Columbia River Project Water Use Plan

Kinbasket and Arrow Reservoirs Revegetation Management Plan

Revelstoke Reach Painted Turtle Monitoring Program

Implementation Year 6

Reference: CLBMON-11B3

Final Annual Report

Study Period: 2015

Okanagan Nation Alliance, Westbank, BC
and
LGL Limited environmental research associates
Sidney, BC

May 18, 2016

EA3414

BRITISH COLUMBIA HYDRO AND POWER AUTHORITY

CLBMON-11B3 Revelstoke Reach Western Painted Turtle Monitoring Program

Monitoring Year 6 2015
Final Annual Report

Prepared for

BC Hydro

BC Hydro Generation

Water Licence Requirements
6911 Southpoint Drive
Burnaby, BC

Prepared by

Charlene M. Wood[1], M.Sc.,

Virgil C. Hawkes[1], M.Sc., R.P. Bio.

and

Krysia Tuttle[1], M.Sc., R.P. Bio.

Okanagan Nation Alliance
and
[1]LGL Limited environmental research associates

Technical Contact: Virgil C. Hawkes, M.Sc., R.P. Bio.
vhawkes@gl.com; 1.250.656.0127

May 18, 2016

syilx Okanagan Nation Alliance

LGL LIMITED environmental research associates

Suggested Citation

Wood, C.M. V.C. Hawkes, and K.N. Tuttle. 2016. CLBMON-11B3 Revelstoke Reach Painted Turtle Monitoring Program. Annual Report – 2015. LGL Report EA3414B. Unpublished report by Okanagan Nation Alliance and LGL Limited environmental research associates, Sidney, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 37 pp + Appendices.

Cover Photographs

From left to right: Hatchling Western Painted Turtles ("scooters"), Female Western Painted Turtle digging nest at Red Devil Hill; Juvenile Western Painted Turtle with transmitter; Juvenile Western Painted Turtle habitat at Airport Marsh. Photos © Jenna Boisvert, Okanagan Nation Alliance, Jessica Zahnd, and, Virgil C. Hawkes, LGL Limited environmental research associates.

EXECUTIVE SUMMARY

This year marked the sixth 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 the operating regime 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 (radiotelemetry, hoop trapping, and visual searches) were used to document the relative abundance, distribution, nest 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 of inundated and non-inundated ponds.

The primary focus of this report is on the trapping and radiotelemetry monitoring that occurred during 2015. We continued our habitat use assessment of previously tracked adult turtles, as well as added a new component of hatchling habitat use. Additionally, we provide assessments of turtle elevation distribution for years 2013 to 2015, sites, and months, based on interpolations from digital elevation models.

One hundred and thirty-seven observations of turtles were made between May and September 2015. Most of these detections occurred at Airport Marsh, including nearly all of the hatchling observations. Twenty-seven confirmed nesting locations were observed, mainly at Red Devil Hill and Airport Firebase (one observation at near Turtle Pond). Turtles were found using elevations from 434 m to 428 m elevation (ASL) in the drawdown zone, as well as elevations > 440.1 m ASL (i.e., outside of the drawdown zone).

Turtle movements (distance travelled per day) were comparable between sites, though the range of variation in movements was large between individuals with one female moving over three kilometers total distance. Hatchling turtles were very restricted in their movements, hugging the shoreline at Airport Marsh, quite close to the nesting site at the Airport Firebase.

Monitoring will continue in 2016 and will follow similar methods used in previous years, focusing on juvenile and female survivorship and habitat use, and female reproductive success.

The status of CLBMON-11B3 after Year 6 (2015) 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	6 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	6 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.
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	6 years of data collected on WPT in the drawdown zone of Revelstoke Reach Growth and body condition comparisons between DDZ and upland reference sites	• 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	6 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 (juveniles) and their habitat use relative to reservoir operations.
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. • Creation of artificial nesting sites as a physical works to improve nesting habitat suitability and availability for WPT

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	6 years of data documenting WPT use of the DDZ for most life history requirements	none
H2: The operations of Arrow Lakes Reservoir do not affect painted turtle survival or productivity.	Partially	6 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, juvenile survivorship, reservoir operation, drawdown zone, Arrow Lakes Reservoir

ACKNOWLEDGEMENTS

The authors express their appreciation to the following individuals for their assistance in coordinating and conducting this study: Alan Peatt (Okanagan Nation Alliance), Dixon Terbasket (Okanagan Nation Alliance), Autumn Solomon (Okanagan Nation Alliance), Amy Duncan (Okanagan Nation Alliance), Jenna Boisvert (Okanagan Nation Alliance), Margo Sadler (BC Hydro), Guy Martel (BC Hydro), Mark Sherrington (BC Hydro), Bryce McKinnon (LGL Limited), Doug Adama (LGL Limited), Mike Miller (LGL Limited), Jessica Zahnd (LGL Limited / TRU), Karl Larsen (Thompson Rivers University), and Julio Novoa (LGL Limited).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF MAPS

1 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. These include: 1) summer habitat with muddy substrates, an abundance of emergent vegetation, and numerous basking sites; 2) nesting habitat with loose, warm, well-drained soils; and 3), aquatic overwintering habitat that does not freeze and does not become severely hypoxic (COSEWIC 2006). 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 radiotelemetry 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 (Wood and Hawkes 2015), providing further insights on painted turtle productivity, habitat use, and overwintering preferences.

This report summarizes work completed in 2015 for BC Hydro's Monitoring Program CLBMON-11B3: *Arrow Lakes Reservoir: Revelstoke Reach Western Painted Turtle Monitoring Program.*

2 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). The focus initiatives for 2015 are in bold

Initiative		Management Question Addressed	Season		Study Years	2015 Scope
			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	Juveniles and females
2	Conduct focused studies on the fine scale seasonal habitat use of turtles	MQ2, MQ4, MQ6, MQ7, MQ8	X	X	2012-2020	Juveniles and females
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	Juveniles and females
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	Juveniles and females
2d	Use radiotelemetry, 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. 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 2015

Work in 2015 focused on Initiatives 2, 2a, and 2c of the monitoring strategy (Table 2-1). During this period, sampling and tracking of adult Western Painted Turtles continued to characterise fine-scale habitat associations to assess the potential impacts of reservoir operations on habitat use, habitat availability, and turtle movements in spring and summer (Initiative #2a). Juvenile survivorship and movement patterns were assessed using a pilot telemetry study, female nest site selection (Initiative #2c) was assessed using telemetry of currently tagged female turtles, and other potential population stresses will be determined via observational studies. Initiative 2d cannot be assessed until habitat enhancement works (physical works) are implemented in Revelstoke Reach. The methods associated with each of these components is discussed in the Methods section

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.

2.5 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 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 five 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 occurring 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, 2015; 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*). The flood-tolerant Reed Canarygrass forms dense stands over much of the area at Cartier Bay, interspersed with patches of Lenticular Sedge (*Carex lenticularis*), Columbia Sedge (*Carex aperta*), and Water Smartweed (*Persicaria amphibia* var*. stipulacea*). The permanent horseshoe-shaped wetland within Cartier Bay also supports macrophytes such as Eurasian Water-milfoil (*Myriophyllum spicatum*) and Common Hornwort (*Ceratophyllum demersum*). 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).

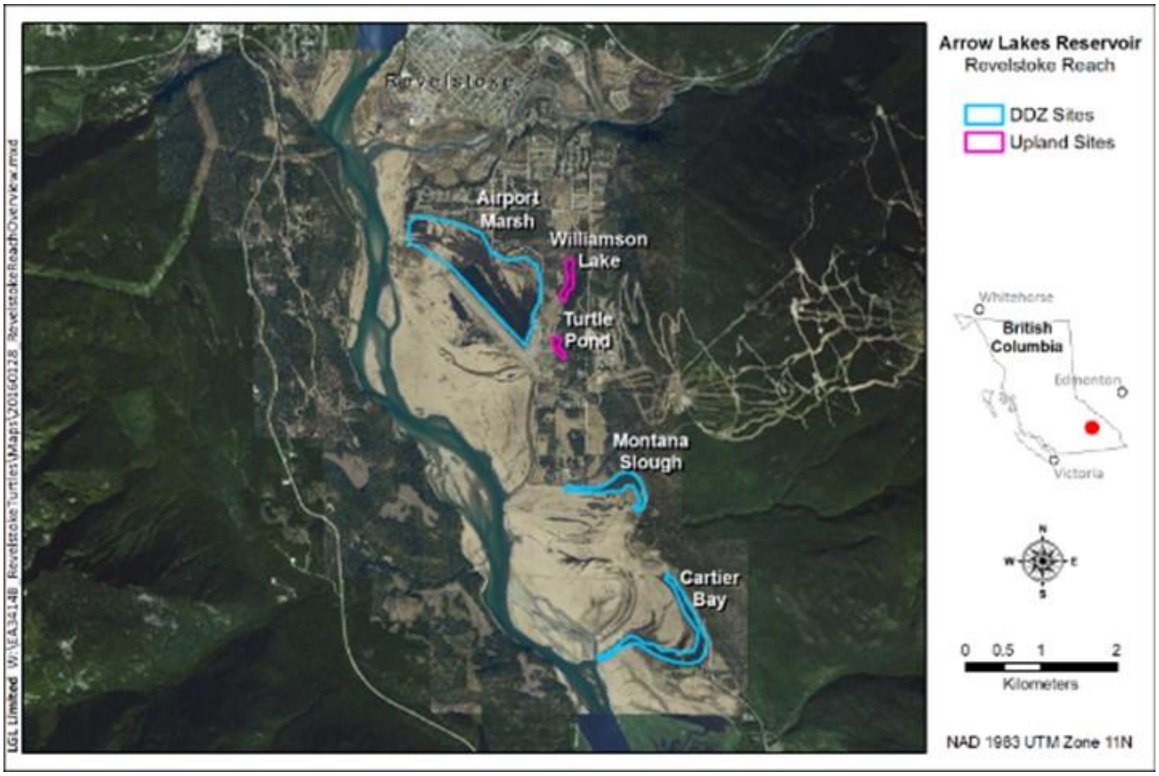


Figure 3-1: Location of Western Painted Turtle study sites in the drawdown zone (DDZ) and upland areas of Revelstoke Reach of Arrow Lakes Reservoir

