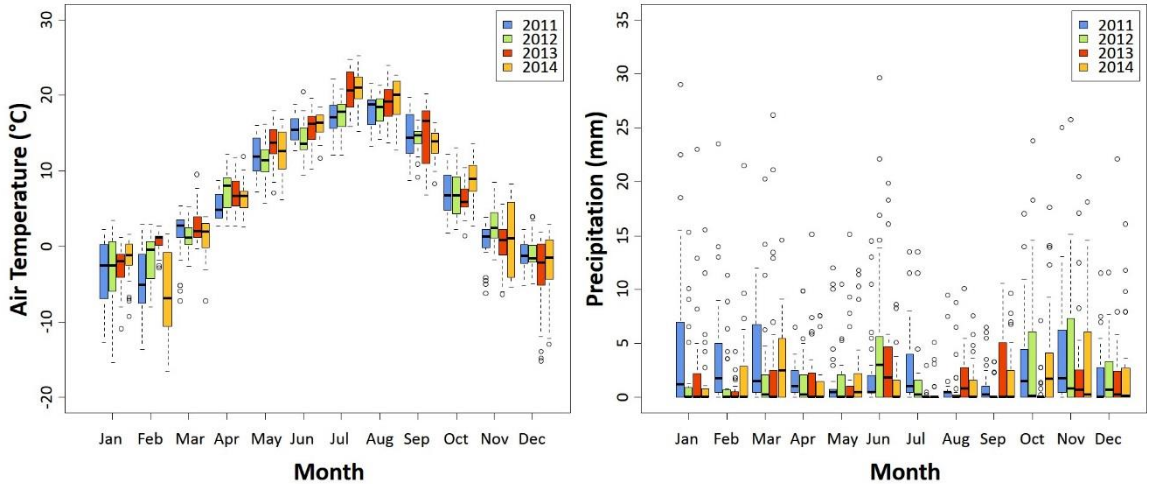

Figure 5-1: Daily temperature (°C, left) and precipitation (mm, right) for January through December, in years 2011 to 2014 as measured at Revelstoke Airport. Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html; accessed February 6, 2015)

5.2 Reservoir Operations

Reservoir operations directly affect spatial and temporal habitat availability and connectivity of aquatic and terrestrial habitats in the drawdown zone. The Arrow Lakes Reservoir has been operated in a variable manner (Figure 5-2), which will likely make it difficult to assess the implications for Western Painted Turtles habitat use in Revelstoke Reach.

The reservoir elevation increased by over 12 meters in 2014, reaching a minimum of 427.06 m on January 31st and a maximum of 439.11 m on July 3rd (mean elevation = 432.03 m). Overall patterns in reservoir elevation was similar to 2013. These fluctuations were within the variation observed for Arrow Lakes Reservoir, since 1969 (Figure 5-2).

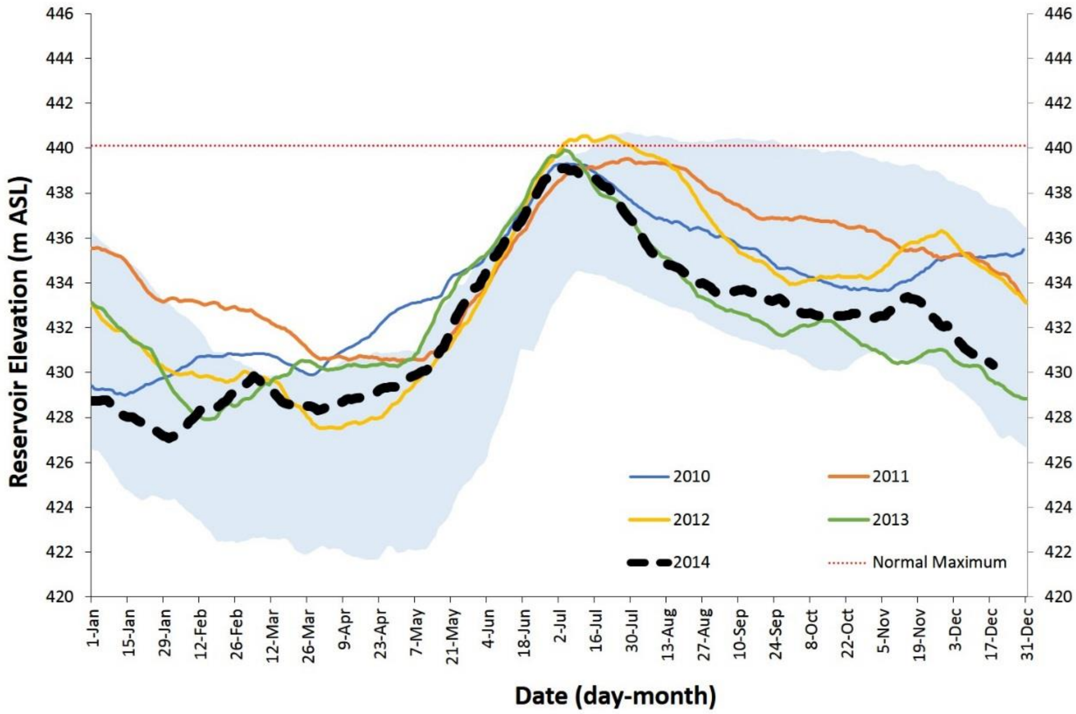

Figure 5-2: Variation in daily reservoir elevations recorded for Arrow Lakes Reservoir during the five study years (2010 to 2014). The dashed line highlights the 2014 reservoir elevation; the blue shaded region depicts the 10th and 90th percentiles in reservoir elevation for 1969 to 2014. The normal operating maximum (red dotted line) is also indicated

5.3 H1: Painted turtles are not dependent on habitats in the drawdown zone of Arrow Lakes Reservoir

Western Painted Turtles have been documented using habitats of the drawdown zone (DDZ) of Arrow Lakes Reservoir in each year of monitoring since the initiation of CLBMON-11B3 in 2010 and during the course of CLBMON-37. Painted turtles appear to use the DDZ to fulfill most of their life history requisites (Table 5-1). Growth, foraging, and overwintering activity have been documented at various sites in the DDZ in previous reports, while reproduction (nesting sites) has only been documented outside of the DDZ (e.g., Red Devil Hill, Williamson Lake, upland areas near Airport Marsh and Montana Slough).

From the past five years of monitoring Western Painted Turtles in Revelstoke Reach, we can conclude that turtles in this population are consistently using habitats in the drawdown zone at different life stages. The extent to which turtles in this system are dependent upon habitats in the drawdown zone will be difficult to assess. Specific results related to this hypothesis are detailed below.

Table 5-1: Summary of observed life history activities of Western Painted Turtles in the drawdown zone and upland sites at Revelstoke Reach of Arrow Lakes Reservoir from 2010 to 2013. Any "Yes" indicates a direct observation of the life history activity or stage, whereas the rest are inferences

	Life History Activity			
Study Site	**Reproduction***	**Growth**	**Foraging**	**Overwintering**
Airport Marsh (DDZ)	No	Yes	Yes	Yes
Cartier Bay (DDZ)	No	Unknown	Likely	Unlikely
Montana Slough (DDZ)	No	Yes	Yes	Yes
Turtle Pond (REF)	Likely	Yes	Yes	Yes
Williamson Lake (REF)	Yes	Yes	Yes	Yes

*nesting sites; breeding occurs in early spring; nesting in June

5.3.1 Site Occupancy

The turtle population of Revelstoke Reach has been monitored since 2010 in three main drawdown zone sites (Airport Marsh, Montana Slough, and Cartier Bay) and two upland reference sites (Turtle Pond and Williamson Lake). Turtles were observed at all five monitoring sites in most years (Table 5-2), with the exception of Cartier Bay, where no turtles were found during surveys conducted in 2010 and 2012. Adult female and male turtles have been observed using all five study sites. Over the past two years, individual turtles tended to only use one site (87.5% of females and 93.5% of males (Table 8-1). Only five females and three males were found using more than one site (Table 8-1). One female (F091) was detected at Airport Marsh, Montana Slough, and Turtle Pond (in 2013-2014). Two females used both Airport Marsh and Turtle Pond (F182 and F189), and the remaining two females used both Montana Slough and Cartier Bay (F061 and F117).

Table 5-2: Western Painted Turtle occurrence (orange fill) at each of the five main study sites (bold) and other locations by monitoring year

LOCATION	2010	2011	2012	2013	2014
Airport Marsh	■	■	■	■	■
Montana Slough	■	■	■	■	■
Cartier Bay		■		■	■
Turtle Pond	■	■	■	■	■
Williamson Lake	■	■	■	■	■
12-Mile	■				
9-Mile	■				
Other	■	■	■	■	

5.3.2 Detection Rates

Detection rates were calculated in terms of catch-per-unit-effort (CPUE), which varied by survey type, season, and site. These are summarized below for the 2013 and 2014 monitoring years (Table 5-3; Table 5-4). Hoop traps were more efficient during the 2014 trapping sessions than in 2013. The 2014 session caught twice as many turtles per trap and 1.3 times the number of turtles per hour as in 2013, despite the lack of a summer trapping session in 2014 (Table 5-3). In both years, Turtle Pond had the greatest detection rates for the spring trapping sessions, whereas Airport Marsh had the greatest detection rates in fall trapping sessions.

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In general, approximately three to four turtles were located in each telemetry survey in 2013 and 2014, consisting of about one turtle being located every hour (Table 5-4). The fall and winter telemetry sessions generated higher detection rates than spring and summer. Airport Marsh and Turtle Pond were the most productive sites across all seasons in terms of telemetry detections (3.5 to 10 turtles per survey in 2014). Montana Slough had high rates of telemetry detections in the winter and spring of 2014 (5.25 to 7 turtles per survey), compared to summer and fall surveys (1.5 to 2 turtles per survey). Only one turtle was radio-tagged at Williamson Lake in 2014 (Female# 148), thus telemetry rates were inherently low at this site.

Table 5-3: Western Painted Turtle trap captures by year, session, and site for the 2013 and 2014 monitoring years. Catch per unit effort is given per trap ($CPUE_{trap}$), per hour of trapping ($CPUE_{hour}$), and for one-trap-day equivalent. Trapping sessions occurred in the months of May (Spring), August (Summer, 2013 only), and September/October (Fall)

Year	Session	Location	No. of Captures	No. of Traps	Total Trap Hours	CPUE trap	CPUE hour
2013	Spring	Airport	2	6	314.97	0.33	0.006
		Montana	0	3	73.30	0	0
		Turtle Pond	11	2	90.92	5.50	0.121
		Williamson	1	5	312.60	0.20	0.003
	Spring Total		**14**	**16**	**791.78**	**0.88**	**0.018**
	Summer	Airport	5	10	515.72	0.50	0.010
		Cartier	0	1	68.10	0	0
		Montana	8	10	794.05	0.80	0.010
		Turtle Pond	10	2	151.12	5.00	0.066
	Summer Total		**23**	**23**	**1528.98**	**1.00**	**0.015**
	Fall	Airport	5	6	389.33	0.83	0.013
		Montana	1	12	627.77	0.08	0.002
	Fall Total		**6**	**18**	**1017.10**	**0.33**	**0.006**
2013 Total			**43**	**57**	**3337.87**	**0.75**	**0.013**
2014	Spring	Airport	11	5	503.30	2.20	0.022
		Montana	9	7	619.47	1.29	0.015
		Turtle Pond	17	3	447.92	5.67	0.038
		Williamson	0	2	49.22	0	0
	Spring Total		**37**	**17**	**1619.90**	**2.18**	**0.023**
	Fall	Airport	13	3	166.83	4.33	0.078
		Montana	3	8	700.65	0.38	0.004
		Turtle Pond	1	5	309.48	0.20	0.003
		Williamson	0	3	433.65	0	0
	Fall Total		**17**	**19**	**1610.62**	**0.89**	**0.011**
2014 Total			**54**	**36**	**3230.52**	**1.50**	**0.017**
Grand Total			**97**	**93**	**6568.38**	**1.04**	**0.015**

Table 5-4: Western Painted Turtle telemetry detections by year, month, and site for the 2013 and 2014 monitoring years. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

	Month	AP	CB	MS	TP	WL	TOTAL
2013	January	8		6	1	2	17
	February	8		6		2	16
	March	3		6		2	11
	May				1	1	2
	June	7		4	12	1	24
	July	4		4	10	1	19
	August	5	2		9		16
	September	6		6	11	1	24
	October	9		7	10	1	27
	November	8		8	10	1	27
	December	9		7	7	1	24
2013 Total		67	2	54	71	13	**207**
2014	January	10		7	7	1	25
	February	10		7	7	1	25
	March	10		7	7	1	25
	April	9		7			16
	May	10		7	6	1	24
	June	5		3	5	1	14
	July	15	1	7	11	2	36
	August	7		2		1	10
	September	10		2	5	2	19
	October	6		3	7	1	17
2014 Total		**92**	**1**	**52**	**55**	**11**	**211**
	Grand Total	**159**	**3**	**106**	**126**	**24**	**418**

Standardized catch rates are useful in comparing turtle use of drawdown zone and upland sites between years. Standardized trap catches were variable between years (Figure 5-3). Turtle trap catch (per hour) was much higher for UPL sites in 2013 than in DDZ, but during the 2014 trapping sessions, the DDZ sites caught more turtles per hour (Figure 5-3).

We compared standardized detection rates of the drawdown zone and upland sites by season in 2014 (Figure 5-4). The results of winter telemetry sessions from the past two years confirm that Montana Slough, Airport Marsh, Turtle Pond and Williamson Lake are consistently used by adult Western Painted Turtles during their hibernation period. Similar to results of 2013, none of the radio-tagged turtles were found to overwinter at Cartier Bay. Across all seasons, telemetry detection rates were much lower at Williamson Lake and Cartier Bay than at other sites. Airport Marsh, Montana Slough, and Turtle Pond all yielded numerous turtle detections per survey in each season, similar to the results seen in 2013 (Wood and Hawkes 2014).

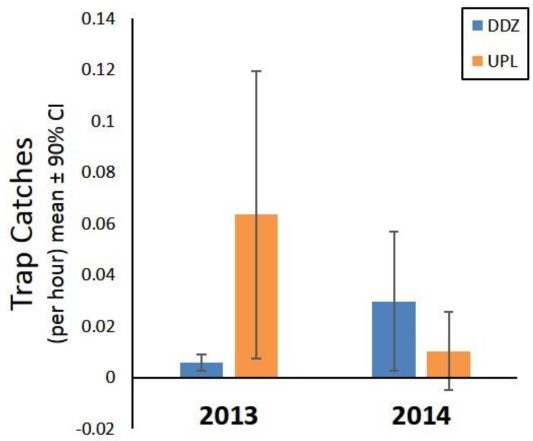

Figure 5-3: Mean turtle captures in 2013 and 2014 monitoring years by reservoir position of sites (DDZ= drawdown zone; UPL= Upland). Data were standardized to catch-per-unit-effort (CPUE) for each hour of trapping session. Error bars represent 90% confidence intervals

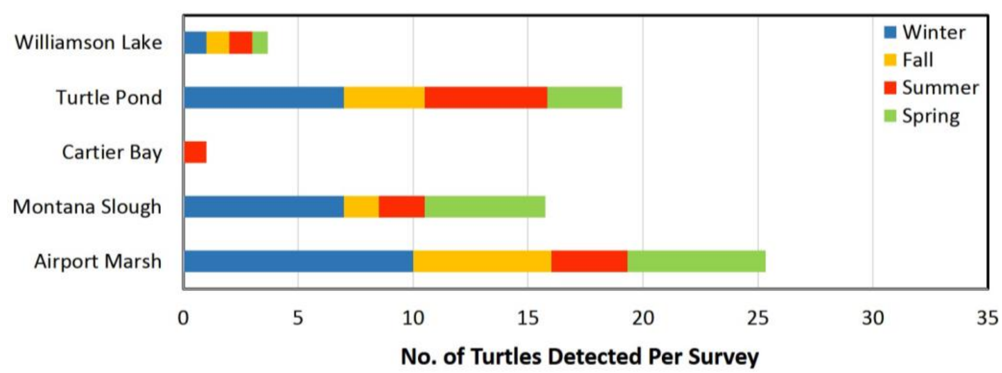

Figure 5-4: Seasonal patterns in site occupancy (number of turtles per survey) for 2014 telemetry surveys

Where the telemetry detection rates in each site are influenced by the original location and number of tagged individuals, standardized trap captures can be used to indicate turtle density at each site. In 2014, we conducted a trapping session in the spring (May 11-17) and fall (September 8-14) in four of the study sites (Airport Marsh, Montana Slough, Turtle Pond, and Williamson Lake). The pattern in standardized turtle catch varied by season (Figure 5-5). In the spring, Turtle Pond had the greatest catch rate, but collected only one-tenth as much during fall trapping sessions. Airport Marsh was more productive than Montana Slough in both sessions, with four times the catch rate (AP= 6.53 turtles/trap; MS= 1.67 turtles/trap). Airport Marsh was also more productive in the fall trapping session (4.3 turtles/trap) than in the spring (2.2 turtles/trap). Williamson Lake failed to yield any turtles in 2014 (5 traps total), possibly indicating a low population density at that site.