4 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 2015 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. Several sampling methods were used to collect field data including: 1) radiotelemetry, 2) visual encounter surveys (VES), 3) live trapping, 4) nest searches, and 5) mark/recapture techniques (Schiller and Larsen, 2012a; RISC, 1998a, b, c). Although aspects of the work completed in 2015 were consistent with previous years (i.e., adult turtle telemetry and turtle live trapping), some work was new (i.e., predator observation surveys, juvenile telemetry). Methods applicable to juvenile turtle monitoring and population-level stressors are described below. Other methods can be found in Wood and Hawkes (2014). These data will contribute to addressing management questions: Q1, Q3, Q4, and Q5 over the 10 year study period.

4.1.1 Juvenile Radiotelemetry

Radiotelemetry 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). We collected juvenile turtles by monitoring known nest locations at Red Devil Hill and near the Revelstoke Airport for hatchlings starting in late April 2015. A sample of 10 juvenile turtles was selected for the telemetry study. Transmitters were affixed onto turtles as soon as they emerged from the nest. On each turtle, a VHF transmitter (Holohil BD-2X, 0.35 g transmitter) was affixed to the carapace using bio-compatible glue. Because these small transmitters have a small battery, the distance over which the signal can be transmitted was relatively short and the transmitters were relatively short-lived (approx. 21 days). As such, animals needed to be re-located up to two times per day. A VHF radio receiver (Lotek biotracker) was used to determine the location of each animal or an approximate location was obtained through triangulation methods (as in Schiller and Larsen 2012a, b; Hawkes et al. 2013). Transmitter weight did not exceed 5 per cent of the turtle's body weight (Millspaugh and Marzluff 2001).

Because the transmitter life span was ~ 21 days, we had a set of 30 transmitters for use in the pilot study. Ten transmitters were deployed for ~ 20 days, then removed and replaced with fresh transmitters. We tracked juvenile turtles from early Mary through the end of August to obtain information on survivorship, habitat use and movements.

4.1.2 Population-Level Stressors

Predator Observation Surveys

In addition to the potential effects of reservoir operations on the turtle population, there are other potential population-level stressors that could contribute to changes in the turtle population over time. For example, several species of wildlife are known to prey on turtle eggs, juveniles and young turtles including raccoons, River Otter, Great Blue Heron, crows, ravens, and garter snakes. In 2014, as many as 30 juvenile turtles were found dead in Airport Marsh with most missing their heads. These turtles were presumably depredated by a River Otter (Figure 4-1).

Figure 4-1: Examples of depredated juvenile turtles in Airport Marsh, June 2014

In 2015, observation-based predator surveys occurred at all currently known turtle locations (i.e., Montana Slough, Airport Marsh, Turtle Pond, and Williamson Lake) to assess which species of wildlife were preying on turtles and to what extent that might serve to limit the population. Data collected included date, time, predator species (and age class of predator if known), predator activity (e.g., hunting, flying, perched, etc.), and number of foraging attempts and success rate. Evidence of road-based mortality was also recorded.

Nest Searches

In addition to predation and road-based stressors, nest mortality is a potential population-level stressor. Nest surveys were conducted at Red Devil Hill to determine the locations and numbers of nests in the area, the physical state of the nests (e.g., some nests required maintenance and removal of vegetation to improve the suitability of the site for nesting), and the evidence of nest predation or other forms of mortalities. Other nesting areas (e.g., Williamson Lake, Airport Firebase) were also assessed for possible maintenance or enhancements to ensure maximal habitat suitability of these locations.

4.1.3 Live-Trapping

Two rounds of trapping were conducted in 2015. The first occurred in the spring (May 12-20) and the second occurred in the fall (September 24-25). 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 either removed (for male turtles only) or 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). Transmitters were affixed to adults using the methods outlined in the May 2013 work plan for CLBMON-11B3.

4.1.4 Visual Searching and Hand Capture

Hand capture (i.e., net trapping) was used less often for surveying turtles in 2015 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.

4.1.5 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, hoop trapping, radio-tracking, and VES surveys. Adult 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. A drop of nail polish on the anterior end of the carapace was used as a temporary marking method for hatchlings. 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 Habitat Data

Habitat data were collected during monitoring surveys to determine turtle habitat associations. These included: location of turtles (using a Garmin® GPSmap60CSx), time, date, water depth, water temperature, pH, dissolved oxygen content, conductivity, air temperature, elevation, precipitation, wind speed, humidity (measured using a Kestrel® 4000), cloud cover, distance to water/shore, position and activity of the turtle, and habitat type. Elevation was interpolated from turtle positions based on the available digital elevation model (DEM) for Arrow Lakes Reservoir. 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.

The physicochemical conditions of ponds and habitats in drawdown areas are likely to be greatly affected by the timing of inundation from the reservoir. To assesses physicochemical differences in and out of the drawdown zone, data loggers were installed during the summer of 2015 at two monitoring locations (Montana Slough and Turtle Pond) and were used to obtain conductivity (Onset U24-001), dissolved oxygen (PME MiniDOT) conditions, and temperature (both data loggers measured temperature)

4.3 Data Analyses

All analyses were performed in R version 3.1.2 (R core team 2014). 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) and Bonferroni-adjusted post-hoc pairwise comparisons 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 Kruskal-Wallis rank sum tests are performed on rank-transformed data (i.e., the lowest value is assigned a rank of 1, the next smallest is assigned a rank of 2, and so on). 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 relative abundance (proportional of observations or proportion of detections) and 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) was used. Trap catches were standardized to a CPUE of catch per 100 trap nights for creation of boxplots and Kruskal-Wallis tests for differences in mean rank CPUE between trapping sessions, study sites, and monitoring years.

Nest counts were tallied in the spring by both direct observations of females nesting and incidental observations of hatchlings, dug up nests, or egg shell presence.

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 2015). The interpolated elevations were generally much less variable than recorded GPS elevations, reinforcing the use of DEM interpolations rather than readily available GPS elevations.

Boxplots of adult turtle elevations for each month of survey in 2015 were overlaid on the reservoir hydrograph for the 2015. Kruskal-Wallis tests were used to identify significant differences in elevation of Western Painted Turtles by month of detection.

4.3.3 Pond Availability and Water Quality

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 2015).

Water quality characteristics could be important determinants of turtle distribution and site occupancy patterns. Therefore, we compared the water conditions (temperature, pH, dissolved oxygen, and conductivity) associated with radio-transmitter tagged turtles during different periods (overwintering and non-overwintering) at each study site.

4.3.4 Movement Patterns

We applied the same methods for assessing turtle movement patterns as in previous years (Wood and Hawkes 2015). We examined the relationship between the daily movements of turtles by month and site in Arrow Lakes Reservoir for the 2015 monitoring year. Turtle movement was expressed as the linear distance (in metres) between subsequent turtle locations of each uniquely identified (marked) turtle (locations from both telemetry detections and turtle captures). 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.

The location and movement of juveniles turtles was assessed in Airport Marsh. Juvenile turtles were marked with either a transmitter or using dots of water-based nail polish applied to the middle of the costal and vertebral scutes of the carapace (Figure 4-2). A customized marking scheme was created that divided the costal and vertebral scutes into three columns (costal, vertebral, costal) and each 'row' of scutes and to ensure individuals could be tracked over time. In addition to applying either a transmitter or dots of nail polish, photographs of the plastron were taken to determine the utility of using the markings as a way to identify individuals and to track changes in mass over time (Figure 4-3).

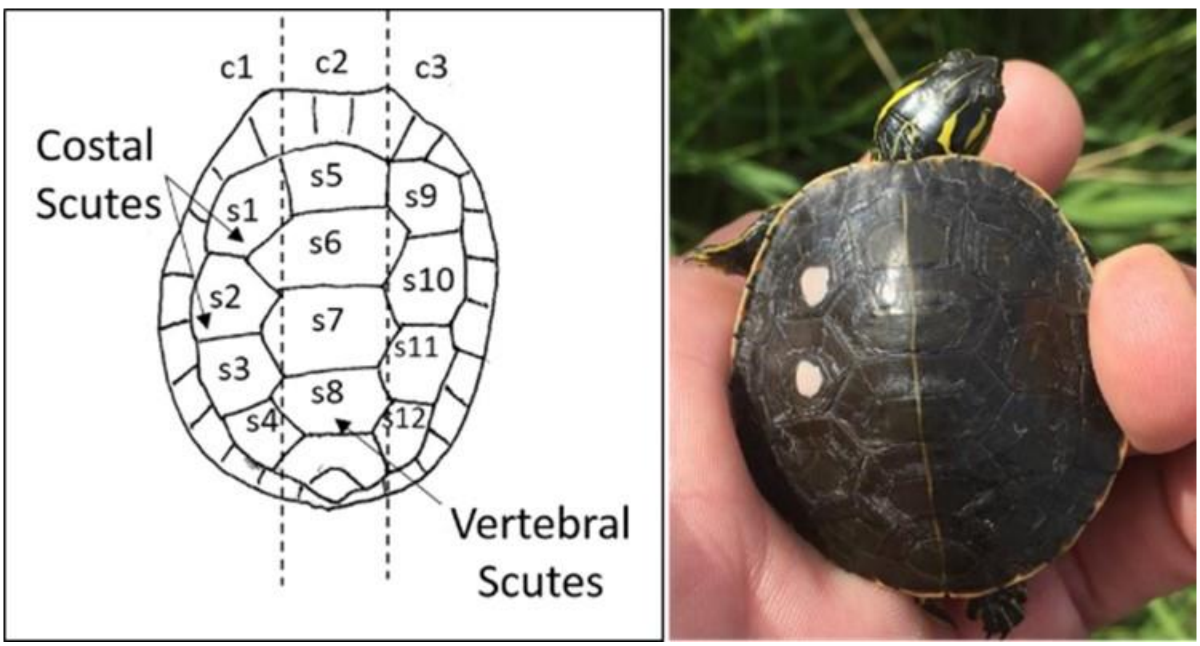


Figure 4-2: Hatchling marking scheme used to mark individual juvenile Western Painted Turtles (left) and an example of a marked turtle (code = c1s1s2).

Figure 4-3: Turtle H1 (hatchling) on June 22 (left) and July 7 (right). The plastron marking are the same and the turtle had gained 6.3 g

4.3.5 Turtle Morphometrics

A common technique for assessing the condition of animal populations is to: 1) compare the mass of individuals from different environments; 2) compare mass relative to body size; and 3) compare indices of body condition. This is founded on the principle that an animal in good condition is assumed to be heavier because of increased fat and protein stores or because it is structurally larger (Dobson 1992). We examined mass and mass relative to body size for turtles captured across all sites for males, females, and juveniles (including hatchlings).

Kruskal-Wallis rank sum tests were performed to detect significant differences in body mass and size of Western Painted Turtles by turtle age class (adult female, adult male, and juvenile) and by study site.

5 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 417388 m E, 5645837 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).

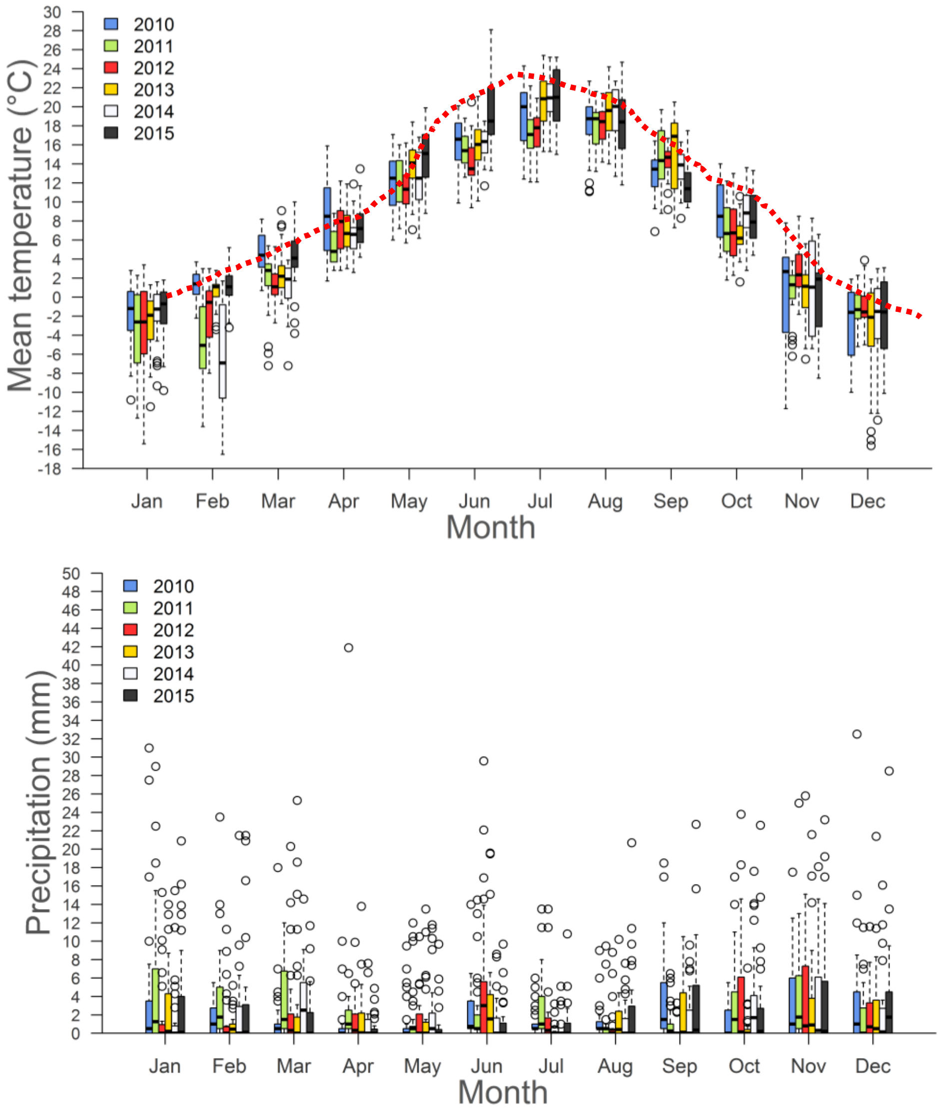


Figure 5-1: **Daily temperature (°C, above) and precipitation (mm, below) for January through December, in years 2010 to 2015 as measured at Revelstoke Airport.** Data source: Environment Canada (http://climate.weather.gc.ca/index_e.html; accessed January 15, 2016)

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. In 2015, the reservoir minimum (m ASL) and maximum (m ASL) levels were lower than in previous years, including falling outside of the normal operating averages during the late summer and fall periods. The reservoir elevation increased by over 11 meters from April to June, but reached its maximum almost a month earlier than in the last five years.

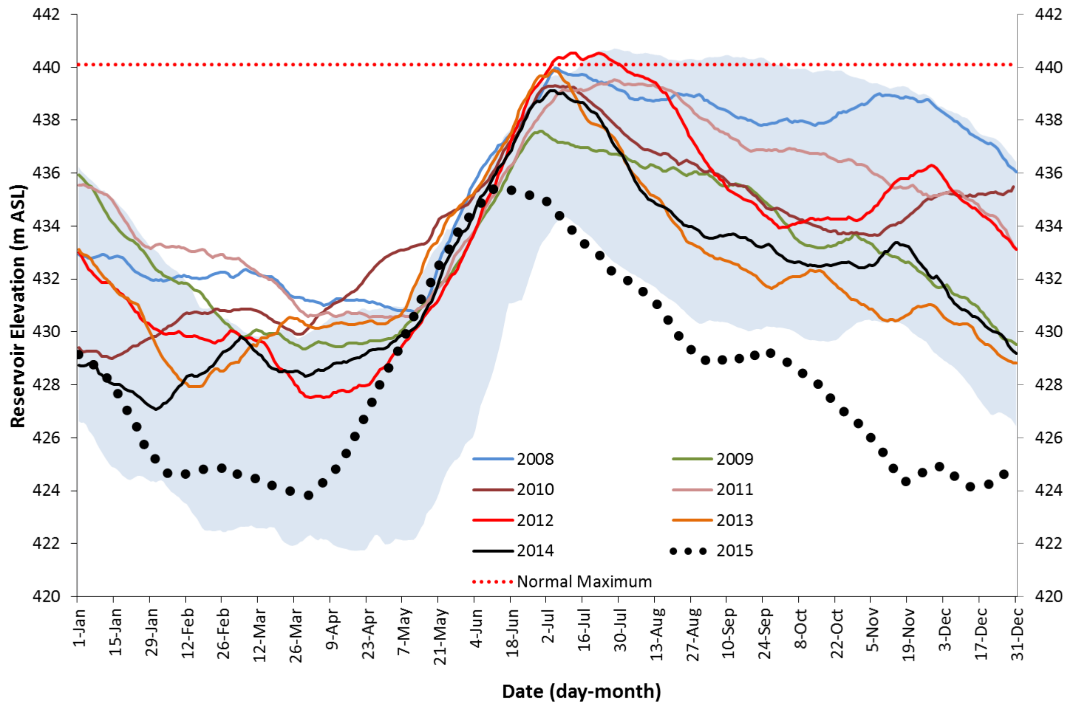


Figure 5-2: Variation in daily reservoir elevations recorded for Arrow Lakes Reservoir during the five study years (2008 to 2015). The dashed line highlights the 2015 reservoir elevation; the blue shaded region depicts the 10th and 90th percentiles in reservoir elevation for 1969 to 2015. The normal 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, Turtle Pond, upland areas adjacent to Airport Marsh and Montana Slough).

From the past six 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 in various 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 2015. Any "Yes" indicates a direct observation of the life history activity or stage, whereas the rest are inferences

Study Site	Life History Activity			
	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, 2012 and 2015. Adult female and male turtles have been observed at all five study sites (Table 8-1), whereas hatchling turtles are mainly found in Airport Marsh.