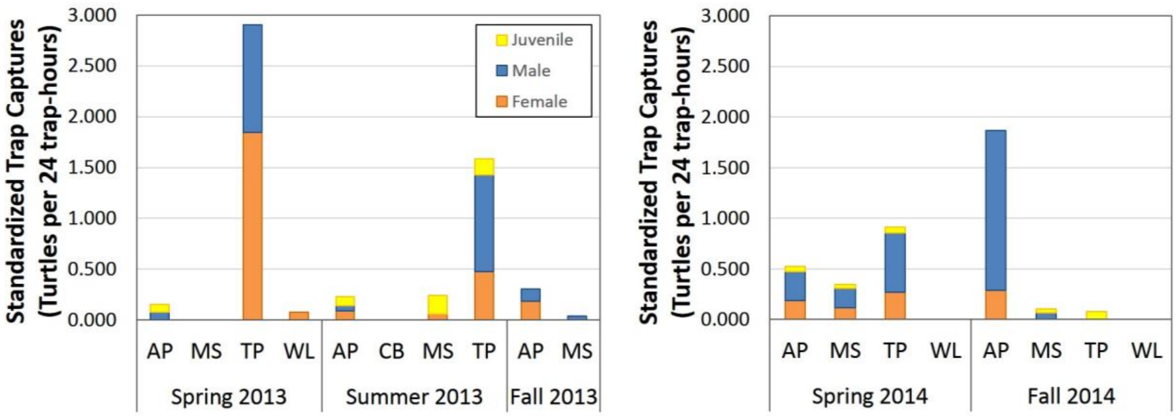

Figure 5-5: Seasonal patterns in site occupancy (number of turtles per trap) for 2013 and 2014 trapping surveys

Unlike sex ratios reported in previous years, which suggested a female bias, 60.6% of marked turtles were identified as males during the 2014 study year (Table 5-5). Males also made up a larger portion of trap captures in all sites surveyed during 2014, suggesting that male turtles may have been more numerous in the population in 2014 compared to 2013 (in the absence of a capture bias between sexes; Figure 5-5). Juveniles were caught in hoop trap surveys at Airport Marsh, Montana Slough, and Turtle Pond. A similar number of juveniles were captured per hoop trap in the spring trapping sessions of 2014, and appear positively related to the number of females collected at those sites (R^2 = 0.95 for spring trapping session; R^2 = 0.30 for fall trapping session).

The results of winter telemetry surveys in 2013 and 2014 confirm that Western Painted Turtles are overwintering at Montana Slough, Airport Marsh, Turtle Pond and Williamson Lake (see Section 5.3.1). No turtles were detected overwintering in Cartier Bay. There were 34 turtles tracked during the overwintering period of western painted turtles (December to March) in the previous two years. Most turtles overwintered in the same ponds in 2013 as 2014, with the exception of one female turtle female (F091) and one male turtle (M147), which both overwintered in Airport Marsh in 2013, but overwintered in Montana Slough in 2014.

Table 5-5: Summary of marked turtles according to monitoring year and sex. Total number of turtles marked is given (note: not all turtles were marked in 2010 and 2011)

Sex	Total No. marked	No. of Marked Turtles 2010	2011	2012	2013	2014
Female	42	13	32	17	23	26
Male	50	6	22	13	22	40
Total	92	19	54	30	45	66

Winter Pond (WP) is a mud-bottom depression surrounded by an island of vegetation within Montana Slough (Map 8-3). This location has been highlighted as an important site for hibernating turtles throughout the five study years (e.g., Schiller and Larsen 2012a). We examined detections of turtles during telemetry surveys in Montana Slough to summarize their use of WP. The proportion of turtles occurring in WP ranged from 0.11 in 2011 to 0.58 in 2013 (mean = 0.32). Overall, few turtles were detected in WP in June, July, and August in any given year (only 7 out of 385 detections; Table 5-6). In contrast, turtles detected in the months of March (0.85) and September (0.83) had the highest proportion within WP (0.85 and 0.83 for March and September, respectively; Figure 5-6). During the overwintering period (generally December through March) the proportion of turtles occurring in WP ranged from 0.43 to 0.85 (mean = 0.65). Based on the seasonal distribution of turtles in Montana Slough during 2013 and 2014, it appears that WP is an important microsite used by turtles in the period from Fall to Spring.

Table 5-6: Count of turtles detected in Montana Slough telemetry surveys that were located in Winter Pond (in) and outside of Winter Pond (out), by month and year

Month	Location	2010	2011	2012	2013	2014	Total	Proportion
Jan	in				6	3	9	**0.75**
	out					4	4	
Feb	in			4	6	3	13	**0.62**
	out			4		4	8	
Mar	in				6	5	11	**0.85**
	out					2	2	
Apr	in		10			5	15	**0.65**
	out		6			2	8	
May	in		19			5	24	**0.33**
	out		46			2	48	
Jun	in		1				1	**0.01**
	out	10	61		4	3	78	
Jul	in	1					1	**0.01**
	out	27	110	2	4	7	150	
Aug	in	3	2				5	**0.03**
	out	16	134				150	
Sep	in	5	1	2	2		10	**0.83**
	out					2	2	
Oct	in	1	6	1	2	2	12	**0.40**
	out	1	7	4	5	1	18	
Nov	in		8		4		12	**0.75**
	out				4		4	
Dec	in				3		3	**0.43**
	out				4		4	
Total	**in**	**10**	**47**	**7**	**29**	**23**	**116**	**0.20**
	out	**54**	**364**	**10**	**21**	**27**	**476**	

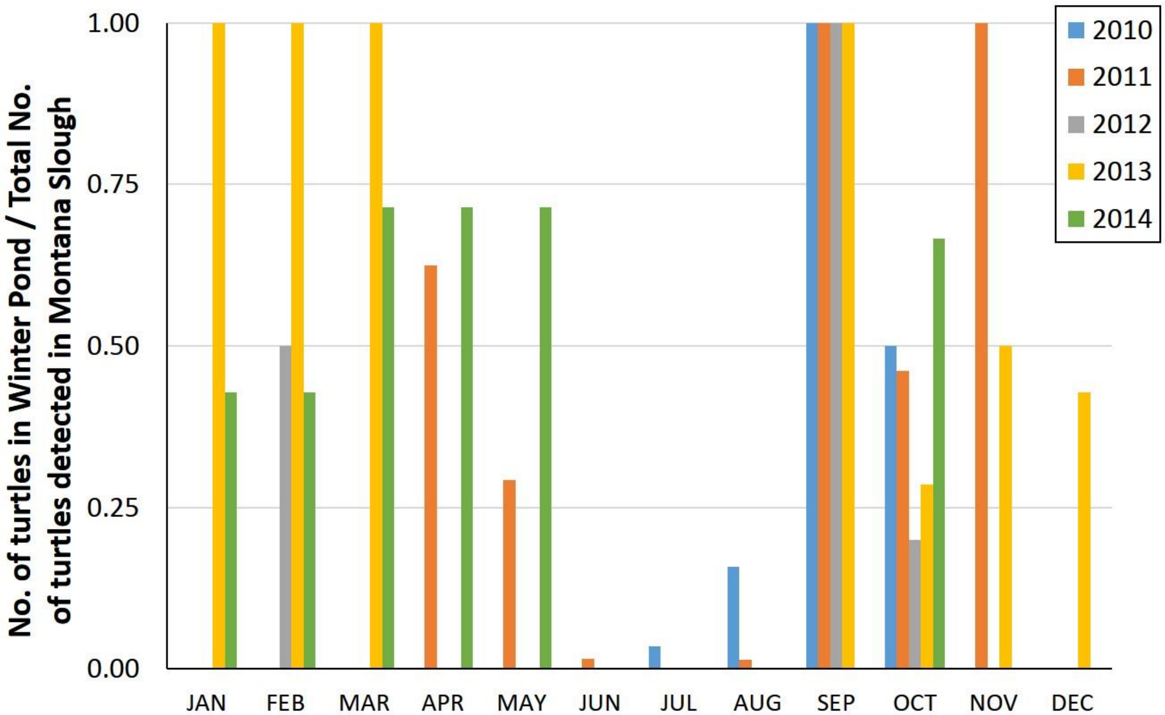

Figure 5-6: Proportion of turtle detections that occurred in Winter Pond within Montana Slough, by month and year. Data included all telemetry detections for Montana Slough, excluding those whose position was estimated by triangulation

5.3.3 Elevation Distribution

Elevation distribution of turtles was very similar between monitoring years and months of telemetry surveys (Figure 5-7). In general, turtles in the DDZ were found at a mean elevation of 438.4 m asl (above sea level), whereas turtles in the upland reference sites occurred six meters higher on average (mean elevation = 444.4 m asl; all years). Variation in the elevation distribution of turtles did not appear to correspond to variations in reservoir elevation (Figure 5-8), contrary to findings of 2013 data (based on GPS elevations). Male and female turtles occurred at similar elevations in both the DDZ and upland sites in 2013 and 2014 (Figure 5-9). On average, females occurred at 437.5 m elevation and males occurred at 437.2 m elevation in the drawdown zone during the 2013-2014 period. At upland sites, females occurred at 442.9 m elevation and males occurred at 442.8 m elevation during 2013-2014 monitoring years (note: earlier years are not included due to lack of data on turtle sex).

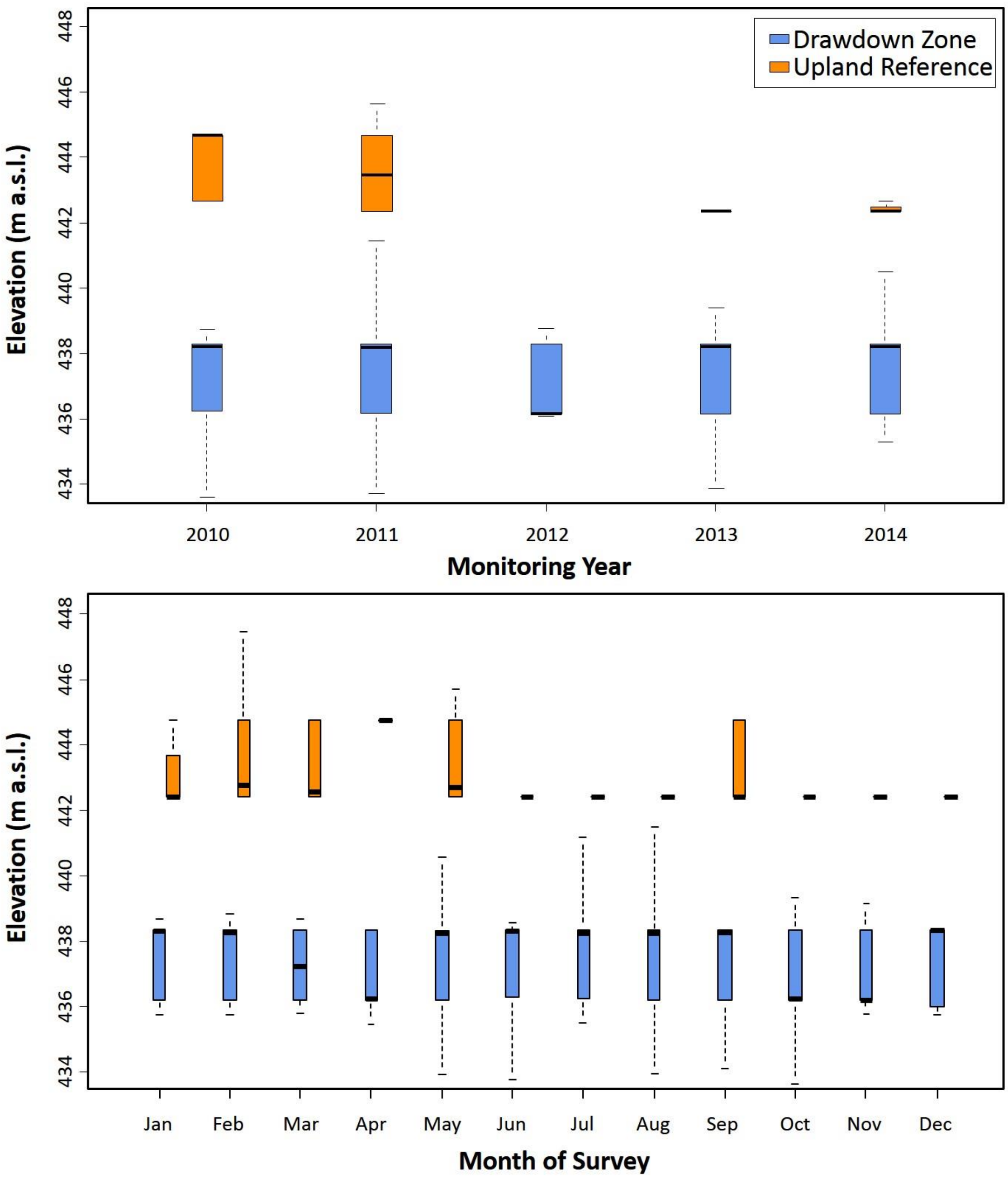

Figure 5-7: Elevation distribution of radio-telemetry located turtles in each year of monitoring (above) and each month (below, all years combined) by location of site (blue = drawdown zone, orange = upland)

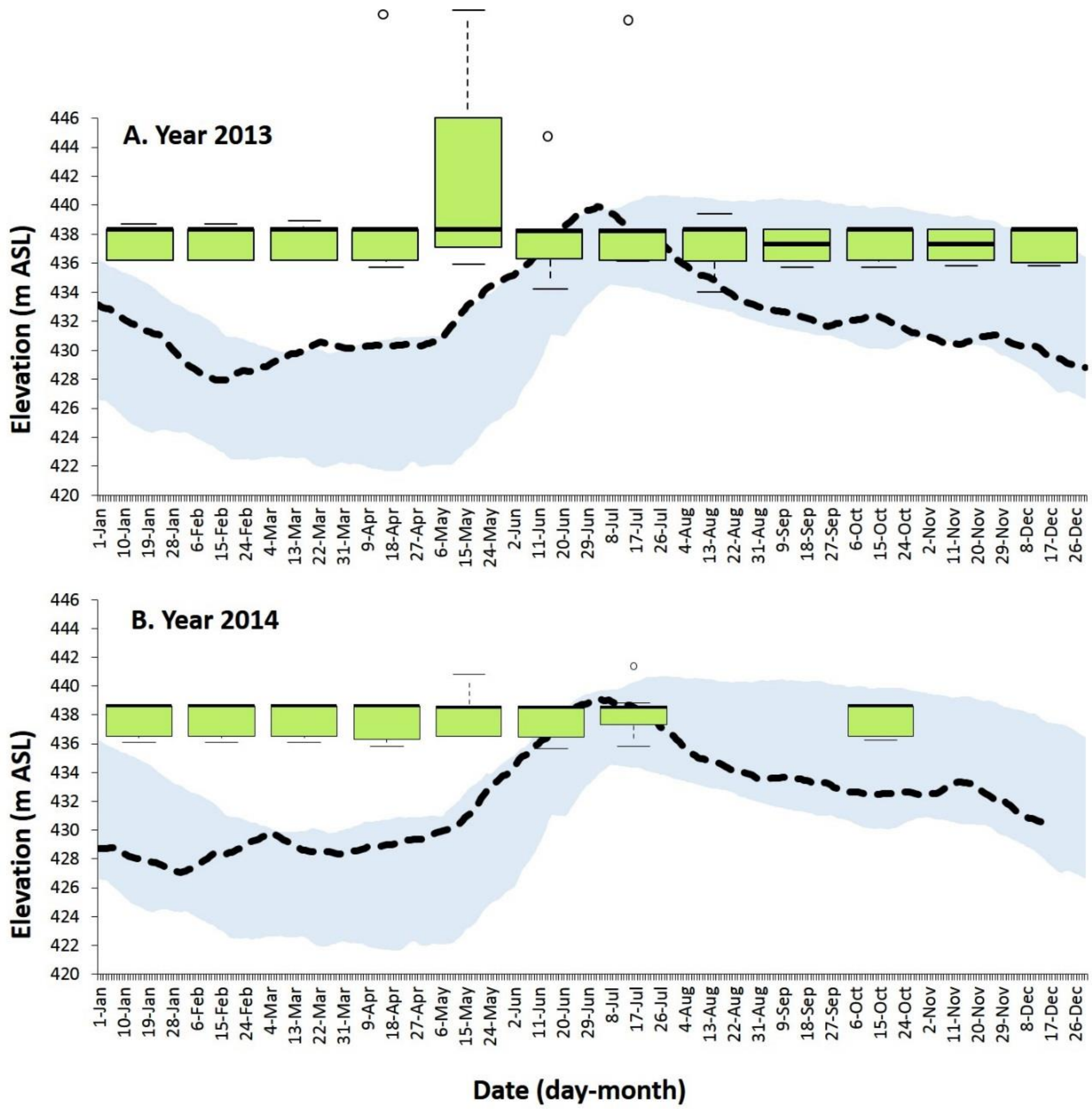

Figure 5-8: Mean daily elevation of Arrow Lakes Reservoir and monthly variation in elevation of radio-telemetry located turtles in drawdown zone sites for 2013 (above) and 2014 (bottom). Boxplots show turtle elevations for telemetry surveys conducted in the drawdown zone sites (includes Airport Marsh, Montana Slough, and Cartier Bay). Black dashed lines show the mean daily reservoir elevation. The blue shaded area represents the 10th and 90th percentile in reservoir elevation for the period from 1969 to 2014; n = 149 turtle detections in 2013; n = 134 turtle detections in 2014