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	2015
Airport Marsh	■	■	■	■	■	■
Montana Slough	■	■	■	■	■	■
Cartier Bay		■		■	■	
Turtle Pond	■	■	■	■	■	■
Williamson Lake	■	■	■	■	■	■

Hatchling turtles were captured on multiple occasions in 2015, both in upland and in drawdown zone areas (Appendix 2). Airport Marsh was the main site where neonate turtles were observed, followed by Red Devil Hill and Williamson Lake. Two neonate turtles were found at Turtle Pond, perhaps having emerged from the nesting site along the sandy hillslope north of the pond.

5.3.2 Nesting Sites

Visual searches for nests were conducted in May and June 2015, revealing a total of 35 nests across three sites: Red Devil Hill, Airport Marsh, and Turtle Pond. Most nests were in the enhanced gravel nesting area south of Airport Road on Red Devil Hill (see Appendix 2: Map 8-5). Twenty-seven of those nest sites were confirmed to have either eggs present, hatchlings present, or evidence of prior emergence (e.g., egg shells, emergence holes). The remaining sites were classified as possible nests based on the appearance of the nest depression, the presence of a dig hole, or the presence of a female digging at a spot for a long period of time.

Most nesting sites were comprised of shallow holes with disturbed surface materials in sand or loose gravel areas. The nesting location at Red Devil Hill has an extensive cover of grass or invasive weeds [e.g., ox-eye daisy (*Leucanthemum vulgare*), white sweet-clover (*Melilotus alba*), hawkweed (*Hieracium* sp.), quackgrass (*Elymus repens*)], which can have an negative impact on the suitability of the site for nesting.

Figure 5-3: Female Western Painted Turtle digging a nest (left) and an excavated nest at the Red Devil Hill nesting location (right, pink flagging) surrounded by in-growing vegetation

5.3.3 Detection Rates

A total of 137 Western Painted Turtles were observed in 2015: 63 new captures, 10 previous marked or tracked turtles, 49 incidental observations of turtles that were not captured (e.g., turtles basking on logs, turtles that dove into water upon approach, etc.), and 15 dead turtles.

A total of 20 hatchlings were captured in 2015, all from Airport Marsh. Ten individuals were outfitted with transmitters. Of the 20 hatchlings, seven (35%) were recaptured during subsequent surveys (three with transmitters and four without transmitters).

In previous years female sex-ratio biases and male sex-ratio biases have been reported. In 2015, the sex ratio of new adult captures was 22 Female:18 Male (1 Unknown), leading to a slight female bias (55% female). All of these 40 newly captured turtles were marked in 2015 (Table 5-3). Hatchlings were caught during nest surveys and during other visual surveys at Airport Marsh and Turtle Pond.

Table 5-3: Summary of marked adult turtles according to monitoring year, sex and age. Total number of adult male and female turtles marked is given (note: not all captured turtles were marked in 2010 and 2011)

Sex	Total No. marked	No. of Marked Turtles 2010	2011	2012	2013	2014	2015
Female	133	13	32	17	23	26	22
Male	121	6	22	13	22	40	18
Total	254	19	54	30	45	66	40

Detection rates were calculated in terms of catch-per-unit-effort (CPUE), which varied by season, and site (Table 5-4). Airport Marsh had the highest number of captures and highest detection rates for the spring trapping session. No captures were made in the fall.

Table 5-4: Western Painted Turtle trap captures by session and site for 2015 monitoring year. Catch per unit effort is given per trap ($CPUE_{trap}$), per hour of trapping survey ($CPUE_{hour}$), and for one-trap-day equivalent. Trapping sessions occurred in the months of May (spring) and September (fall)

Session	Location	No. of Captures	No. of Traps	Total Trap Hours	CPUE trap	CPUE hour
Spring	Airport Marsh	47	4	588.2	11.8	0.08
	Montana Slough	0	3	483.8	0.0	0.00
	Turtle Pond	5	2	321.0	2.5	0.02
	Williamson Lake	4	2	233.2	2.0	0.02
Spring Total		**56**	**11**	**1626.2**	**5.1**	**0.03**
Fall	Montana Slough	0	2	52.0	0	0
Fall Total		**0**	**2**	**52.0**	0	0
Total		**56**	**13**	**1678.2**	**4.3**	**0.03**

Standardized catch rates can be useful in comparing turtle densities among sites. Standardized trap catches (CPUE= catch per 100 trap nights) were variable between sites, years, and sessions, with no consistent trends in turtle catches between sites (Figure 5-4). Kruskal-Wallis tests for differences in mean ranks of CPUE between sites were not significant for spring (H= 5.62, df=3, p=0.13; all years combined) or fall sessions (H= 2.39, df= 3, p= 0.50; all years combined). In Spring of 2015, mean ranks of CPUE were significantly greater at Airport Marsh than Montana Slough, with Turtle Pond and Williamson Lake not different from either of these drawdown zone sites (H= 7.27, df= 3, p= 0.06). No significant differences were detected between sites for the Spring 2014 trapping session (H= 5.78, df= 3, p= 0.12). Traps were only set at Airport Marsh in the Fall of 2015, thus no comparisons could be made for this session. No differences in mean ranks of catch per 100 trap nights were found among sites for the Fall 2014 trapping session (H= 4.32, df=3, p= 0.23). Overall, standardized trap catches did not provide any meaningful assessments of turtle density between study sites.

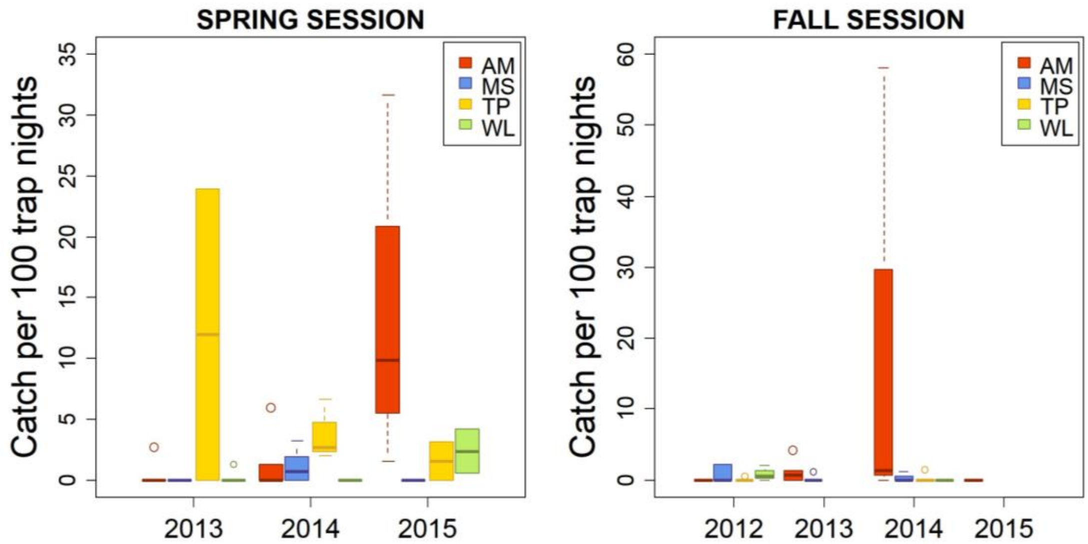


Figure 5-4: Boxplots of standardized turtle captures (catch per 100 trap nights) in each study site between 2012 and 2015 monitoring years. Only spring and fall trapping session data are included (no spring trapping session in 2012). Drawdown zone sites: AM= Airport March and MS= Montana Slough; Upland reference sites: TP= Turtle Pond and WL= Williamson Lake

5.3.4 Elevation Distribution

Elevation distribution of turtles in the drawdown zone was very similar between monitoring years and months of telemetry surveys (Figure 5-5). Similar to previous years, adult radio-tagged turtles were found at a mean elevation of 437.6 m ASL (range 435.3 to 438.4 m ASL).