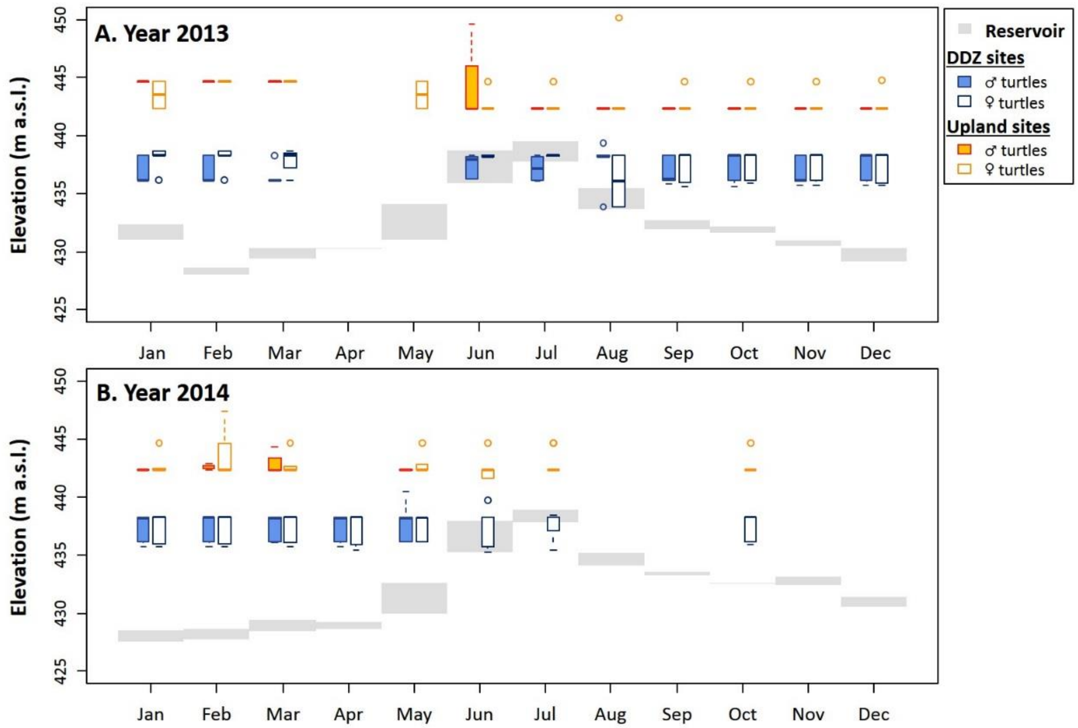

Figure 5-9: Elevation distribution of Arrow Lakes Reservoir and radio-telemetry located turtles in each month, by sex for the years 2013 (A) and 2014 (B). Grey shaded boxes represent the interquartile range in reservoir elevation for each month in 2013 and 2014 (first to third quartile); n=20 males and 18 females in 2013, n=13 males and 23 females in 2014; locations estimated by triangulation were excluded

5.3.4 Water Depth and Ice Thickness

Western painted turtles are found at a wide range of pond depths in Revelstoke Reach. The vertical distribution of turtles varies throughout the year, with turtles generally occurring on (or within) the bottom substrate during the winter hibernation period (December to March). For most of this period ice cover is present over the ponds and reservoir levels are low. In warmer months, later in the year, turtles were found in deeper water (Figure 5-10). During the summer months, turtle activity is greater and they are found swimming throughout the water column more often (as well as basking and searching for nesting sites on shore). This period also corresponds to the peak of reservoir levels.

Summer water depth associated with turtle locations was clearly deeper than winter water depth (Figure 5-10). Summer turtle locations of upland sites were also deeper than drawdown zone turtle locations ($H= 6.65$, $df= 1$, $p= 0.01$; means= 167.5 cm and 121.4 cm). In winter of 2014, turtles were found in locations with shallower water than random locations, both in the drawdown zone (Kruskal-Wallis Test: $H= 4.12$, $df= 1$, $p< 0.04$; means= 36.0 cm and 52.5 cm for turtle and random locations, respectively) and upland reference sites ($H= 25.11$, $df= 1$, $p= 0.001$; means= 27.0 cm and 61.9 cm for turtle and random locations, respectively). In the drawdown zone, turtles overwintered in locations ~ 9 cm deeper than turtles in the upland reference ponds ($H= 6.56$, $df= 1$, $p= 0.01$).

Overwintering turtle locations also had significantly thinner ice than nearby random (non-turtle) locations for both drawdown zone (Kruskal-Wallis Test: H= 7.45, df= 1, p= 0.006; means= 39.8 cm and 48.3 cm) and upland reference sites (H= 8.14, df= 1, p= 0.004; means= 43.0 cm and 52.6 cm).

Western painted turtles are known to tolerate very low temperatures and freezing water conditions. For example, Western Painted Turtles are reported to survive up to 4 months under conditions of exceptionally low oxygen at near freezing temperatures (Ultsch and Jackson 1982). During the winter of 2013, we reported turtles in very little water (≤ 5 cm water depth) in Montana Slough (Wood and Hawkes 2014). In winter of 2014, turtles were found in locations in the drawdown zone that were completely frozen (0 cm water depth; 30 to 43 cm ice thickness) at Airport Marsh and Montana Slough. Behavioural strategies (e.g., burrowing in the substrate) likely alleviate winter conditions in the drawdown zone, such as low water levels and cold temperatures.

Altogether, western painted turtles of Revelstoke reach occupied a wide range of water depths throughout the years studied and appeared to tolerate shallow water columns in the winter (DDZ mean water depth = 36.0 cm and UPL mean water depth = 27.0 cm, for January-March 2014).

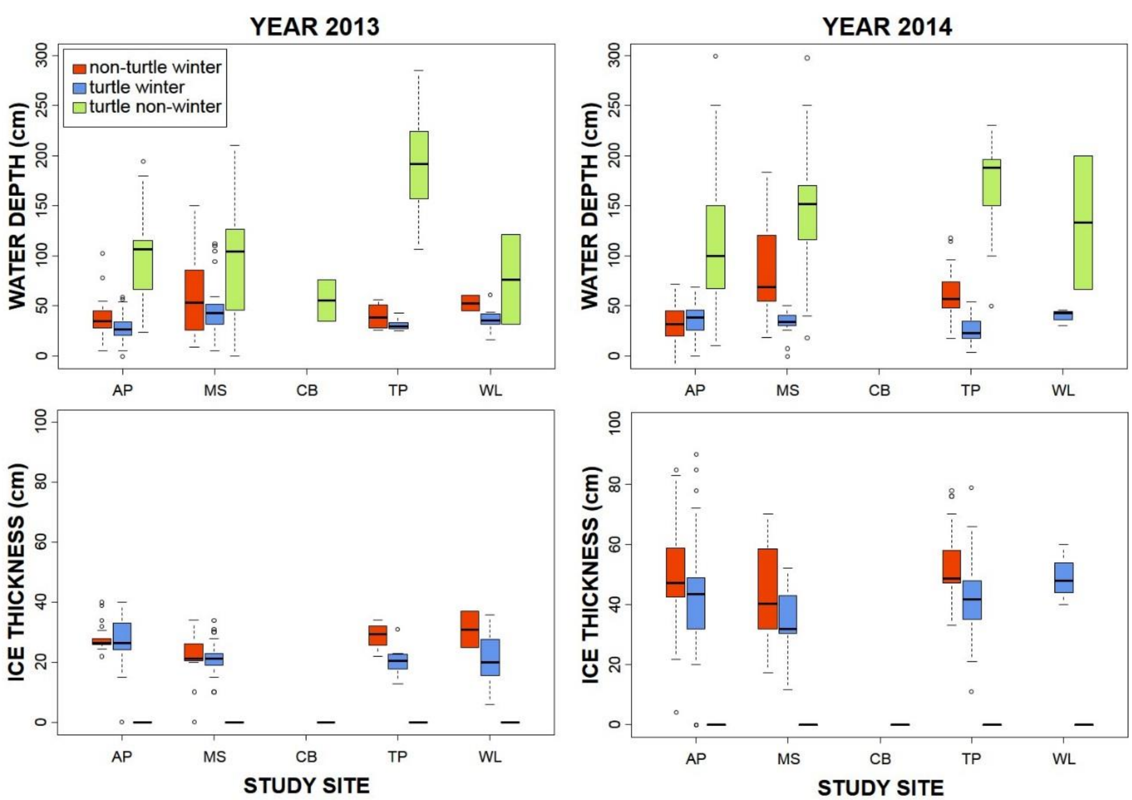

Figure 5-10: Variation in water depth and ice thickness for winter locations not used by turtles (non-turtle winter), locations of overwintering turtles (turtle winter) and locations of turtles during the active season (turtle non-winter) by site and year (2013, left; 2014, right). Replication was uneven between years, months, and sites. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

5.3.5 Water Quality

We compared the water quality for locations of radio-tagged turtles and random (non-turtle) locations within each study site in order to assess habitat-use/availability relationships in the winters of 2013 and 2014. The point data are summarized in Figure 5-11 and Appendix 8-2. Additionally, we include water quality data for locations of radio-tagged turtles during the summer active period (non-winter) in order to compare with turtle overwintering habitat.

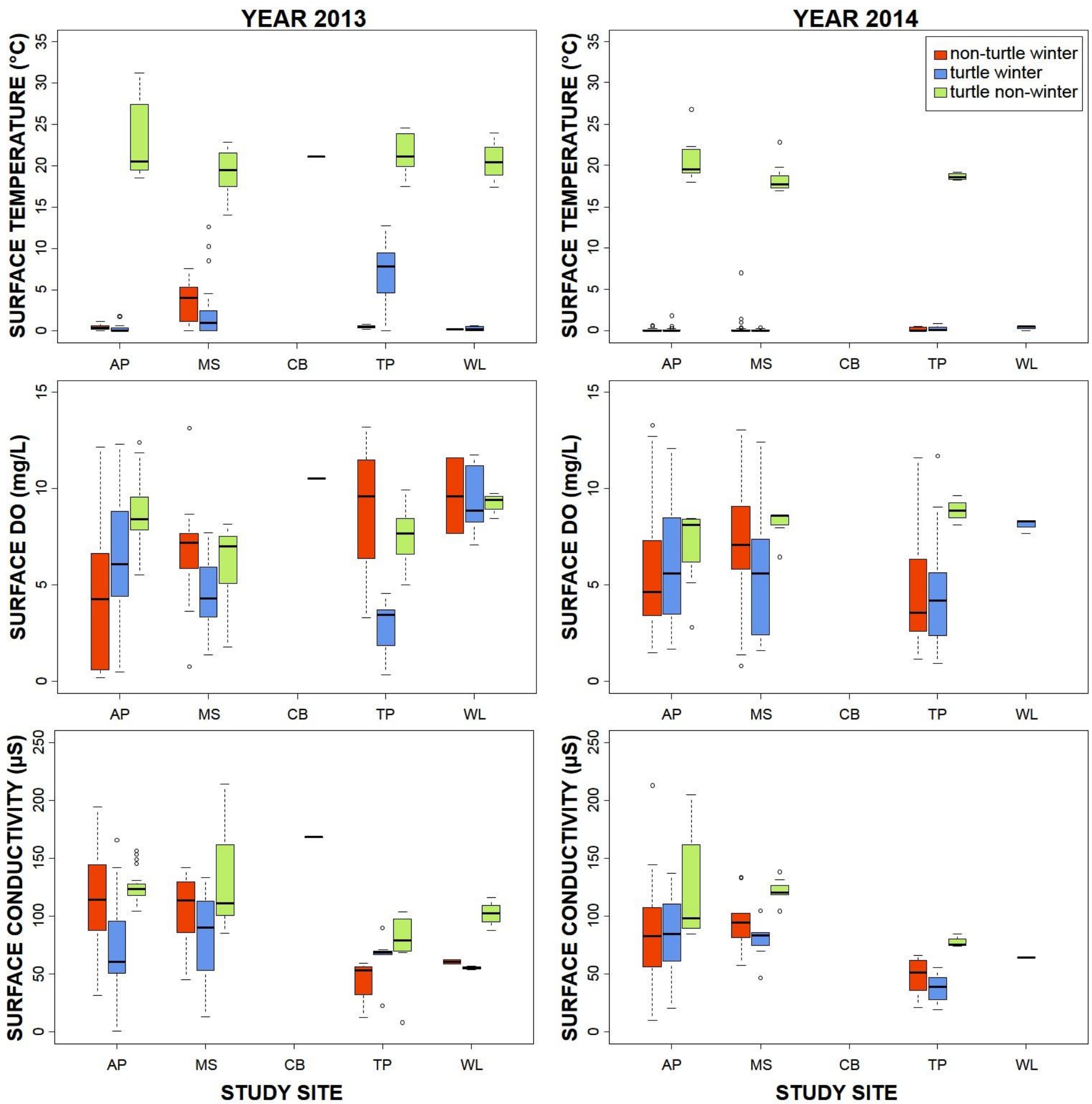

Figure 5-11: Variations in water physicochemical conditions at locations not used by turtles (non-turtle winter), locations of overwintering turtles (turtle winter) and locations of turtles during the active season (turtles non-winter) by site and year (2013, left; 2014, right). Replication was uneven between years, months, and sites. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

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From the current data, it is unlikely that differences in pond water quality between upland reference sites and drawdown zone ponds produce ecologically meaningful effects on Western Painted Turtles. Conditions were variable between seasons and not markedly different between overwintering turtle locations and unoccupied habitats (Figure 5-11). Painted turtles appear to tolerate a wide range of water physicochemical conditions, which is consistent with the published literature (e.g., Bickler and Buck 2007).

In winter 2014, the water surface temperature of turtle locations were at freezing levels in all sites. However, the mean rank in surface temperature was lower for drawdown zone locations than turtle locations in upland reference ponds (Kruskal-Wallis Test: H= 7.31, df= 1, p= 0.007; means= 0.09 °C and 0.22 °C). Note that although statistically different, the biological difference between 0.09 °C and 0.22 °C is negligible. Summer temperatures were not different for drawdown zone and upland ponds (H=0.2, df= 1, p= 0.7; means= 19.7 °C and 18.7 °C). For both drawdown zone and upland ponds, turtle-occupied overwintering locations had surface temperatures similar to random (non-used) locations (DDZ: H= 0.01, df= 1, p= 0.9; UPL: H= 1.94, df= 1, p= 0.16).