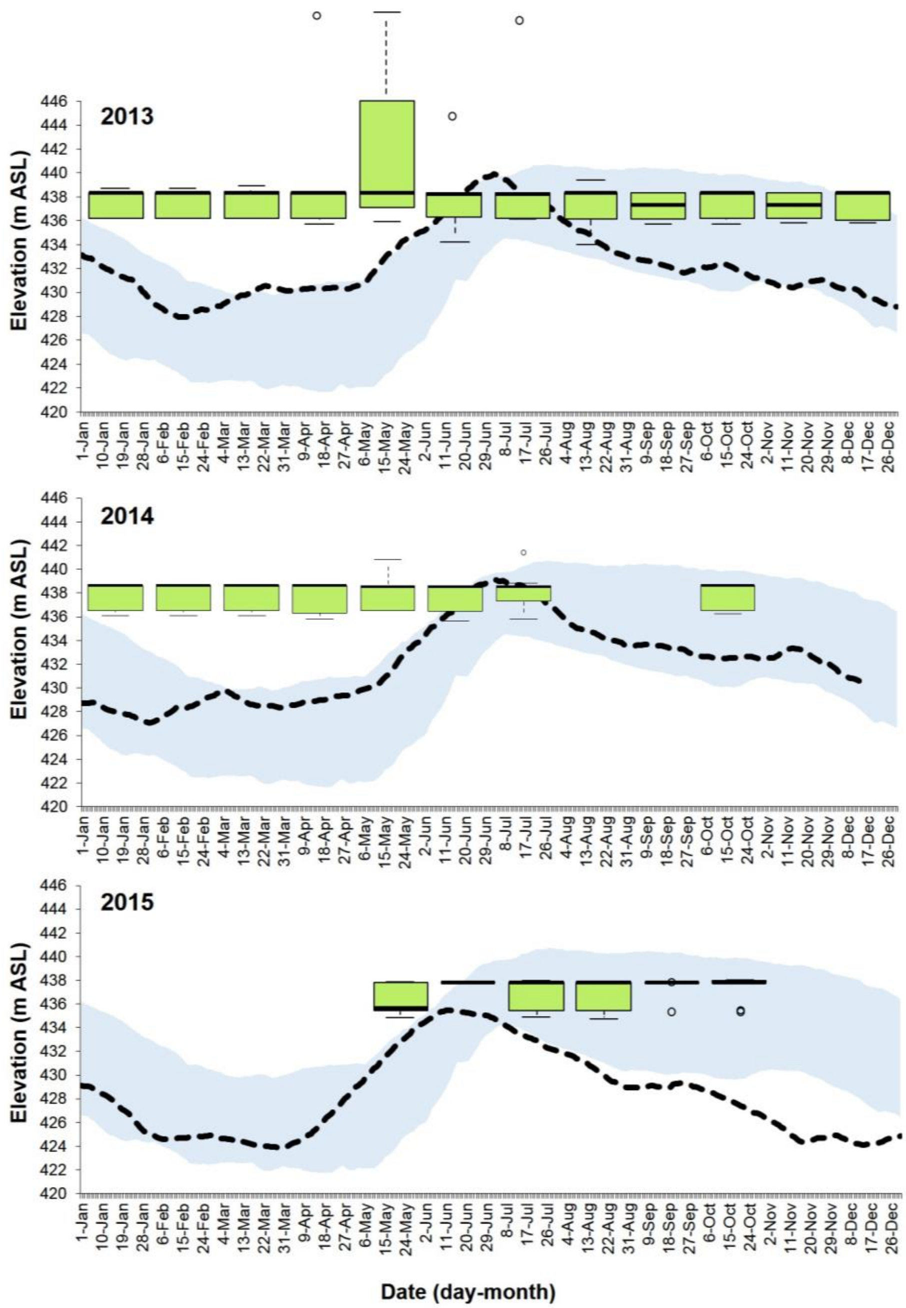


Figure 5-5: Mean daily elevation of Arrow Lakes Reservoir and monthly variation in elevation of radiotelemetry located turtles in drawdown zone sites for 2013 to 2015. Boxplots show turtle elevations for telemetry surveys conducted in the drawdown zone sites (includes Airport Marsh, Montana Slough, and 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 2015; n = 149 turtle detections in 2013; n = 134 turtle detections in 2014, n= 85 turtle detections in 2015

5.3.5 Pond Availability and Water Quality

The location, elevation, and number of ponds available in the drawdown zone were mapped for Cartier Bay and Montana Slough in Revelstoke Reach (Figure 5-6). 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. The pond areas are continuously changing with reservoir operations (e.g., erosion, flooding, and drought) and are not expected to drive patterns of habitat use in the drawdown zone. At present, we know that both Montana Slough and Cartier Bay possess a variety of pond sizes, however few turtles have been observed in Cartier Bay.

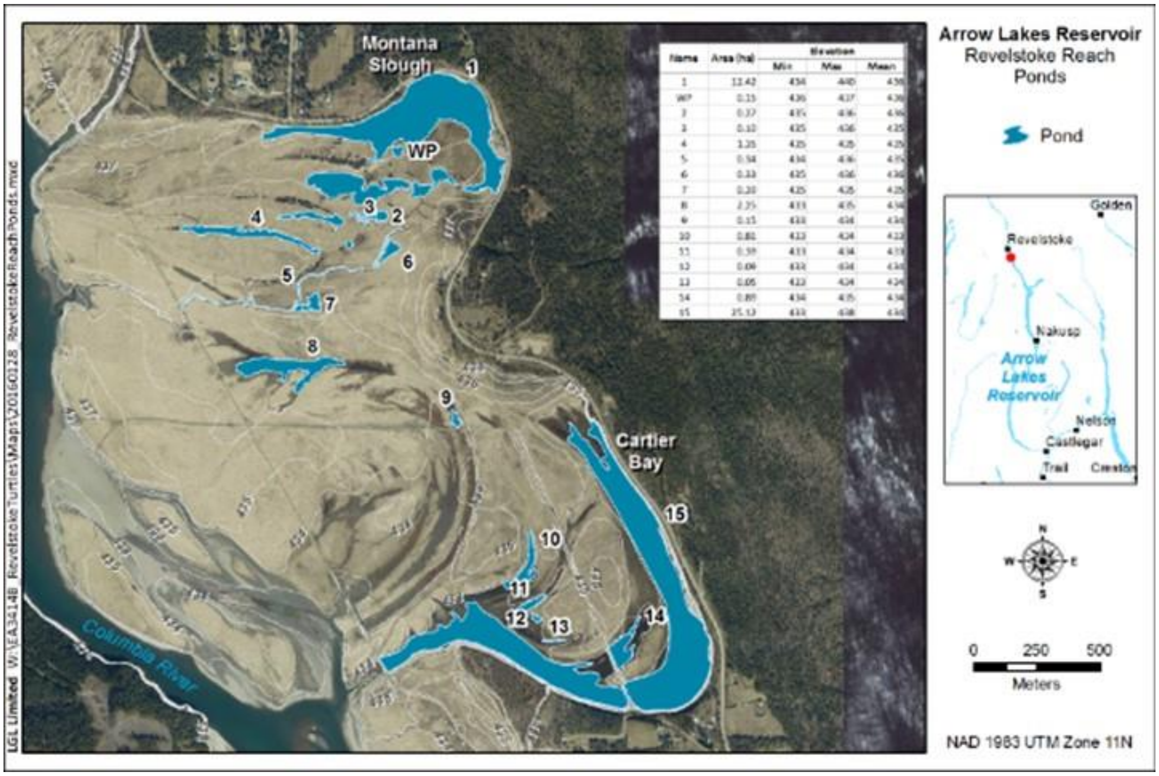


Figure 5-6: Delineation of 15 ponds in the drawdown zone at Montana Slough and Cartier Bay. The ponds polygons are based on 2015 imagery. Area and elevation data are provided in the inset table. Image modified from Hawkes and Tuttle (2013). WP = Winter Pond

The DO and temperature profiles of a large pond in the drawdown zone (Montana Slough) and in the upland (Turtle Pond) were compared (Figure 5-7).In general, DO and temperature varied similarly between both ponds and due to lower than average reservoir elevations, Montana Slough was not inundated in 2015. As such the influence of inundation on DO or temperature could not be assessed.

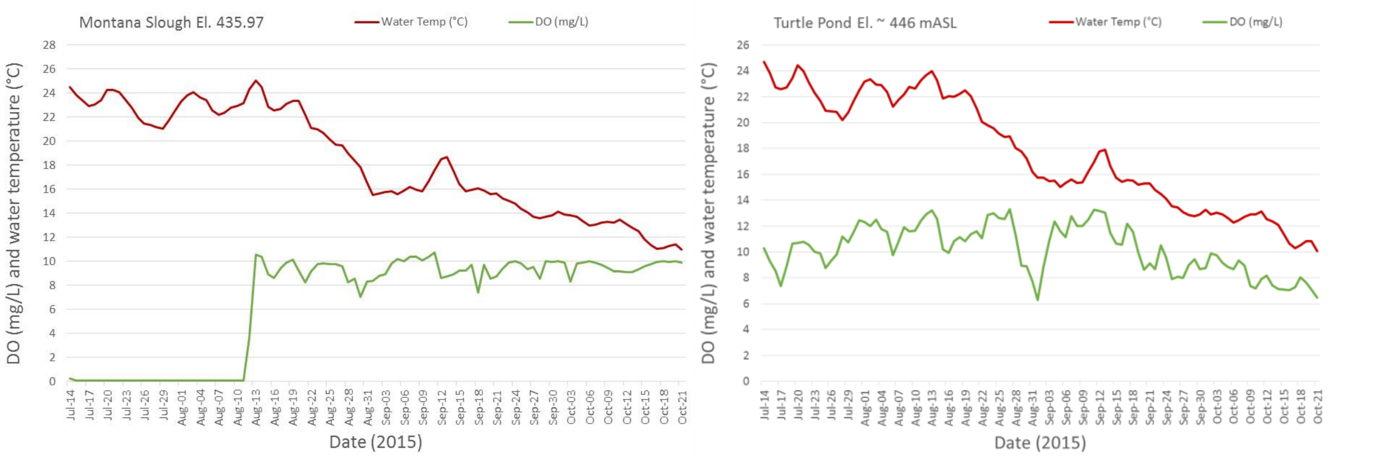


Figure 5-7: Temperature and DO profiles obtained from a DO and temperature logged deployed in Montana Slough (left) and in Turtle Pond (right). The reservoir elevation is shown in the left panel only (Turtle Pond is not in the drawdown zone)

Point data [Conductivity (µS/cm), Dissolved Oxygen (mg/L), pH, and Temperature (°C)] are summarized for most hatchlings observations (Table 5-5). Our data suggest that most values are characteristic of sites with relatively low dissolved oxygen, neutral pH, low conductivity, and warm spring and summer temperatures. Young 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).

Table 5-5: Summary of water physicochemistry data collected for turtle observations at Airport Marsh, Arrow Lakes Reservoir in 2015. Average and standard deviation values are provided, N = number of measurements

Survey Site	N	Conductivity		Dissolved Oxygen		pH		Temperature	
		$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Airport Marsh	66	129.9	24.0	0.7	1.4	7.1	0.7	21.9	3.6

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 the western painted turtle population(s) of Revelstoke Reach are stable.

5.4.1 Predator Observations

A total of 38 dead turtles were observed in 2015: 26 hatchlings and 12 juveniles. Cause of death for the turtles was likely the result of road crossings and traffic hits (n=5), nest mortality (n=15), predation (n=9), or unknown causes (n=9). In cases where a predator cause was assumed, turtles had bite marks on the shell and typically were missing head, limbs or both.

During predator surveys, several potential predators were observed foraging in or over areas where turtles were present including raptors (e.g., Bald Eagle, Osprey), Common Raven, Belted Kingfisher, Turkey Vulture, Great Blue Heron, and River Otter. The most common predators noted were Great Blue Heron and River Otter; however, the only actual sighting of a predation event on a turtle was of a River Otter eating a small turtle. Other signs of predation include injuries observed in live captured turtles such as damaged shells, bitten off limbs, and tail injuries.

5.4.2 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. However, reservoir elevations in 2015 were lower than average (Figure 5-2) thus inundation did not likely affect habitats used by Western painted turtles in the drawdown zone of Arrow Lakes Reservoir.

5.4.3 Movement Patterns

In 2015, 20 females, two males, and 10 hatchlings were captured and fitted (or re-fitted) with radio transmitters in Revelstoke Reach. Nineteen of these were recaptures from previous years of this study and 13 were new individuals that were outfitted with new radio-transmitters (three females and 10 hatchlings). New female turtles ranged in size from 14.3 cm to 22 cm straight carapace length and 400 to 1500 g. Hatchling turtles ranged in size from 2.8 cm to 5.8 cm carapace length and 4.1 to 32 g. Between May and October, individual female turtles were tracked between 27 and 167 days (average = 110 days), and hatchlings between 1 and 47 days (average = 16 days).

Juvenile Movements

Juvenile turtles were tracked from May 17th to August 25th 2015. All captures were made at Airport Marsh and all turtles remained in the vicinity for the remainder of the tracking period. Eight of the 10 turtles had only one transmitter attached with batteries that lasted up to 18 days, and two turtles had their transmitters replaced once or twice (e.g., H4 and H5 respectively).

Tagged hatchling turtles remained clustered around the east end of Airport Marsh (Figure 5-8). Of the 10 juveniles monitored, eight were detected on multiple occasions. These turtles occupied a home range of between 2.5 and 181.5 m^2 (Table 5-6), further emphasizing how little the juveniles moved between May 17 and August 25, 2015. The juveniles monitored are believed to have originated from the nesting area at the north end of the airport (at the firebase), which is between 75 and 100 m to the east.

Figure 5-8: **Distribution of hatchling Western Painted Turtle detections between May 17 and August 25, 2015.**

Table 5-6: **Minimum convex polygon (MCP) calculated for eight juvenile Western Painted Turtles tracked in Airport Marsh between May 17 and August 25, 2015 (n= number of locations from telemetry sessions)**

TURTLE ID	n	AREA (m^2)	PERIMETER (m)
H.1	7	15.00	21.31
H.2	6	2.50	16.58
H.3	3	12.00	26.17
H11	3	6.00	24.90
H16	3	117.50	93.87
H3	3	2.50	12.50
H4	10	62.50	61.23
H5	22	181.50	75.52

Adult Movements

A total of 59 individually marked turtles were located during the 2015 monitoring year. Of these, 19 were detected more than once, making assessment of their movements possible. Successive distances travelled by these adults are shown in Figure 5-9, with individuals moving an average of 172.5 m between detections (min= 0 m, max= 3637.4 m).

Two adult female turtles (F243 and F176) switched locations during the survey period. F243, a large gravid female, was captured and fitted with a radio-transmitter at Williamson Lake on May 16th. Subsequent surveys located F243 at Airport Marsh just ten days later. This movement amounts to 786.9 m horizontal distance travelled and a descent of 6.4 m elevation. F176 moved from Montana Slough on July 21st to Airport Marsh (by September 23rd), amounting to over 3.6 km of linear distance travelled in 64 days.

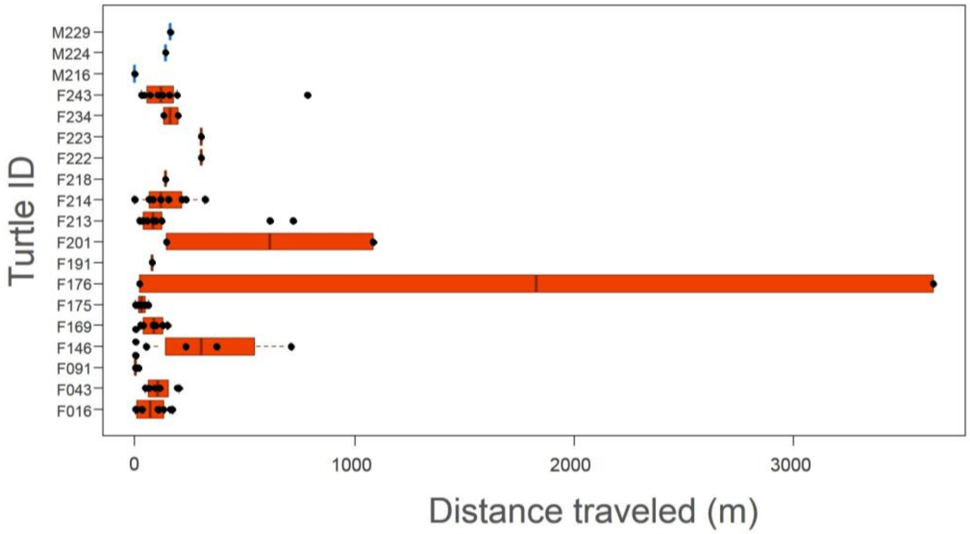


Figure 5-9: Variation in turtle distance (m) travelled between subsequent detections of marked adult turtles. Data is for 2015 telemetry locations and captures. Number of detections for each site was variable: Airport Marsh (n= 79), Montana Slough (n= 24), and Williamson Lake (n= 1); individual data points are overlaid on boxplots for each turtle movement; M= male, F= female

Adult turtle movements varied from stationary to over four kilometers distance per day (turtle F222 at Airport Marsh was captured twice in 1.75 hours with 300 m distance between captures). Movements per day (Figure 5-10) seemed lowest for the month of September relative to other months, but no significant differences were found (H= 7.06, df= 4, p= 0.13). Daily turtle movements were also similar between study sites (Williamson Lake represented by only 1 data point).

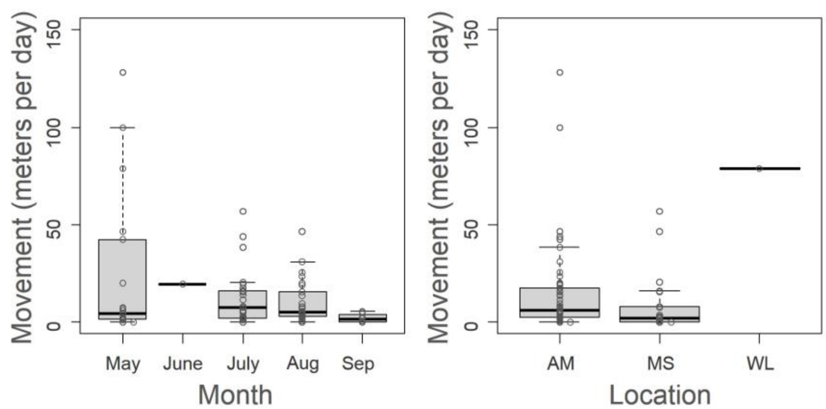


Figure 5-10: Variation in adult turtle movement (meters per day) for the 2015 monitoring year, in each month (left) and by study site (right). Individual data points are overlaid for each turtle movement; one outlier turtle distance of >4000 m per day in May has been cropped from the final figure to improve visualization. AM= Airport Marsh, MS= Montana Slough, and WL= Williamson Lake

5.4.4 Turtle Morphometrics

Consistent with results of previous years, the greatest weights were from adult female turtles (mean = 925.3 g), followed by males (mean = 515.4 g), and hatchlings (mean = 14.2 g). Turtle masses also showed some variation by study site (Figure 5-11). Adult female mass was significantly greater for individuals caught in the upland Williamson Lake study site compared to adult females caught in Airport Marsh in 2015 (Kruskal-Wallis Test: H= 3.24, p= 0.07; n= 3 female turtles at Williamson Lake, n= 22 female turtles at Airport Marsh). Adult male turtles did not differ in mass between study site locations in 2015 (H= 0.63, p> 0.1; n= 18 male turtles at Airport Marsh, n= 5 male turtles at Turtle Pond, and n= 1 male turtle at Williamson Lake). A similar trend in greater adult weight in upland sites was reported previously (Wood et al. 2015).