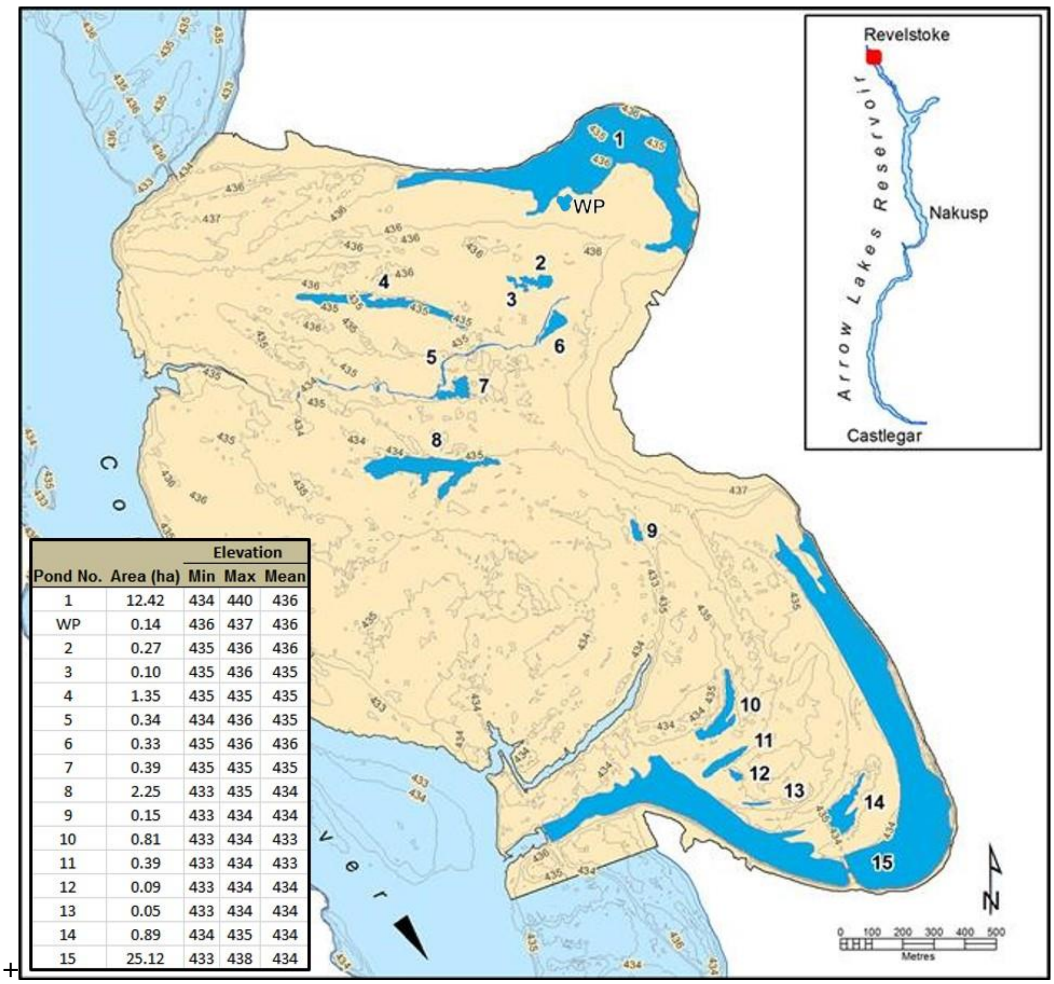
The dissolved oxygen content of water at turtle locations did fall within anoxic levels (<2 mg/L) in the winter of 2014 (as in 2013). Turtles were located in anoxic water in both DDZ and UPL ponds (Airport Marsh, n= 5; Montana Slough, n= 4; Turtle Pond, n= 3). Surface water dissolved oxygen content was similar for overwintering locations in the drawdown zone and upland reference ponds (H= 1.28, df= 1, p= 0.26; means= 5.91 mg/L and 4.78 mg/L). However, surface dissolved oxygen was greater in upland ponds than the drawdown zone during the summer active period (H= 3.24, df= 1, p= 0.07). For both drawdown zone and upland ponds, dissolved oxygen was not different between turtle-occupied overwintering locations and random (non-used) locations (DDZ: H= 0.4, df= 1, p= 0.5; UPL: H= 0.4, df= 1, p= 0.5).

Drawdown zone habitats appear to have higher concentrations of dissolved electrolyte ions than upland turtle habitats. Surface conductivities of turtle locations in the drawdown zone were almost twice that of turtle locations in upland reference ponds during the winter (Kruskal-Wallis Test: H= 8.83, df= 1, p= 0.003; means= 80.6 µS and 40.9 µS). Summer conditions were also different for turtle locations in drawdown zone and upland ponds, with conductivity ~1.7 times greater in DDZ locations (H= 8.42, df= 1, p= 0.004; means= 133.8 µS and 77.2 µS). For both drawdown zone and upland ponds, turtle-occupied overwintering locations had surface temperatures similar to those of random locations (DDZ: H= 0.3, df= 1, p= 0.5; UPL: H= 0.9, df= 1, p= 0.3).

The pH of surface water of turtle locations were generally neutral during the winter; pH of drawdown zone turtle locations were not found to be different from upland turtle locations in winter (Kruskal-Wallis Test: H= 2.64, df= 1, p= 0.104; means= 7.6 and 7.7). The pH of turtle locations was greater during the summer, but was also not different for drawdown zone and upland ponds (H=0.02, df= 1, p= 0.9; means= 8.4 and 8.3). For both drawdown zone and upland ponds, turtle-occupied overwintering locations had similar pH to random locations (DDZ: H= 0.01, df= 1, p= 0.9; UPL: H= 0.6, df= 1, p= 0.4).

Statistical comparisons between monitoring years were not possible due to unbalanced data and inconsistency in month of water measurements. General patterns in water quality appear similar between the past two monitoring years (Figure 5-11).

The location, elevation, and number of ponds available in the drawdown zone were mapped for Cartier Bay and Montana Slough in Revelstoke Reach (Figure 5-12). The ponds mapped in these sites range in size from 0.05 ha to 25.1 ha ($\bar{x}$ = 2.99; SD = 6.86 ha). Most of the pond area (~64 per cent, 28.8 ha) is situated at ~433 m ASL, an additional 30 per cent (13.6 ha) at 434 m ASL and ~ 5 per cent (~2.5 ha) at 435 m ASL. Turtle associations with pond size were not explored in detail during the CLBMON-11B3 study. At present, we know that both Montana Slough and Cartier Bay possess a variety of pond sizes, however few turtles have been observed at Cartier Bay. Majority of the turtles detected at Montana Slough were found in pond number 1 and Winter Pond (Figure 5-12). Pond 1 covers a large area (12.42 ha) and occurs at a higher elevation than any other ponds available in Montana Slough/Cartier Bay (range: 434 to 440 m ASL, vs. 433 to 438 m ASL). Winter Pond occurs at the second highest elevation (436 to 437 m ASL) and is one of the smaller ponds mapped at Montana Slough (0.14 ha). Thus, turtles are found using ponds greatly varying in area.



Pond No.	Area (ha)	Elevation Min	Max	Mean
1	12.42	434	440	436
WP	0.14	436	437	436
2	0.27	435	436	436
3	0.10	435	436	435
4	1.35	435	435	435
5	0.34	434	436	435
6	0.33	435	436	436
7	0.39	435	435	435
8	2.25	433	435	434
9	0.15	433	434	434
10	0.81	433	434	433
11	0.39	433	434	433
12	0.09	433	434	434
13	0.05	433	434	434
14	0.89	434	435	434
15	25.12	433	438	434

Figure 5-12: Delineation of 15 ponds in the drawdown zone at Montana Slough and Cartier Bay ('WP' = Winter Pond). The ponds polygons are based on 2011 imagery. Area

and elevation data are provided in the inset table. Image modified from Hawkes and Tuttle (2013)

5.4 H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity

Survival and productivity were not directly measured in the study. In future years we will better be able to assess juvenile survival and this will help address this hypothesis. Current data shows a high rate of recapture of marked adults between years and few incidences of mortality have been observed. This suggests that turtle populations are being maintained across years.

5.4.1 Habitat Availability

Reservoir operations affect the availability of both terrestrial and aquatic habitat. The degree to which specific areas in the drawdown zone are affected depends on reservoir elevations in any given year and month. The relationship between reservoir elevation and habitat availability has been examined for Cartier Bay and Montana Slough from 2008 to 2014 during CLBMON-37. Although turtles were found at a wide range of water depths, current understanding is that shallow water habitat is paramount (e.g., Orchard 1986). The degree to which the operations of Arrow Lakes Reservoir may affect pond habitat quality and the survival/productivity of painted turtles is not currently known.

5.4.2 Movement Patterns

Overall turtle movement patterns varied by monitoring year (Figure 5-13). Mean ranks of turtle movements were significantly different by month in all years (Table 5-7), in general due to greater travel distances during summer months, which corresponds to the active period (foraging, breeding, etc.). Turtle movements do not clearly vary between study sites across years (Figure 5-14). Mean ranks of turtle movements were significantly different by site in 2011, 2012, and 2013 (Table 5-8). Post-hoc multiple comparisons revealed that main differences were explained by greater distances travelled by turtles in the DDZ at Airport Marsh than turtles in upland habitats (e.g., turtle pond in 2011 and Williamson Lake in 2012).

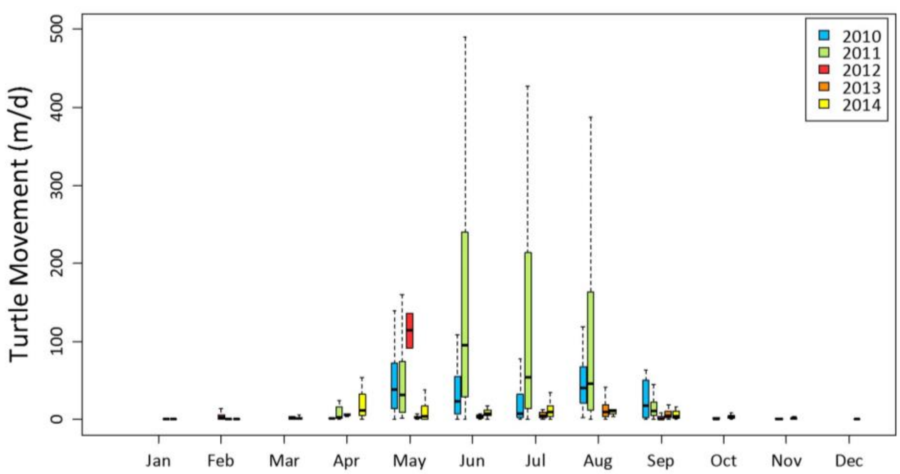


Figure 5-13: Variation in turtle movement (meters per day) in each month by monitoring year (all sites combined)

Table 5-7: **Results of Kruskal-Wallis tests for differences in turtle movement (m/d) by month in each monitoring year**. Results of Bonferroni-corrected pairwise comparisons are presented for each test, with months differing from each other (α = 0.1) indicated with different letters

				Post-hoc Pairwise Comparisons		
K-W Test:	**H**	**d.f.**	**p-value**	Month	Mean Rank	Sig. Diff.
Year 2010:	**18.82**	**5**	**0.002**	Aug	119.67	a
				May	113.03	a
				Jun	100.02	ab
				Sep	92.44	ab
				Jul	73.93	b
				Apr	25.00	b
Year 2011:	**95.77**	**7**	**<0.001**	Jun	404.25	a
				Jul	361.61	ab
				Aug	345.09	b
				May	291.37	bc
				Sep	187.65	cd
				Apr	151.92	cd
				Oct	55.10	d
				Nov	32.75	d
Year 2012:	**6.85**	**3**	**0.077**	May	21.50	a
				Apr	13.33	ab
				Feb	10.71	ab
				Sep	6.67	b
Year 2013:	**96.36**	**10**	**<0.001**	Aug	158.61	a
				Sep	147.62	ab
				Jul	142.94	ab
				Jun	125.85	abc
				Oct	110.04	bc
				May	103.20	bcd
				Nov	92.00	cd
				Mar	79.50	cde
				Feb	57.42	de
				Dec	46.74	e
				Jan	31.25	e
Year 2014:	**69.54**	**8**	**<0.001**	Aug	149.33	a
				Apr	143.63	a
				Jul	137.15	a
				Jun	130.21	ab
				Sep	120.68	ab
				May	99.11	ab
				Mar	82.50	bc
				Jan	58.40	c
				Feb	47.12	c

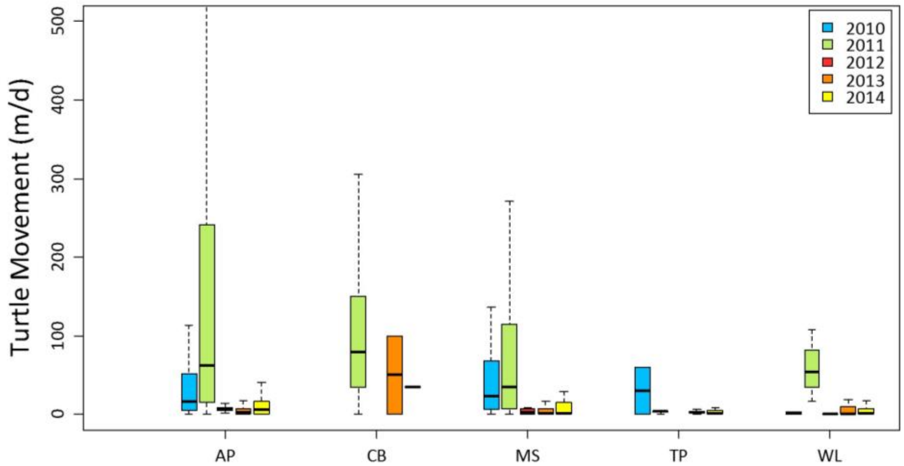


Figure 5-14: Variation in turtle movement (meters per day) in each study site by monitoring year. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

Table 5-8: Results of Kruskal-Wallis tests for differences in turtle movement (m/d) by study site in each monitoring year. Results of Bonferroni-corrected pairwise comparisons are presented for each test, with sites differing from each other (α = 0.1) indicated with different letters. Drawdown zone sites (AP, MS, CB) are shown in bold to differentiate from upland sites (TP, WL); n.s.= not significant

				Post-hoc Pairwise Comparisons		
K-W Test:	**H**	**d.f.**	**p-value**	Site	Mean Rank	Sig. Diff.
Year 2010:	**5.35**	**3**	**0.148**	**MS**	101.51	
				AP	93.13	n.s.
				TP	73.00	
				WL	18.00	
Year 2011:	**27.21**	**4**	**<0.001**	**AP**	376.55	a
				CB	371.92	ab
				WL	346.25	abc
				MS	306.33	bc
				TP	64.50	c
Year 2012:	**7.61**	**2**	**0.022**	**AP**	15.25	a
				MS	10.67	ab
				WL	1.50	b
Year 2013:	**5.68**	**4**	**0.224**	**AP**	118.13	
				TP	111.59	
				CB	107.00	n.s.
				MS	93.98	
				WL	92.00	
Year 2014:	**9.99**	**4**	**0.04**	**CB**	170.00	a
				AP	97.05	a
				MS	86.39	a
				TP	83.37	a
				WL	73.11	a

Turtle movements were also compared for groups based on general reservoir inundation period (Figure 5-15; pre-inundation: Jan-Apr, inundation: May-Aug, post-inundation: Sep-Dec). Similar to the results of Wood and Hawkes (2014), both DDZ and UPL sites exhibited an increase in turtle movement for the inundation and post-inundation period. Turtle movement was also more variable in DDZ sites than in upland reference sites (Figure 5-16). Turtle movement by reservoir position (DDZ vs UPL) and month is also provided to compare turtle activity in each month of survey (Figure 5-17). Turtle movement increased in April and May and declined in September of each year. However, it is worth noting that reservoir inundation periods closely correspond to turtle activity periods, such that overwintering (when activity is typically low) occurs during the pre-inundation period, and summer activity corresponds to the inundation period. The variation in turtle movement between upland and drawdown zone habitats in relation to reservoir levels will be assessed further in future years.