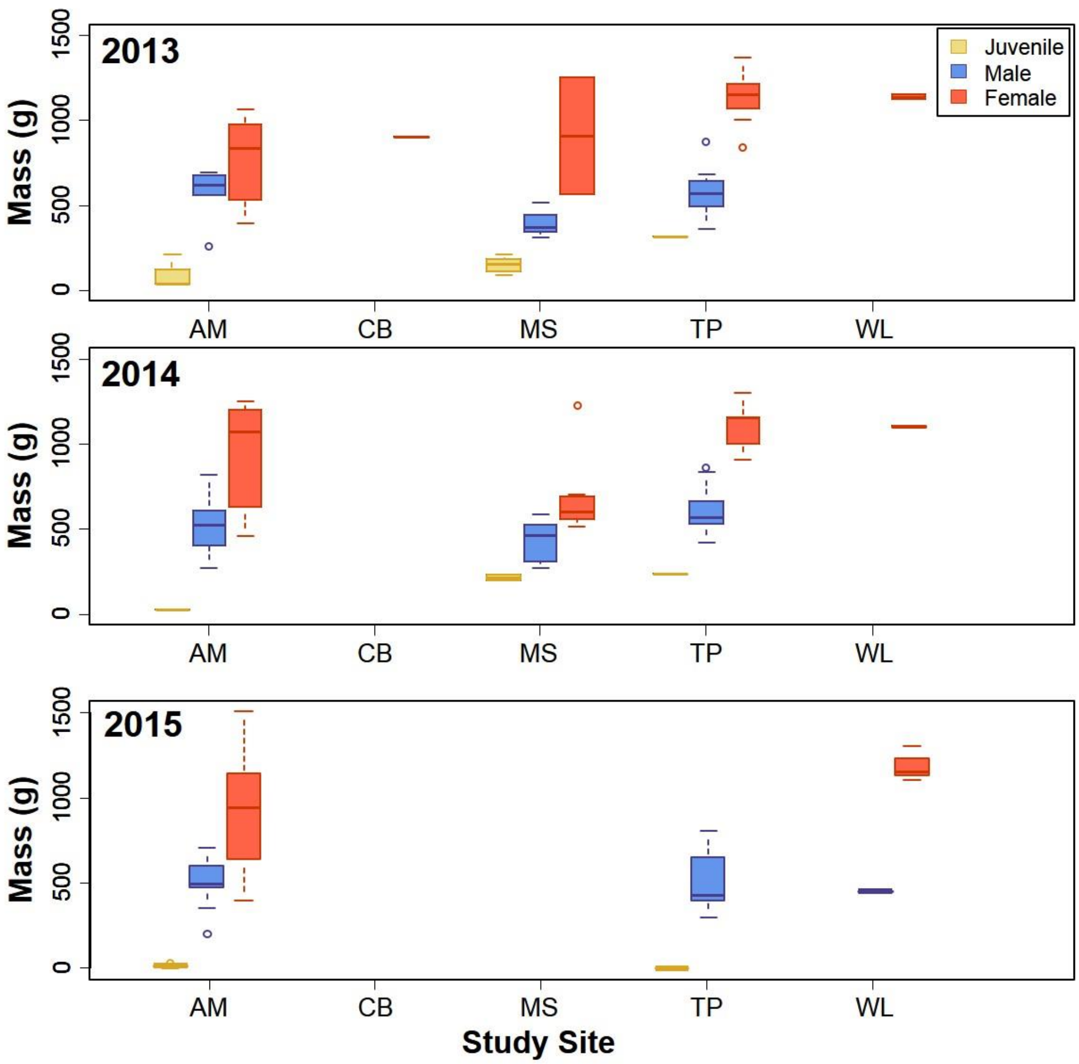


Figure 5-11: Variation in turtle mass (g) by study site for juvenile, adult female, and adult male Western Painted Turtles. Data shown is from captures during 2013-2015. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

For years 2011 to 2015, female turtle mass differed by location (Kruskal-Wallis Test: H= 28.96, p< 0.0001; Table 5-7), with females at upland sites (Turtle Pond and Williamson Lake) weighing significantly more than females of drawdown zone sites (Mean female weight upland= 1122 g, DDZ= 833 g). The same was true of adult female straight carapace length (H= 28.31, p< 0.0001; mean upland= 20 cm, DDZ= 18 cm). Adult male mass and size also differed by site (Table 5-7). However, differences were not grouped by reservoir location. Instead, male turtles of Airport Marsh and Turtle Pond were significantly heavier than those of Montana Slough (not differing from Williamson Lake).

Table 5-7. Mean values for turtle mass and straight-line carapace length (SCL) at each study site at Revelstoke Reach for five years of monitoring (2011-2015). H= Kruskal-Wallis statistic, superscript letters "a" and "b" indicate significant differences between locations resulting from Bonferroni-corrected post-hoc comparison tests on mean ranks (in brackets). AM= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake; "-" = no data available

		Mean and (Mean Rank) values by Location:						
		AM	**CB**	**MS**	**TP**	**WL**	**H**	**p-value**
Adult Female	**Mass (g)**	879.1 (54.0)[b]	900.0 (52.5)[b]	750.8 (40.4)[b]	1122.2 (87.3)[a]	1122.2 (86.6)[a]	28.96	< 0.0001
	SCL (cm)	18.5 (56.3)[b]	18.1 (38.0)[b]	17.0 (37.5)[b]	19.9 (83.1)[a]	20.1 (88.7)[a]	28.31	< 0.0001
Adult Male	**Mass (g)**	541.6 (59.6)[a]	-	422.4 (33.6)[b]	579.9 (66.1)[a]	471.5 (39.8)[ab]	16.58	0.0009
	SCL (cm)	16.4 (58.4)[a]	-	14.8 (31.9)[b]	16.9 (70.1)[a]	15.9 (36.8)[ab]	21.26	< 0.0001

Females of upland reference sites (Turtle Pond and Williamson Lake) are generally among the heaviest and largest of all turtles measured (Figure 5-12). Adult female turtles from Airport Marsh and Montana Slough showed a greater range of variation in size and mass. Adult male turtles from various sites largely overlapped in their mass:size relationships, with no clear differences between upland and drawdown zone locations. Juvenile and hatchling turtle data is too limited at this stage in the study to interpret patterns.

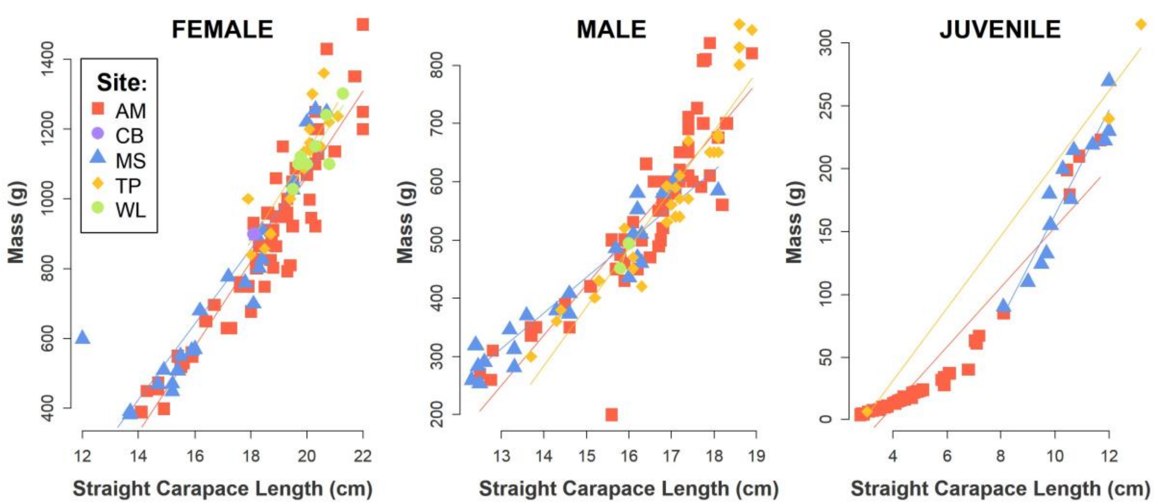


Figure 5-12: Relationship between turtle mass (g) and turtle size (cm) by study site for adult male (left) and adult female (right) Western Painted Turtles. Data shown is from captures during 2011-2015. AP= Airport Marsh, CB= Cartier Bay, MS= Montana Slough, TP= Turtle Pond, WL= Williamson Lake

During 2015 surveys, hatchling mass ranged from 4.1 g to 32.0 g (mean = 14.2 g). Six individual hatchlings were detected in multiple surveys throughout summer of 2015 allowing their mass to be tracked between detections (Figure 5-13; all from Airport Marsh). All but one of these turtles increased in mass throughout the summer, with an average weight gain of 367 mg per day. The mass of turtle "H.0" decreased by 71 mg over a 14 day period. This hatchling was not subsequently captured, thus it is not clear whether turtle growth remained on a negative trajectory.

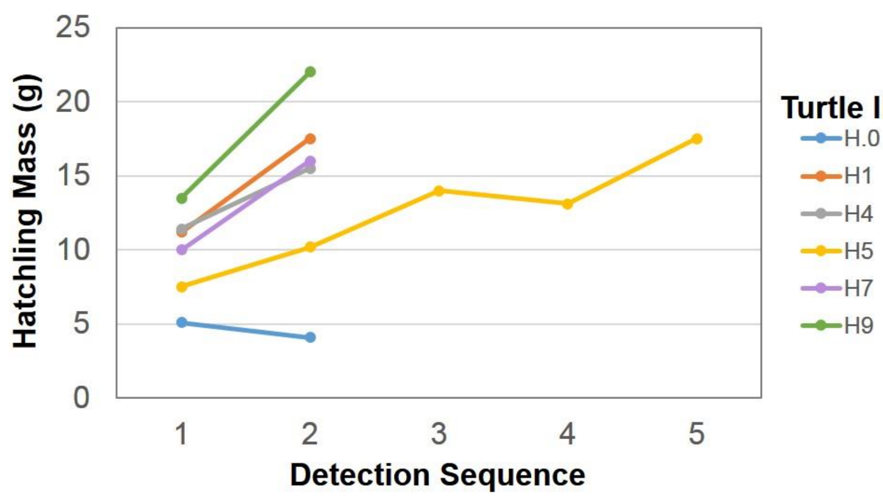


Figure 5-13: Trend in individual hatchling turtle growth between subsequent captures (in chronological order) in 2015. All turtles were located at Airport Marsh, with one turtle caught and measured during 5 surveys. Five turtles were caught and measured during two surveys. Fourteen other turtles were individually marked and measured, but were not recaptured in subsequent surveys

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

1.1.1 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.