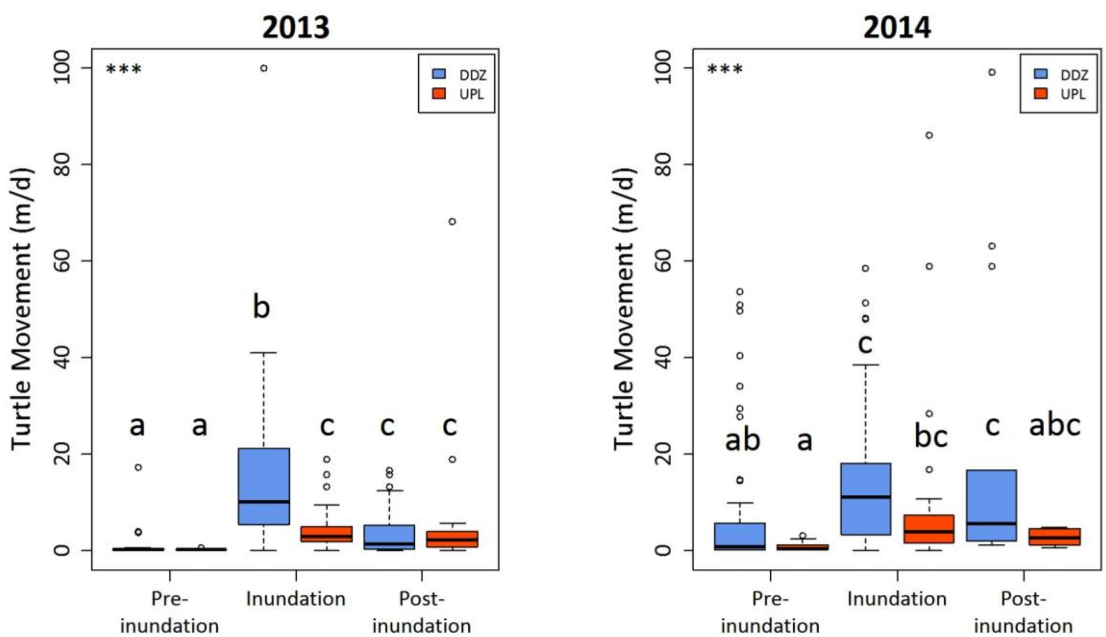


Figure 5-15: Variation in turtle movement (meters traveled per day) by reservoir inundation period for the drawdown zone (DDZ) and upland reference sites (UPL) of Revelstoke Reach for years 2013 (left) and 2014 (right). Turtle movement patterns are plotted separately by reservoir inundation period and year, where "Pre-Inundation"= Jan-Apr, "Inundation"= May-Aug, and "Post-Inundation"= Sep-Dec. Significance of Kruskal-Wallis tests (top right) as follows: n.s.= p>0.1, *p<0.1, **p<0.01, ***p<0.001

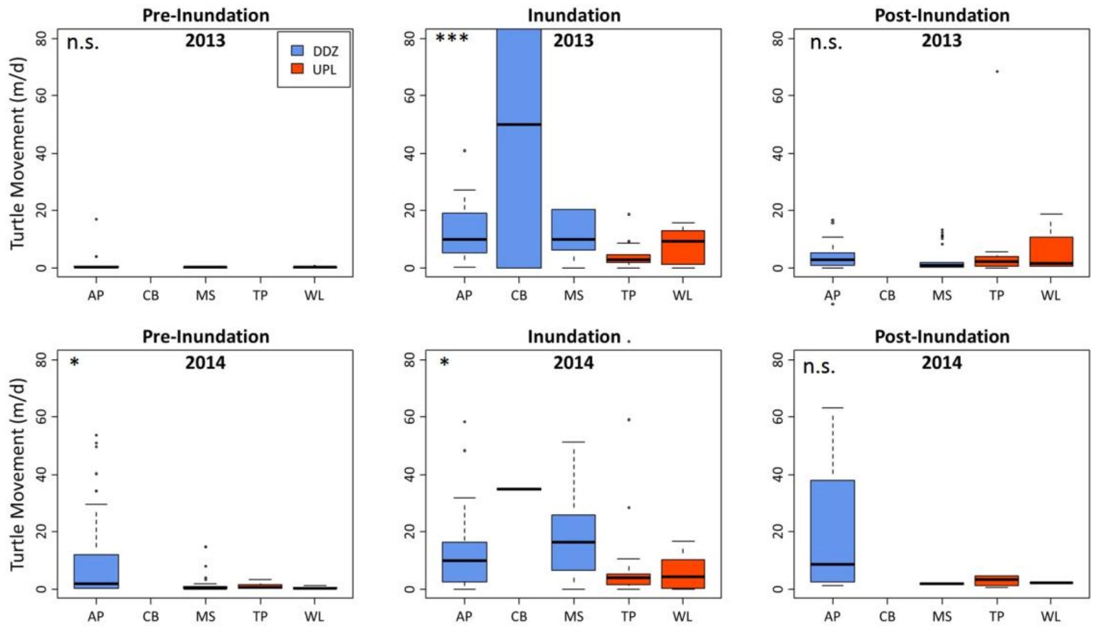


Figure 5-16: Variation in turtle movement (meters traveled per day) by each site of the drawdown zone (DDZ) and upland reference sites (UPL) of Revelstoke Reach for years 2013 (top) and 2014 (bottom). Turtle movement patterns are plotted separately by reservoir inundation period and year, where "Pre-Inundation"= Jan-Apr, "Inundation"= May-Aug, and "Post-Inundation"= Sep-Dec. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake; pre-inundation= Jan-Apr, inundation= May-Aug, post-inundation= Sep-Dec. Significance of Kruskal-Wallis tests (top right) as follows: n.s.= p>0.1, *p<0.1, **p<0.01, ***p<0.001

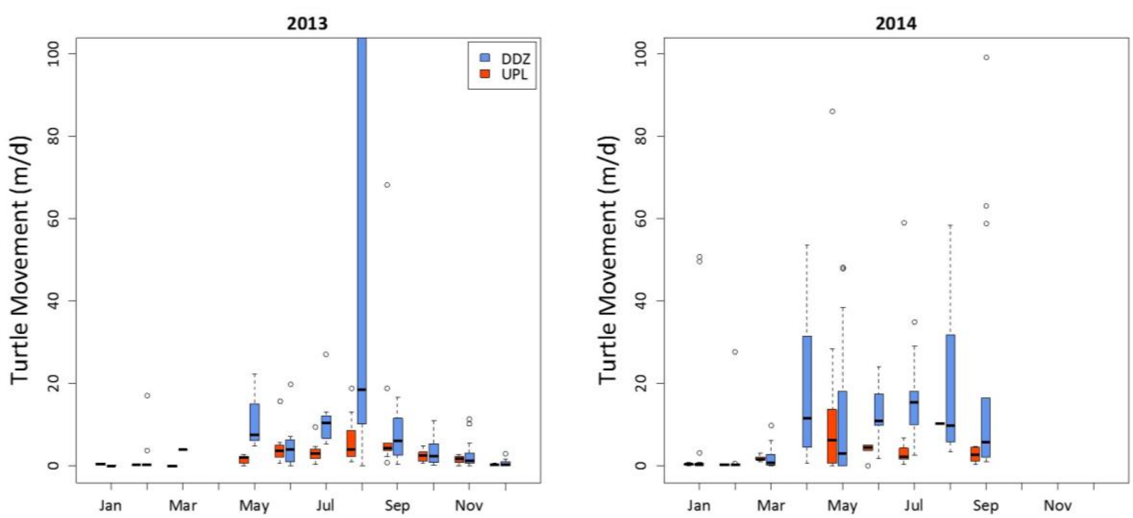


Figure 5-17: Variation in turtle movement (meters traveled per day) by month for drawdown zone (DDZ) and upland reference sites (UPL) of Revelstoke Reach for years 2013 (left) and 2014 (right)

5.4.3 Mass and Body Condition

Consistent with results of 2013, turtle mass differed between individuals, with the greatest weights found among female turtles (mean = 900 g), followed by males (mean = 523 g), and juveniles (mean = 175 g). Adult turtle mass also differed by site (Figure 5-18), with Montana Slough having lower female and male mass than Turtle Pond. Airport Marsh was intermediary in mass of adult turtles compared with Montana Slough and Turtle Pond in most years.

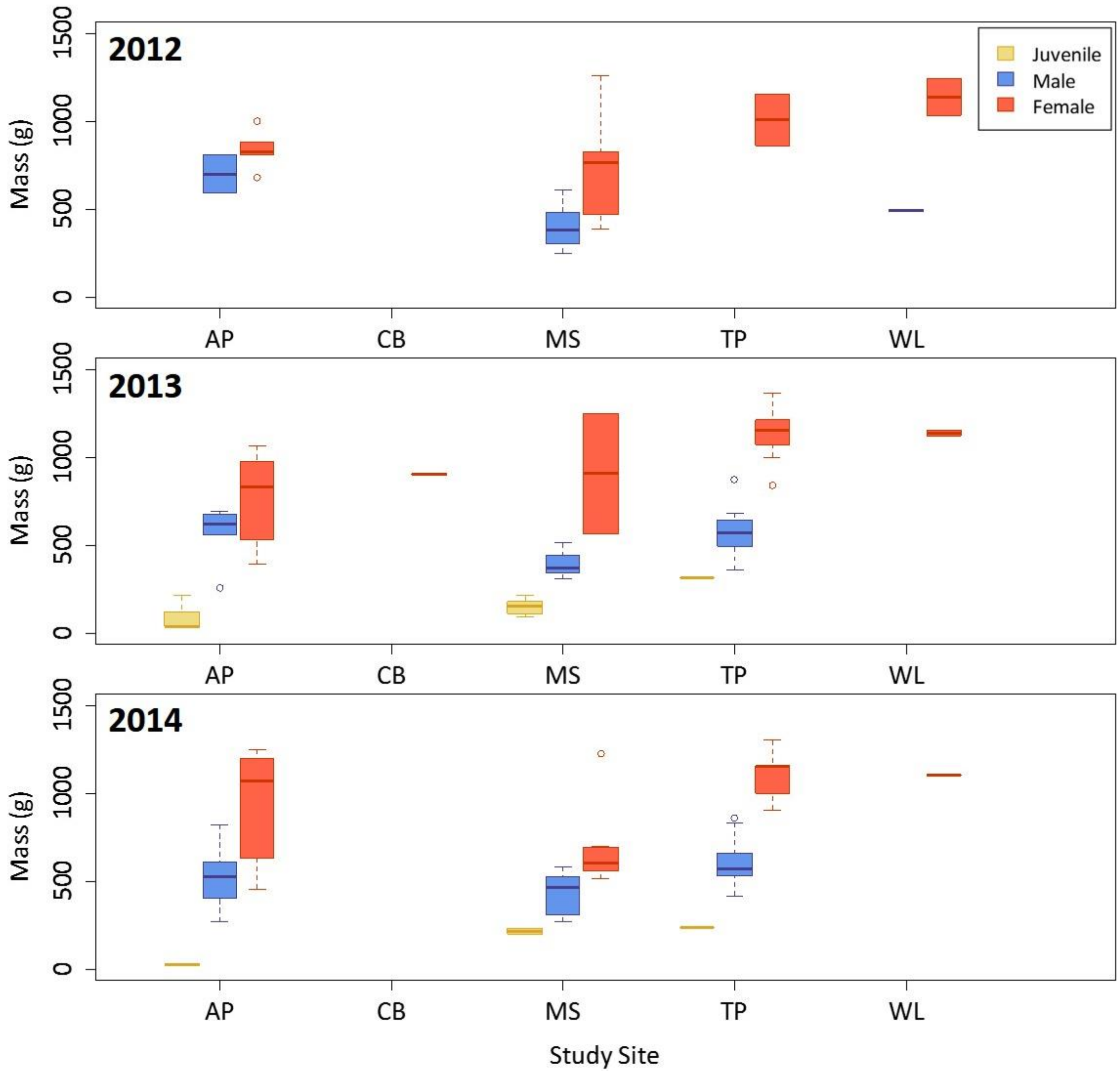


Figure 5-18: Variation in turtle mass (g) by study site for juvenile, adult female, and adult male Western Painted Turtles. Data shown is from captures during 2012-2014. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

The scatterplot of turtle mass (g) by turtle size (i.e., straight-line carapace length in cm) shows that females of upland reference sites (Turtle Pond and Williamson Lake) are heavier and larger, with less size variation than females in the drawdown zone (Airport Marsh, Montana Slough; Figure 5-19). Males from various sites largely overlapped in their mass:size relationships.

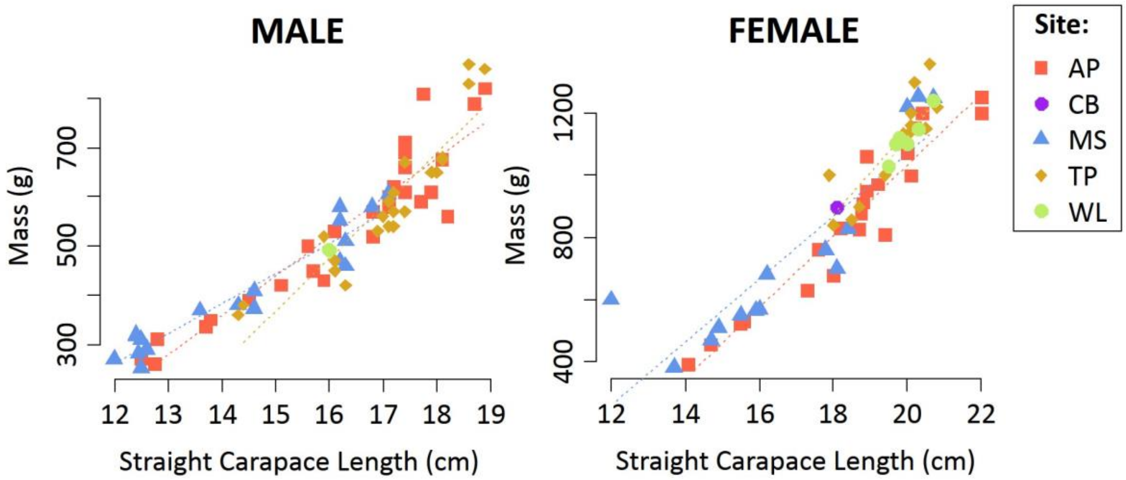


Figure 5-19: Relationship between turtle mass (g) and turtle size (cm) by study site for adult male (left) and adult female (right) Western Painted Turtles. Data shown is from captures during 2012-2014. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

Log-transformed turtle mass was strongly related to turtle size (straight-line carapace length) for both male and female turtles (Male: R^2= 0.92, $F_{1,67}$= 766.1, p<0.0001 ; female: R^2= 0.85, $F_{1,56}$= 320.5, p<0.0001). A greater proportion of female turtles in upland reference sites had greater weight than predicted for their size (residuals REF: 19 positive, 2 negative vs. residuals DDZ: 10 positive, 26 negative). This pattern was not consistent for adult male turtles, which had 50 to 60 per cent positive residuals in DDZ sites for years 2012-2014; more males in reference sites weighed less than expected based on body size (Figure 5-20).

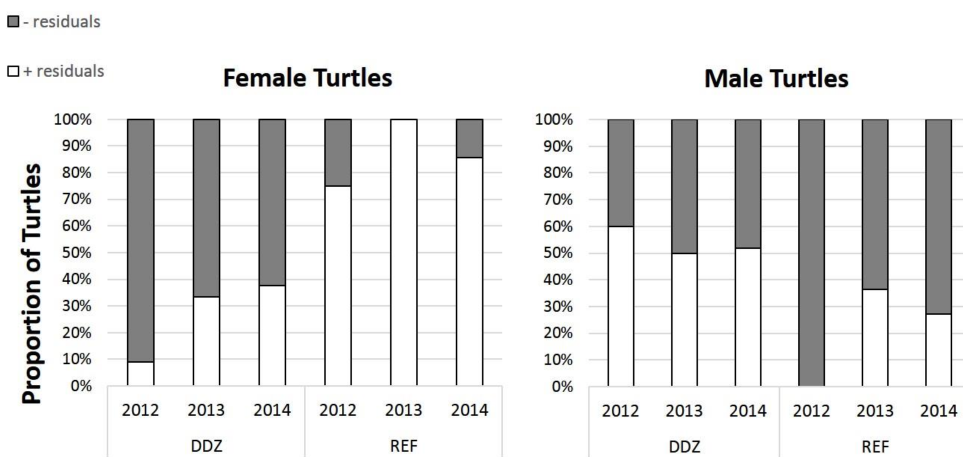


Figure 5-20: Proportion of turtles with body mass greater than expected (+ residuals) and less than expected (- residuals) for their body size, based on linear regression. Data ae from captures during 2012-2014; n= 57 females and 68 males; DDZ= drawdown zone site, REF= upland reference site. Three of the 36 DDZ females were gravid, while two of the 21 upland females were gravid

5.5 H3: Habitat enhancement through revegetation or physical works does not mitigate the effects of reservoir operations on painted turtles. More specifically, wildlife physical work and revegetation projects do not change the utilization of the drawdown zone habitats by painted turtles in Revelstoke Reach

5.5.1 Revegetation

The revegetation prescriptions applied in Revelstoke Reach of Arrow Lakes Reservoir are not considered relevant nor beneficial to reptiles. The relationship between revegetation prescriptions and Western Painted Turtles habitat utilization will not be assessed in the present study. Relationships between revegetation prescriptions and other taxa (e.g., invertebrates and small mammals) and productivity are being studied as part of the Arrow Lakes Wildlife Effectiveness study (CLBMON-11B1). However, that study is constrained to mid- and lower-Arrow Lakes Reservoir.

5.5.2 Physical Works

Several wildlife physical works have been proposed for implementation in select areas of in Revelstoke Reach (Golder 2009a and 2009b); however, these projects have not yet been implemented. Of particular interest is the proposed physical works at Cartier Bay, which would reportedly increase the amount of shallow wetland habitat in that area. Currently, Cartier Bay does not provide nesting or over-wintering habitat for this Western Painted Turtle and Hawkes et al (2014) found no support for an obvious benefit to Western Painted Turtle from the proposed physical works in Cartier Bay. However, until such time that physical works are implemented in Revelstoke Reach it is not possible to determine the effects of those physical works on turtles.

6.0 DISCUSSION

The occurrence, life history, habitat use, and productivity of Western Painted Turtles in the drawdown zone of Arrow Lakes Reservoir have been studied since 2010. This long-term study focuses primarily on the demographics and habitat use of a population of Western Painted Turtles in Revelstoke Reach, on how reservoir operations may affect the population and/or the habitats they use, and whether physical works can be implemented to mitigate any potentially adverse effects of reservoir operations on this population or its habitats. Monitoring painted turtles 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-11B3.

The current study year focuses on two key initiatives (#1 and 2a,b, Table 6-1; see Table 2-1 for the ten-year initiatives). The majority of the work in 2014 supports these key initiatives, whilst future study of turtle nesting habitats and offspring survivorship in Revelstoke Reach will further our ability to address additional management questions.

Table 6-1: Relationship between management questions, hypotheses, and long-term monitoring strategy for Western Painted Turtles in Revelstoke Reach, Arrow Lakes Reservoir. Seasons are grouped into S/S (spring /summer) and F/W (fall/winter)

Initiative		Management Question Addressed	Season		Study Years
			S/S	F/W	
1	Long term tracking of turtle demographics to monitor population trends (abundance, recruitment/productivity, and mortality) and assess the impacts of reservoir operations on these parameters	Q1, Q3, Q4, Q5	X	X	2012-2020
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	Q2, Q4, Q6, Q7, Q8	X	X	2012-2020
2a	Conduct a focused study on the fine-scale habitat use by turtles during spring and summer and investigate potential impacts of reservoir operations on summer habitat use, habitat availability, and turtle movements	Q2, Q4, Q5	X		2014-2016
2b	Conduct a focused study on fine-scale habitat use by turtles during winter and investigate potential impacts of reservoir operations on winter habitat use and habitat availability	Q2, Q4, Q5		X	2012-2014

6.1 Management Questions and Hypotheses

Several management questions (MQ1 – 6; Section 2.2) focus on the effect of reservoir operations on turtle occurrence, habitat use, and productivity in the drawdown zone of Arrow Lakes Reservoir. Concurrent with the assessment of population characteristics and habitat use, certain components seek to determine whether revegetation prescriptions (MQ7) and/or future physical works projects (MQ8) could affect habitat quality or turtles use of the drawdown zone. The ability to address each of the management questions with is discussed below. The methods we have used with Initiatives #1 and #2b appear to have been appropriate for collecting data adequate to address the questions. It is expected that the future completion of Initiatives #2a, 2c and 2d and use of a time-series approach to data analyses will provide the means necessary to address each management question.

6.1.1 Theme 1: Life History and Habitat Use

MQ1: During what portion of their life history (e.g., nesting, foraging, and overwintering) do painted turtles utilize the drawdown zone in Revelstoke Reach?

Our current understanding of the use of the drawdown zone by Western Painted Turtles in Revelstoke Reach is that turtles use the DDZ to fulfill most of their life history requirements (Table 5-1). The onset of breeding is generally governed by spring water temperatures. By late June, Western Painted Turtles are typically nesting, finding suitable habitat usually within 150 m of water (Matsuda et al. 2006). Neonates hatch by late summer and generally overwinter in the nest. Several neonate turtles have been observed in Airport Marsh in previous years (as part of CLBMON-11B4). Nesting sites are known to occur at Red Devil Hill and Williamson

Lake. In future years (i.e., 2015 to 2018), we will focus on nesting sites, juvenile overwintering, and juvenile survivorship, which will address Initiative #2c.

MQ2: Which habitats do painted turtles use in the drawdown zone and what are their characteristics (e.g., pond size, water depth, water quality, vegetation, elevation band)?

Western Painted Turtles in and adjacent to the drawdown zone in Revelstoke Reach depend on aquatic habitats to fulfill their life history requisites (e.g., foraging, basking, and overwintering). In the summer, turtles were dispersed in wetland areas with an abundance of vegetation (emergent and submergent) and basking capabilities (e.g., logs, lily pads, floating mats of vegetation). During the winter, turtles were located in Montana Slough and along the shoreline areas of Airport Marsh, Williamson Lake, and Turtle Pond.

Consistent with previous years' results, water physicochemical conditions in ponds suggest little evidence of an effect of dissolved oxygen, water temperature, conductivity, or pH on turtle habitat use (see Section 5.3.5). Rollinson et al. (2008) classified temperature and dissolved oxygen levels as important factors that may contribute to overwintering site selection by Western Painted Turtles. However, we did not find significant differences between the conditions at turtle locations and random locations during the 2014 overwintering period. This is not surprising, given that painted turtles have the ability to depress their metabolic activity and limit dissolved oxygen uptake while overwintering, allowing them to survive in near-freezing, anoxic conditions for long periods of time. In summary, over the two years that overwintering habitat association were examined in detail, there was no detectable pattern in habitat suitability based on water conditions for ponds where turtles were present.

Western painted turtles were found using elevations from 435.3 m to 440.5 m elevation (a.s.l.) in the drawdown zone of Arrow Lakes Reservoir. Males and Females appear to occur at similar elevations and contrary to previous results, turtle elevational distribution does not correspond with reservoir elevation (Figure 5-9). They also use a wide range of water depths (min= 0 cm, at frozen water columns in the winter; max= 300 cm, in the summer at Airport Marsh and Montana Slough). The range in water depth used by turtles in upland reference sites was similar (water depth: 4 cm to 230 cm).

Refinements to pond mapping are needed for Revelstoke Reach. Currently, many ponds within Montana Slough and Cartier Bay (n = 15) have been mapped and their areas have been calculated (see Wood and Hawkes 2014). Pond 1 at Montana Slough is consistently productive for turtle detections and is the largest pond in that location (12.42 ha c.f. mean= 2.99; SD = 6.86 ha). Coincidently, Pond 1 also occurs at the highest elevation band in that system (mean= 436 m). Turtles were also often clustered within Winter Pond, adjacent to pond 1, and this is one of the smallest ponds mapped in Montana Slough (Table 5-6).

MQ3: What is the abundance and productivity of painted turtles in Revelstoke Reach and how do these vary across years?

We calculated various measures of relative abundance to allow for comparisons between sites at Revelstoke Reach, among months, and with data from future years of monitoring (see Section 5.3.2). All sites monitored at Revelstoke Reach supported turtles, but Airport Marsh, Montana Slough, and Turtle Pond generated the highest number of standardized trap catches and telemetry detections. Montana Slough and Airport Marsh were also used consistently by overwintering turtles during the hibernation period in 2013 and 2014.

Productivity (nest and egg counts) has not yet been assessed; however this component of the long-term turtle monitoring study will be addressed as part of Initiative #2c in future years. Data collection indicates that all life stages of turtles use habitats in the drawdown zone. However, additional years of data collection on reproductive success and hatchling survivorship is required to assess productivity at various sites in the drawdown zone of Revelstoke Reach.

MQ4: Does the operation of the Arrow Lakes Reservoir negatively impact painted turtles directly or indirectly (e.g., mortality, nest inundation, predation, and habitat change)?

Currently, there is little evidence of increased turtle mortality, nest inundation, or predation that could be linked to the operations of Arrow Lakes Reservoir.

Eleven turtle mortalities have been recorded from 2010 to 2012; all occurred in sites within the drawdown zone (nine turtles at Airport Marsh, two turtles at Montana Slough). Evidence of predation was noted for three of the mortalities. Cause of death was unknown. Deceased turtles have not been found in upland reference sites. There were no observations of dead turtles in 2013. An additional 14 mortalities were documented in 2014, at Airport Marsh. The cause of death was presumed to be predation.

Additionally, body condition can be used to assess fitness of individuals. Consistent with results of 2013, we found evidence that turtles of the DDZ had lower condition than those of reference sites, at least for females (fewer positive residuals of the mass:size OLS regression).

Contrary to the findings in 2013, we did not find turtles moving further distances in the drawdown zone habitats in 2014. Rather turtle movements were more variable in the drawdown zone, compared to upland reference sites. In 2014, we did not find any correlations between turtle elevation and reservoir elevation.

In future years, our assessment of juvenile survivorship (via telemetry and female nesting success) will help to elucidate whether reservoir operations negatively impact western painted turtles. Other population-level pressures on turtles will also be noted during this detailed assessment, as predation, road-based mortality, and interactions with humans/animals, may be important.

6.1.2 Theme 2: Mitigation – Reservoir Operations and Effects

MQ5: Can minor adjustments be made to reservoir operations to minimize the impact on painted turtles?

This management question is related to H_2 and the discussion associated with this hypothesis relates to Qs 1 to 6 (Section 2.2). Several additional years of documenting the presence of the various life stages and their related habitat use in the DDZ will help determine how the timing of reservoir inundation potentially affects turtles. Based on these data, we will be able to provide recommendations on managing reservoir elevations to benefit the Western Painted Turtle population in Revelstoke Reach.

Currently, we know that cold water can significantly slow movements, alter foraging behaviours, or affect overwintering habits in ectothermic animals, which in turn can delay growth, decrease survival, and reduce reproductive output (e.g., Rollinson et al. 2008). The rapid inundation of ponds, wetlands and shallow drawdown zone areas with cold reservoir water could have an effect on painted turtles, especially if active season basking locations are submerged or displaced during inundation. Basking logs (or other equivalent forms of floating basking material) are important to turtles' thermoregulatory system, as well as offering a certain measure of protection from predators (as opposed to shoreline basking). Additionally, during the winter, stable aquatic habitat with appropriate water temperatures, dissolved oxygen levels, and substrates may be most desired by overwintering turtles. We have yet to find evidence for particular water quality associations, though it is likely that significant changes to reservoir levels during winter would affect the overwintering survival of turtles in the drawdown zone.

MQ6: Can physical works be designed to mitigate the impacts of reservoir operations on painted turtles?

Certain physical works, such as the addition of floating islands in Montana Slough and Airport Marsh could potentially mitigate any effects of reservoir operations as they would partially mitigate the loss of available habitat in the spring and summer due to reservoir inundation. Montana Slough generally supports a large portion of the Western Painted Turtles at Revelstoke Reach. The addition of anchored floating islands would provide refuge to turtles during inundation, increased availability of basking habitat during summer months, and add to habitat heterogeneity as this feature is currently lacking in the reservoir. Additional physical works have been proposed to improve the suitability of Revelstoke Reach to painted turtles, such enhancement of known nesting locations (e.g., Red Devil Hill) and other important upland sites. Enhancing or managing existing upland nesting habitat is essential to ensure the long-term viability of this population.

6.1.3 Theme 3: Effectiveness Monitoring

MQ7: Does revegetation of the drawdown zone affect the availability and use of habitat by painted turtles?

MQ8: Do wildlife physical works (e.g., habitat enhancement) affect the availability and use of habitat in the drawdown zone by painted turtles?

Management questions #7 and #8 are difficult to address at this point, because neither projects (revegetation, physical works) have been implemented in Revelstoke Reach. Several wildlife physical works have been proposed for implementation in select areas of at Revelstoke Reach (Golder 2009a and 2009b). 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 painted turtles, pond-breeding amphibians, and birds (waterfowl). However, as noted in Hawkes et al. (2014) there is no evidence that these physical works would improve turtle habitat in Revelstoke Reach, particularly in Cartier Bay.

6.2 Recommendations

The objective of CLBMON-11B3 is to monitor trends in the Western Painted Turtle population (relative abundance, productivity), determine whether reservoir operations impact these turtles, determine their habitat use, and assess the impacts of any revegetation and physical works on species that use habitats within the drawdown zone of Revelstoke Reach, Arrow Lakes Reservoir.

Monitoring of painted turtles in Revelstoke Reach in 2015 should continue using similar methods applied during previous years. A radio-telemetry component will also be pursued for studying movements (and survival) of juvenile turtles in the drawdown zone. A NSERC undergraduate student has been hired for this work in the summer of 2015, which will function as a pilot project to determine the feasibility of these methods for a future master's student research project.

Additional recommendations include:

1. Year-round surveys should continue to obtain data of seasonal and annual movements of turtles. Telemetry data should be obtained in all months.
2. Digital elevation models should be generated via the acquisition of LiDAR for Revelstoke Reach (and ideally, all of ALR) in order to interpolate turtle elevations and the availability of pond habitat more accurately.
3. Triangulated turtle locations have low accuracy and have been excluded for most assessments of turtle habitat use. Because triangulation data are variable, effort should be taken to acquire exact turtle locations (e.g., via canoe/kayak). Where this is not possible, surveyors should ensure that a minimum of 3 telemetry points and bearings are taken (ideally more for accuracy).
4. Graduate research should continue on the turtle population in Revelstoke Reach. The current focus of over-wintering strategies and success has been assessed and the focus of future research should shift to juvenile turtle survival. Discussions with Dr. Karl Larsen (Thompson Rivers University) are ongoing and a summer NSERC undergraduate student is currently collecting initial data on juvenile survivorship. This study will be considered for a future master's student research project.
5. Data loggers to obtain continuous temperature, DO and conductivity data should be installed in Williamson Lake, Turtle Pond, Airport Marsh, Montana Slough, and Cartier Bay. Ideally 2 per location. The costs for these data loggers could be shared between multiple projects (e.g., CLBMON-37, CLBMON-11B3, CLBWORKS-30).
6. Refinements to pond mapping are needed for Revelstoke Reach. This effort could be shared between CLBMON-37, 11B3, and perhaps CLBMON-33 and 12.

7.0 REFERENCES

BC Hydro. 2005. Consultative Committee report: Columbia River Water Use Plan, Volumes 1 and 2. BC Hydro Power Corporation, Burnaby, B.C.

BC Hydro. 2007. Columbia River project water use plan. BC Hydro Generation, Burnaby, B.C. 41 pp

Bickler, P.E. and L.T. Buck. 2007. Hypoxia tolerance in reptiles, amphibians, and fishes: life with variable oxygen availability. Annu. Rev. Physiol. 2007. 69:145–70.

Cagle, F.R. 1939. A System of Marking Turtles for Future Identification. Copeia, 3: 170–173.

Cohen, M. 1992. The Painted Turtle, *Chrysemys picta*. Tortuga Gazette 28(10): 1-3.

Congdon, J.D., S.W. Gotted, and R.W. McDiarmid. 1992. Ontogenic changes in habitat use by juvenile turtles, *Chelydra serpentina* and *Chrysemys picta*. Canadian Field Naturalist, 106(2): 241-248.

COSEWIC. 2006. COSEWIC assessment and status report on the Western Painted Turtle *Chrysemys picta bellii* (Pacific Coast population, Intermountain-Rocky Mountain population and Prairie/Western Boreal - Canadian Shield population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 40 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

de Mendiburu, F. 2013. agricolae: Statistical Procedures for Agricultural Research. R package version 1.1-6. <http://CRAN.R-project.org/package=agricolae>

Dinkelacker, S.A., J.P. Costanzo, and R.E. Lee Jr. 2005. Anoxia tolerance and freeze tolerance in hatchling turtles. Journal of Comparative Physiology B, 175: 209-217.

Dobson, F.S. 1992. Body mass, structural size, and life-history patterns of the Columbian ground squirrel. American Naturalist, 140:109–125.

Enns, K., P. Gibeau, and B. Enns. 2008. CLBMON-33 Arrow Lakes Reservoir inventory of vegetation: 2008 final report. Report prepared by Delphinium Holdings Inc. for BC Hydro, Castlegar, B.C.

Fenneman, J.D., and V.C. Hawkes. 2012. CLBMON-11B4 Monitoring Wetland and Riparian Habitat in Revelstoke Reach in Response to Wildlife Physical Works. Annual Report – 2011. LGL Report EA3234. Unpublished report by LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, B.C. 41 pp.

Gamble, T. 2006. The relative efficiency of basking and hoop traps for painted turtles (*Chrysemys picta*). Herpetological Review, 37: 308–312.

Golder Associates. 2009a. Columbia River Project Water Use Plan; Reference: CLBWORKS-29A. Volume I: Arrow Lakes Reservoir Wildlife Physical Work feasibility Study: 2008. Prepared for BC Hydro. 60pp. + appendices.

Golder Associates. 2009b. Arrow Lakes Reservoir wildlife physical works feasibility study, phase II. Report prepared for BC Hydro and Power Authority, Castlegar, B.C.

Hawkes, V.C., and K.N. Tuttle. 2013. CLBMON-37. Arrow Lakes Reservoir: Amphibian and Reptile Life History and Habitat Use Assessment.

Comprehensive Report – 2013. LGL Report EA3450. Unpublished report by LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 32 pp.

Hawkes, V.C., H. van Oort, M. Miller, N. Wright, C. Wood, and A. Peatt. 2014. CLBWORKS-30 Ecological Impact Assessment – Wildlife Physical Works Project 14 & 15A. Unpublished Report by LGL Limited environmental research associates, Cooper, Beauchesne and Associates, Ecofish Research Ltd. and Okanagan Nation Alliance for BC Hydro, Burnaby BC. 95 pp. + Appendices

Hawkes, V.C., K. Tuttle, A. Leeming, D. Adama. 2013 CLBMON-11B3 Revelstoke Reach Painted Turtle Monitoring Program. Annual Report – 2012. LGL Report EA3414. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, B.C. 34 pp.

Hollander, M. and D.A. Wolfe. 1973. Nonparametric statistical methods. John Wiley & Sons, New York.

Jakob, E.M., S.D. Marshell, and G.W. Uetz. 1996. Estimating fitness: a comparison of body-condition indices. Oikos, 77: 61–67.

Krebs, C.J. 1999. Ecological methodology. 2nd edition. Benjamin Cummings, Menlo Park, California. 620 pp.

Maltby, F.L. 2000. Painted turtle nest site enhancement and monitoring, Red Devil Hill nest site at Revelstoke, B.C. Page 18. Report submitted to the Columbia Basin Fish and Wildlife Compensation Program, Nelson, British Columbia.

Matsuda, B.M., D.M. Green, and P.T. Gregory. 2006. Amphibians and Reptiles of British Columbia. Royal BC Museum Handbook. Victoria, B.C. 288 pp.

Microsoft. (2013). Microsoft Excel [computer software] v. 15.0.4551.1006. Redmond, Washington.

Miller, M.T. and V.C. Hawkes. 2013. CLBMON-11B4 Monitoring Wetland and Riparian Habitat in Revelstoke Reach in Response to Wildlife Physical Works. Annual Report – 2012. LGL Report EA3413. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, B.C., for BC Hydro Generation, Water Licence Requirements, Burnaby, B.C. 50 pp

Millspaugh, J., and J.M. Marzluff (editors). 2001. Radio Tracking and Animal Populations. Academic Press.

Orchard, S. 1986. Painted turtle (*Chrysemys picta*) habitat use information and habitat suitability index model. Research Branch, Ministry of Forests, Victoria, B.C. 24 pp.

R Core Team. 2014. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. <http://www.R-project.org/>

Resource Inventory Standards Committee (RISC). 1998a. Inventory methods for pond-breeding amphibians and painted turtles. Standards for components of British Columbia's Biodiversity No. 37. Version 2.0. Government of British Columbia, Victoria, B.C.

Resource Inventory Standards Committee (RISC). 1998b. Wildlife Radio-telemetry. Standards for Components of British Columbia's Biodiversity No. 5. Version 2. Government of British Columbia, Victoria, B.C.

Resource Inventory Standards Committee (RISC). 1998c. Live animal capture and handling guidelines for wild mammals, birds, amphibians and reptiles. Standardized Inventory Methodologies for Components of British Columbia's Biodiversity. No. 3. Version 2.0. Government of British Columbia, Victoria, B.C.

Rollinson, N., G.J. Tattersall, and R.J. Brooks. 2008. Overwintering habitats of a northern population of painted turtles (*Chrysemys picta*): winter temperature selection and dissolved oxygen concentrations. Journal of Herpetology, 42:312–321.

Schiller, N.R., and K.W. Larsen. 2012a. 2011 Annual Report - Revelstoke Reach Western Painted Turtle Monitoring Program**.** Kamloops, B.C., Prepared for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 77 pp.

Schiller, N.R., and K.W. Larsen. 2012b. Arrow Lakes Reservoir, Revelstoke Reach Western Painted Turtle (*Chrysemys picta bellii*) Monitoring Strategy (2012-2019). Kamloops, B.C., Prepared for BC Hydro Generations, Water License Requirements, Burnaby, B.C. 26 pp.

Schulte-Hostedde, A.I., B. Zinner, J.S. Millar, and G.J Hickling. 2005. Restitution of mass–size residuals: validating body condition indices. Ecology, 86(1): 155–163.

Sokal, R.R. and F.J. Rohlf. 1995. Biometry: the principles and practice of statistics in biological research, 3rd ed. Freeman: New York. 887 pp.

Ultsch G.R., and D.C. Jackson. 1982. Long-term submergence at 3-degrees-C of the turtle, *Chrysemys picta bellii*, in normoxic and severely hypoxic water. 1. Survival, gas-exchange and acid-base status. Journal of Experimental Biology, 96:11-28.

Ultsch, G.R., R.W. Hanley, and T.R. Bauman. 1985. Responses to anoxia during simulated hibernation in northern and southern painted turtles. Ecology, 66: 388–395.

Welsh Jr., H.H., K.L. Pope, and C.A. Wheeler. 2008. Using multiple metrics to assess the effects of forest succession on population status: a comparative study of two terrestrial salamanders in the US Pacific Northwest. Biological Conservation, 141: 1149–1160.

Whitfield, S.M., D.E. Scott, T.J. Ryan, K.A. Buhlmann, T.D. Tuberville, B.S. Metts, J.L. Greene, T. Mills, Y. Leiden, S. Poppy, and C. T. Winne. 2000. The global decline of reptiles, déjà vu amphibians. Bioscience, 50:653–666.

Wood, C.M. and V.C. Hawkes. 2014. CLBMON-11B3 Revelstoke Reach Painted Turtle Monitoring Program. Annual Report – 2013. LGL Report EA3414. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 44 pp + Appendices.

8.0 APPENDICES

Appendix 8-1: Site occupancy for each identified (marked) turtle recorded during 2013 and 2014 monitoring years in Revelstoke Reach (Table 8-1)

Table 8-1: Site occupancy of individually identified turtles at each of the five main study sites (2013-2014); orange= female present; blue= male present. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

	SITE					
Female	AP	MS	CB	TP	WL	No. of Sites
F016	■					1
F043	■					1
F061		■	■			2
F091	■	■		■		3
F106	■					1
F116	■					1
F117		■	■			2
F120	■					1
F146		■				1
F148					■	1
F150				■		1
F151				■		1
F155				■		1
F16	■					1
F162				■		1
F163				■		1
F164				■		1
F165				■		1
F166				■		1
F169		■				1
F171				■		1
F175	■					1
F176	■					1
F178		■				1
F181	■					1
F182	■			■		2
F183	■					1
F189	■			■		2
F191	■					1
F192	■					1
F194				■		1
F195	■					1
F196	■					1
F198				■		1
F201	■					1
	18	6	2	14	1	35

	SITE					
Male	AP	MS	CB	TP	WL	No. of Sites
M048				■		1
M082	■					1
M084	■					1
M090		■	■			2
M094		■				1
M099	■					1
M147	■	■				2
M149		■				1
M152		■				1
M153					■	1
M154		■				1
M157	■					1
M158				■		1
M159				■		1
M160				■		1
M161				■		1
M167	■					1
M170				■		1
M172				■		1
M174		■				1
M177				■		1
M179	■					1
M180	■					1
M184		■				1
M185	■					1
M186	■					1
M187	■					1
M189				■		1
M190		■				1
M193				■		1
M195	■					1
M197				■		1
M199		■		■		2
M200				■		1
M201		■				1
M202	■					1
M203	■					1
M204	■					1
M205	■					1
M206	■					1
M207	■					1
M208	■					1
M209	■					1
M210	■					1
M211	■					1
M212	■					1
	23	11	1	13	1	46

Appendix 8-2: Overwintering habitat water quality measurements recorded for 2013 in locations where turtles were present and random locations where turtles were absent. Tables are presented separately by month of winter telemetry survey, including January (Table 8-2), February (Table 8-3), and March (Table 8-4)

Table 8-2: Average water depths and measurements associated with turtle locations (turt) and random non-turtle locations (ran) at each study site for the month of January in 2013 and 2014. Some measurements are provided at two depths: surface and at the depth of the water column.

		JANUARY 2013				JANUARY 2014				Mean Total
		AP	MS	TP	WL	AP	MS	TP	WL	
Mean Total Depth (cm)	turt	57.00	72.67	58.00	48.50	76.25	65.86	69.43	70.00	**67.55**
	ran					76.69	117.79	112.13		**97.13**
Mean Ice Depth (cm)	turt	24.14	22.00	31.00	13.00	36.40	28.86	37.14	40.00	**29.85**
	ran					41.47	35.08	49.00		**41.04**
Mean Water Depth (cm)	turt	32.86	50.67	27.00	35.50	39.85	37.00	32.29	30.00	**37.70**
	ran					35.22	82.71	63.13		**56.09**
Mean Surface Temp (°C)	turt	0.06	0.50	0.10	0.00	0.21	0.09	0.19	0.50	**0.19**
	ran					0.04	0.08	0.01		**0.05**
Mean Surface DO (mg/L)	turt	5.71	4.58	3.76	8.88	5.40	4.91	3.47	7.69	**5.12**
	ran					5.11	7.41	2.17		**5.21**
Mean Depth DO (mg/L)	turt	3.74	3.00	2.05	7.90	4.66	4.87	2.45	7.16	**4.09**
	ran									
Mean Surface Conductivity (µs)	turt	46.75	85.88	22.40						**65.88**
	ran									
Mean Depth Conductivity (µs)	turt	66.67	114.93	24.00						**91.36**
	ran									
Mean Surface pH	turt					7.51	7.61	7.39	7.90	**7.52**
	ran					7.44	7.66	7.43		**7.51**
Mean Depth pH	turt					7.64	7.53	7.47	7.80	**7.56**
	ran									

Table 8-3: Average water depths and measurements associated with turtle locations (turt) and random non-turtle locations (ran) at each study site for the month of February in 2013 and 2014. Some measurements are provided at two depths: surface and at the depth of the water column

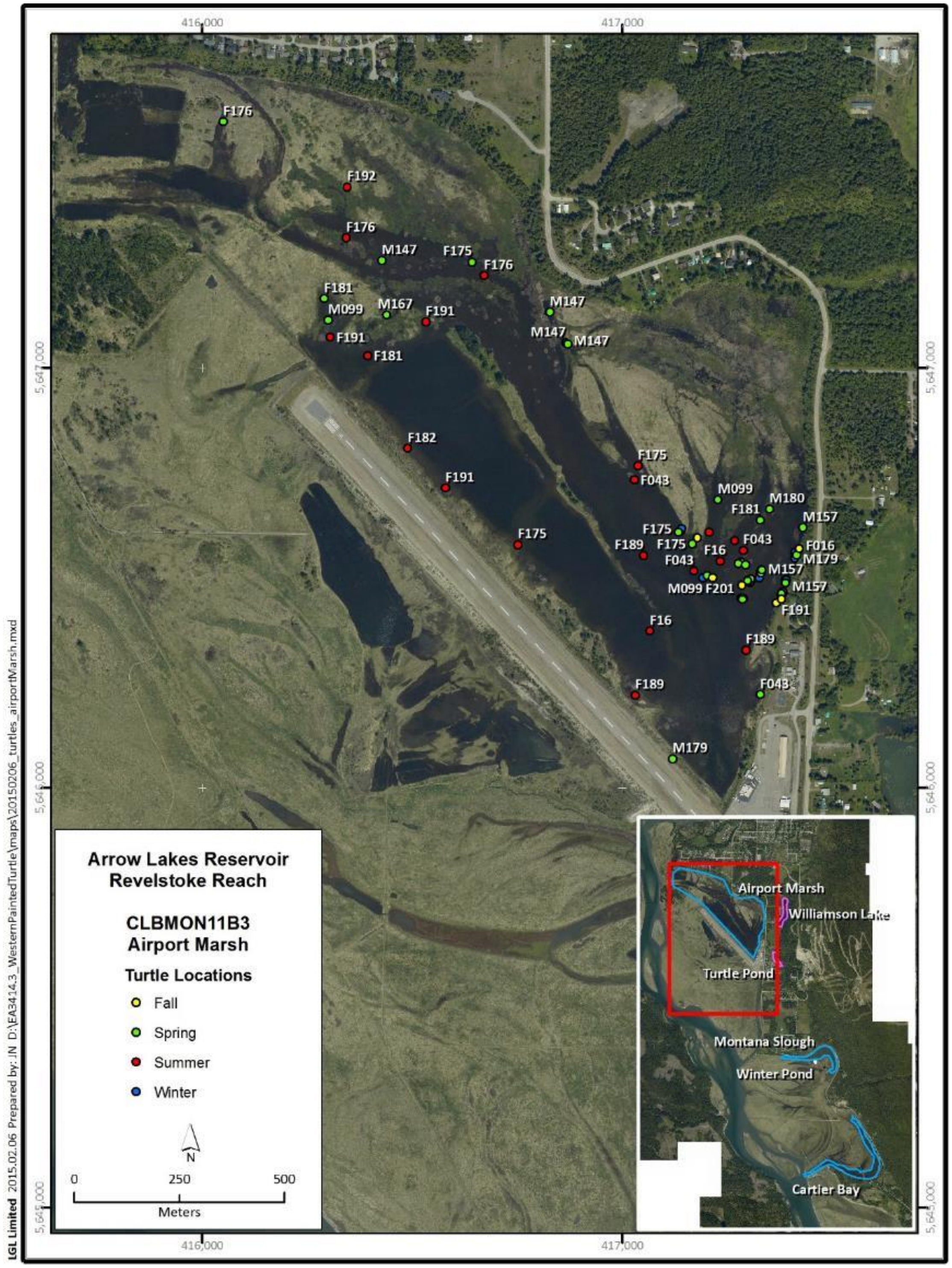
		FEBRUARY 2013				FEBRUARY 2014				Mean Total
		AP	MS	TP	WL	AP	MS	TP	WL	
Mean Total Depth (cm)	turt	62.50	68.50		73.50	77.10	70.14	63.14	94.00	**69.66**
	ran	97.00	75.00	74.00	98.00	80.83	139.10	112.25		**99.09**
Mean Ice Depth (cm)	turt	34.00	29.00		34.50	38.40	32.29	40.71	48.00	**35.56**
	ran	37.67	33.50	31.00	37.00	47.36	35.80	45.63		**41.14**
Mean Water Depth (cm)	turt	28.50	39.50		39.00	38.70	37.86	22.43	46.00	**34.10**
	ran	59.33	41.50	43.00	61.00	36.25	103.30	66.63		**59.01**
Mean Surface Temp (°C)	turt	0.39	0.05		0.25	0.06	0.01	0.00	0.00	**0.11**
	ran	0.60	0.10	0.60	0.20	0.05	0.00	0.00		**0.12**
Mean Surface DO (mg/L)	turt	6.55	2.28		7.68	4.09	3.81	2.88	8.28	**4.33**
	ran	5.90	4.01	7.50	7.66	3.83	5.08	3.56		**4.69**
Mean Depth DO (mg/L)	turt	4.74	1.08		7.13	4.46	3.58	3.27	7.10	**3.84**
	ran	4.23	3.46	4.00	6.09					**4.80**
Mean Surface Conductivity (µs)	turt	56.55	69.97		55.05		105.00			**63.96**
	ran	85.73	92.40	55.00	58.40					**91.38**
Mean Depth Conductivity (µs)	turt	68.57	95.10		42.50		125.00			**78.79**
	ran	102.00	110.15	53.73	66.70					**101.99**
Mean Surface pH	turt					7.61	7.64	7.96	8.40	**7.75**
	ran					7.60	7.81	8.18		**7.79**
Mean Depth pH	turt					7.50	7.50	7.95	8.30	**7.64**
	ran									

Table 8-4: Average water depths and measurements associated with turtle locations (turt) and random non-turtle locations (ran) at each study site for the month of March in 2013 and 2014. Some measurements are provided at two depths: surface and at the depth of the water column

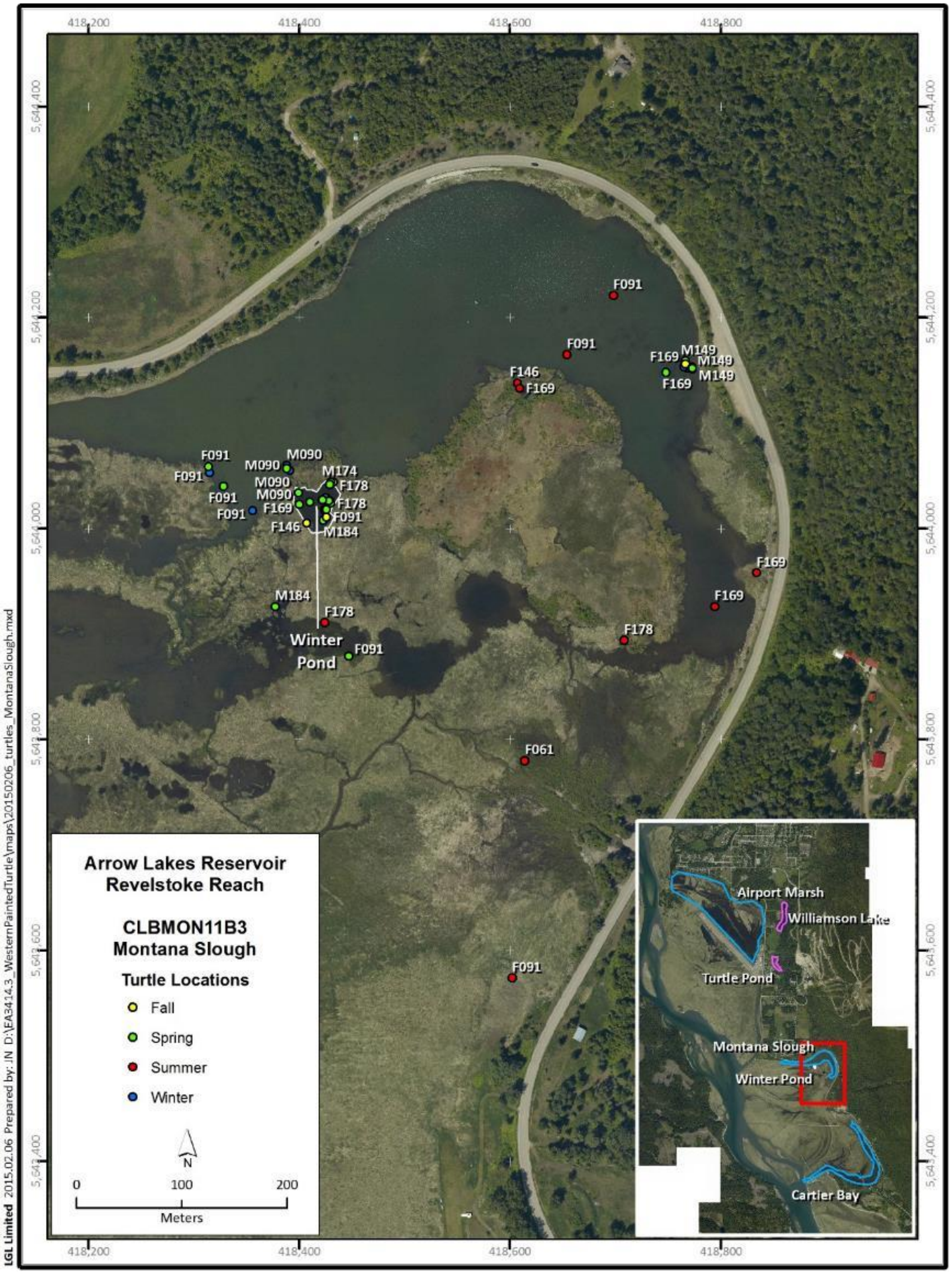
		MARCH 2013				MARCH 2014				Mean Total
		AP	MS	TP	WL	AP	MS	TP	WL	
Mean	turt	52.00	58.00		52.00	87.40	77.67	69.43	103.00	**72.49**
Total Depth (cm)	ran	56.00	40.00	53.00	70.00	89.00	137.80	119.25		**99.28**
Mean	turt	28.67	14.33		15.50	53.40	46.50	48.43	60.00	**40.43**
Ice Depth (cm)	ran	27.00	5.00	22.00	25.00	63.78	63.00	63.13		**55.67**
Mean	turt	23.33	43.67		36.50	34.00	26.71	21.00	43.00	**31.17**
Water Depth (cm)	ran	29.00	35.00	31.00	45.00	25.22	74.80	56.13		**43.60**
Mean	turt	0.03	1.17		0.55	0.07	0.05	0.44	0.60	**0.37**
Surface Temp (°C)	ran	0.20	1.15	0.20	0.20	0.06	0.98	0.41		**0.52**
Mean	turt	11.37	4.75		11.47	8.92	8.12	7.25	8.33	**8.07**
Surface DO (mg/L)	ran	11.78	8.39	13.18	11.57	8.47	8.83	8.76		**9.06**
Mean	turt	8.06	3.24		10.32	6.49	5.59	5.57	7.80	**5.97**
Depth DO (mg/L)	ran	9.64	2.90	5.10	10.84	5.65	4.38	4.77		**5.38**
Mean	turt	37.97	51.15		55.25	81.41	75.07	37.57	64.40	**60.66**
Surface Conductivity (µs)	ran	39.90	50.55	12.10	62.20	85.83	94.85	48.11		**76.56**
Mean	turt	51.60	93.75		60.00	105.46	84.83	47.83	71.40	**79.64**
Depth Conductivity (µs)	ran	56.75	115.30	35.70	62.20	113.62	125.27	70.16		**100.85**
Mean	turt					7.56	7.75	7.69	7.90	**7.66**
Surface pH	ran					7.45	7.65	7.49		**7.52**
Mean	turt					7.44	7.40	7.62	8.10	**7.52**
Depth pH	ran									

Appendix 8-3: Locations of western painted turtles determined by telemetry surveys at Revelstoke Reach in 2014 by season.

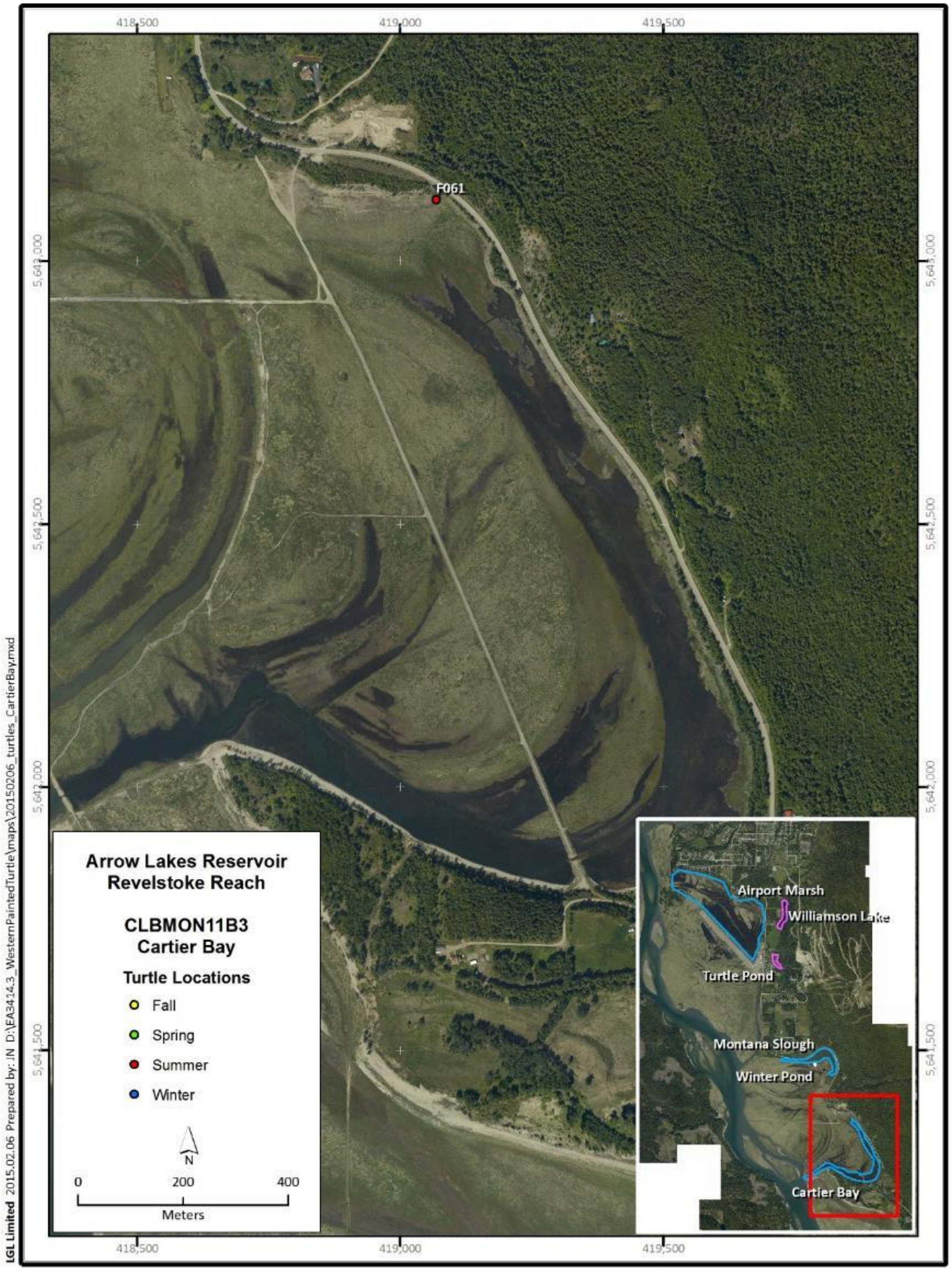
The following maps identify the locations of individual turtle observations (marked with turtle IDs) in each study area



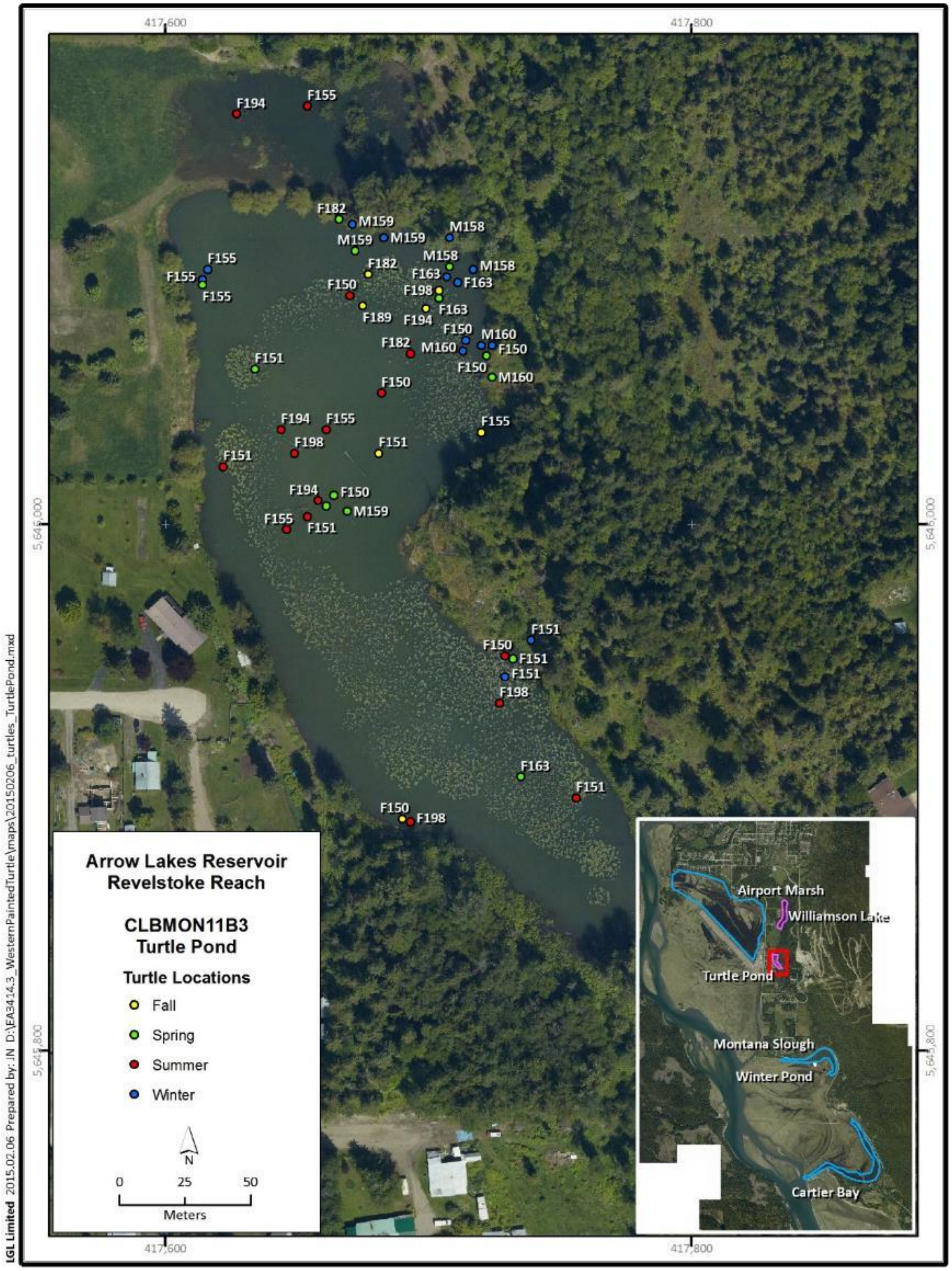
Map 8-1: **The location of Western painted turtles at Airport Marsh, detected during telemetry surveys in 2014.** Point labels identify individual turtles (F= female, M= male); color of points indicate season, based on three-month intervals (Fall = Sep-Nov, Spring = Mar-May, Summer = Jun-Aug, Winter = Dec-Feb); triangulation points were excluded due to low accuracy



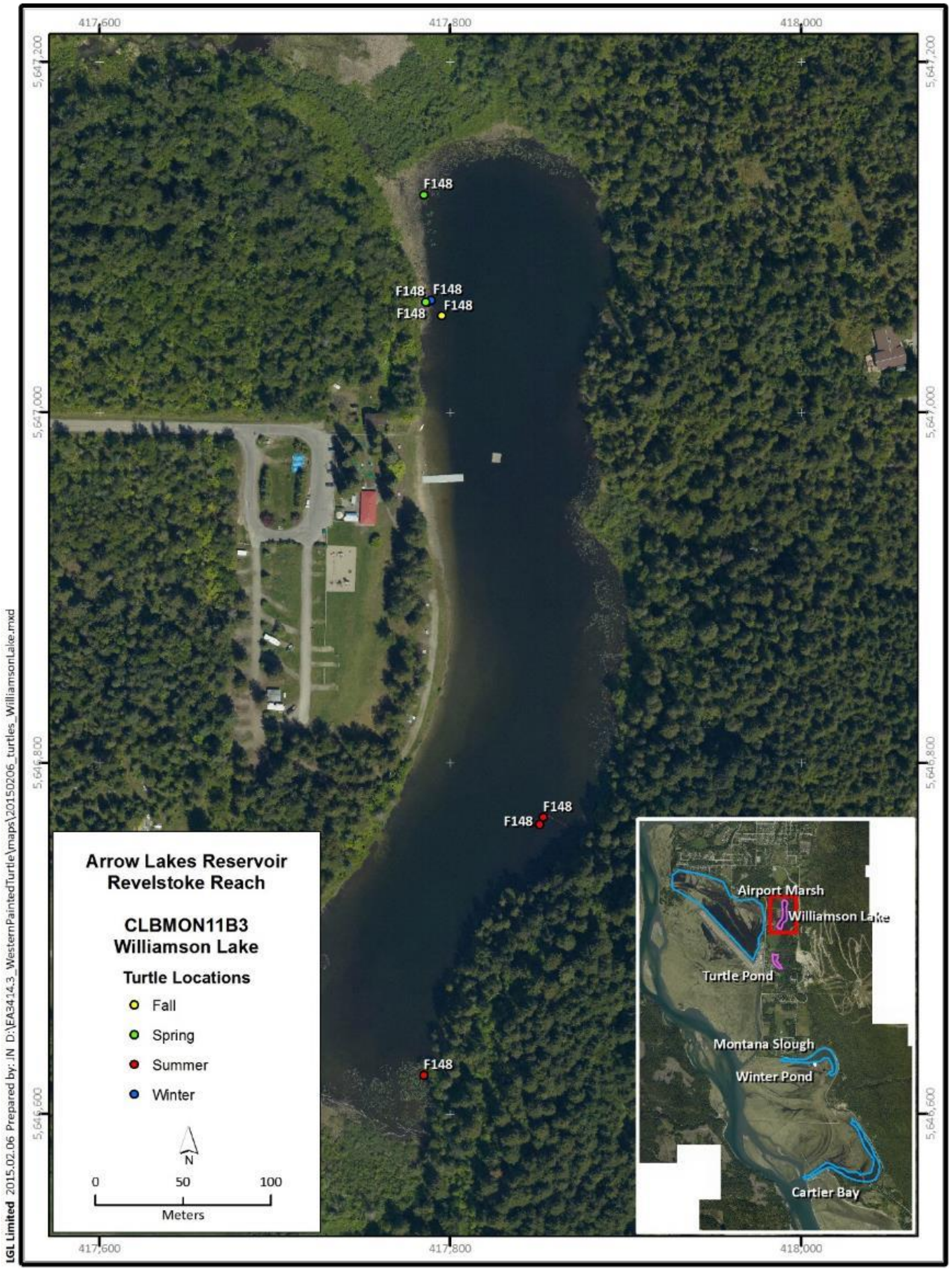
Map 8-2: The location of Western painted turtles at Montana Slough, detected during telemetry surveys in 2014. Additionally, the perimeter of Winter Pond is overlaid. Point labels identify individual turtles (F= female, M= male); color of points indicate season, based on three-month intervals (Fall = Sep-Nov, Spring = Mar-May, Summer = Jun-Aug, Winter = Dec-Feb); triangulation points were excluded due to low accuracy



Map 8-3: The location of Western painted turtles at Cartier Bay detected during telemetry surveys in 2014. Point labels identify individual turtles (F= female, M= male); color of points indicate season, based on three-month intervals (Fall = Sep-Nov, Spring = Mar-May, Summer = Jun-Aug, Winter = Dec-Feb); triangulation points were excluded due to low accuracy



Map 8-4: The location of Western painted turtles at Turtle Pond detected during telemetry surveys in 2014. Point labels identify individual turtles (F= female, M= male); color of points indicate season, based on three-month intervals (Fall = Sep-Nov, Spring = Mar-May, Summer = Jun-Aug, Winter = Dec-Feb); triangulation points were excluded due to low accuracy



Map 8-5: The location of Western painted turtles at Williamson Lake, detected during telemetry surveys in 2014. Point labels identify individual turtles (F= female, M= male); color of points indicate season, based on three-month intervals (Fall = Sep-Nov, Spring = Mar-May, Summer = Jun-Aug, Winter = Dec-Feb); triangulation points were excluded due to low accuracy