5.5.1 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 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 focused on two key initiatives (2a and 2c, Table 6-1; see Table 2-1 for the ten-year initiatives). The majority of the work in 2015 examined turtle nesting habitats and offspring survivorship in Revelstoke Reach, and previous key initiatives such as adult habitat use and long term demographics of this population (1,2b).

Table 6-1: Relationship between management questions, study initiatives, 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
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**

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 #2a,b 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?

Western Painted Turtles use the drawdown zone in Revelstoke Reach 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 above the drawdown zone at Red Devil Hill, the Airport Firebase, Turtle Pond, and Williamson Lake. In future years (i.e., 2016 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, adult turtles disperse into wetland areas with an abundance of vegetation and basking habitat. During the winter, adults are located in Montana Slough and along the shoreline areas of Airport Marsh, as well as upland habitats at Williamson Lake and Turtle Pond (Wood and Hawkes 2015). We are currently assessing hatchling habitats and their associations will be detailed in the future. Each habitat characteristic specified in MQ2 are outlined below for adult turtles.

Pond size. The relationship between turtle habitat use and pond size cannot be assessed under the current CLBMON-11B3 monitoring program. Determining turtle associations with pond size is complicated by the daily and annual changes in reservoir elevations, which makes pond areas temporally dynamic. Although we provide the areas of 16 ponds occurring in the drawdown zone at Montana Slough and Cartier Bay (section 5.3.5), these ponds are inundated as reservoir elevations rise each year. This program is not designed to measure the temporal changes in pond areas, nor do we expect pond area to be a biologically significant driver of western painted turtle habitat-use.

Water depth. Turtles are known to use a wide range of water depths, however, shallow habitat may be preferred during certain life-history periods. During the summer foraging period shallow waters are generally warmer and more productive, providing enhanced foraging opportunities, which may be especially important for young turtles (which exhibit higher growth rates than reproductively mature turtles).

Currently we have assessed associations with water depth for adult turtles in different seasons and have shown that turtles generally occur on (or within) the bottom substrate during the winter hibernation period (Wood and Hawkes 2015). During this period turtles used water depths from 0 to 128 cm (mean= 36.0 cm). 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). In these warmer months, adults were found in water up to 300 cm deep (mean= 121.4 cm).

Water quality. Our current results suggest little evidence of an effect of water physicochemical conditions on turtle habitat use in the drawdown zone (Wood and Hawkes 2014, 2015).

Western painted turtles tolerate very low temperatures and freezing water conditions. They can survive up to 4 months under conditions of exceptionally low oxygen at near freezing temperatures (Ultsch and Jackson 1982). We reported turtles using completely frozen areas of the drawdown zone (0 cm water depth with 30 to 43 cm of ice above) and in very little water (≤ 5 cm water depth) during the winters of 2013 and 2014. Adults also used ponds with a wide range in dissolved oxygen from anoxic (<2 mg/L) to 14 mg/L during the winters of 2013 and 2014.

The pH of turtle locations in the drawdown zone was generally neutral during the winter and increased slightly in the summer (mean= 8.4).

Vegetation. Turtles were often found in habitats with basking potential (e.g., logs, lily pads, floating mats of vegetation) and abundant vegetation cover (e.g., sedges, reed-canary grass, common cattails, submerged aquatic vegetation, etc.). Associations with vegetation has not been examined in detail.

Elevation band. Adult Western painted turtles use elevations from 435.3 to 440.5 m ASL in the drawdown zone of Arrow Lakes Reservoir, as well as elevations much higher outside of the drawdown zone (e.g., at Turtle Pond and Williamson Lake).

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

Various measures of relative abundance have been calculated to allow for comparisons between sites at Revelstoke Reach, among seasons, and with data from future years of monitoring. All sites monitored at Revelstoke Reach support turtles, but Airport Marsh, Montana Slough, and Turtle Pond consistently generate the highest number of standardized trap catches.

Productivity (nest and egg counts) has not yet been assessed in great detail as of yet; however this component of the long-term turtle monitoring study will be addressed as part of Initiative #2c in 2016 and 2017. The main nest sites for turtles in Revelstoke Reach are at Red Devil Hill and Airport Firebase (immediately east of Airport Marsh), both of which had nests and hatchlings emerge in 2015. Data collection indicates that all life stages of turtles use habitats in the drawdown zone. However, additional data collection on reproductive success and hatchling survivorship is required to assess productivity at various sites in the drawdown zone of Revelstoke Reach. This would require an assessment of nest failure and success (intensive monitoring of nest locations in the spring) and more information on hatchling survival, which would require a more intensive mark-recapture program.

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 were 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 and cause of death was unknown for the remaining. 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, and nine in 2015 at Airport Marsh/Red Devil Hill area. The cause of death for these turtles was presumed to be predation. The number of nest and hatchling mortality is consistent with our current understanding of turtle demography (Congdon et al. 1993, 1994) and is not presently expected to pose a risk to the turtle population in Revelstoke Reach.

In future years, our assessment of juvenile and female survivorship (via telemetry and female nesting success) will help to elucidate whether reservoir operations negatively impact younger 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). 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 have not found support for the notion that turtles move slower after inundation due to cold water. Weight of adult female turtles and length of both male and female turtles is less in the drawdown zone that upland reference sites, which could be related to slower growth rate or delayed maturity in response to food resources, but also to differences in age distributions. Our sample size of individual turtles that have been collected in multiple years for morphometric data is too limited to assess growth rates at this time.

Forthcoming data on hatchling survivorship will help determine if changes can be made to reservoir operations to minimize the impact on this life stage of western painted turtle.

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 from predators during inundation, increased availability of basking habitat during summer months, and add to habitat heterogeneity as this feature is currently lacking in the reservoir. Loafing logs would also be beneficial and would provide important basking habitat for turtles.

Enhancement of known nesting locations (e.g., reducing ingress of weedy vegetation at the Red Devil Hill nesting site) and other important upland sites would also 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 cannot be addressed 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 2016 should continue using similar methods applied during previous years. The radiotelemetry component used for studying movements (and survival) of hatchling turtles in the drawdown zone during 2015 are recommended to continue in 2016 (relevant to answering MQ 2, 3, 4, 5, 6).

Work in 2016 should focus on the distribution and habitat use of juvenile turtles and an update on nesting habitat suitability, including counts of nests. Trapping sessions in the spring (to remove expired transmitters) and the fall should focus on increasing the number of females outfitted with transmitters.

Additional recommendations include:

1. 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.
2. 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).
3. Graduate research should continue on the turtle population in Revelstoke Reach. The current focus of juvenile turtle survival should be continued. Discussions with Dr. Karl Larsen (Thompson Rivers University) are ongoing and a graduate student should continue to collect data on juvenile survivorship.
4. 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 two per location. The costs for these data loggers could be shared between multiple projects (e.g., CLBMON-37, CLBMON-11B3, CLBWORKS-30).
5. 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 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.

Bjorndal, K.A, A.B. Bolten, and M.Y Chaloupka. 2000. Green turtle somatic growth model: evidence for density dependence. Ecological Applications, 10: 269–282.

Brooks, R.J., Brown, G.P., Galbraith, D.A., 1991. Effects of a sudden increase in natural mortality of adults on a population of the common snapping turtle (*Chelydra serpentina*). Canadian Journal of Zoology 69, 1314–1320.

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

Congdon, J.D., Dunham, A.E., Van Loben Sels, R.C., 1993. Delayed sexual maturity and demographics of Blanding's turtles (*Emydoidea blandingii*): implications for conservation and management of long-lived organisms. Conservation Biology 7, 826–833.

Congdon, J.D., Dunham, A.E., Van Loben Sels, R.C., 1994. Demographics of common snapping turtles (*Chelydra serpentina*): implications for conservation and management of long-lived species. Am. Zool. 34, 397–408.

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>

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.

Fox, J., and S. Weisberg. 2011. An R Companion to Applied Regression, Second Edition. Thousand Oaks California, USA: Sage. <http://socserv.socsci.mcmaster.ca/jfox/Books/Companion>

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

Gibbs, J.P., Shriver, W.G., 2002. Estimating the effects of road mortality on turtle populations. Conservation Biology 16, 1647–1652.

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.

Hines, J.E., M.O. Wiebe, S.J. Barry, V.V. Baranyuk, J.P. Taylor, R. McKelvwey, S.R. Johnson, and R.H. Kerbes. 1999. Survival rates of Lesser Snow Geese in the pacific and western central flyways, 1953-1989.Pages 89 – 110. In: R.H. Kerbes, K.M. Meeres, and J.H. Hines (eds). Distribution, survival, and numbers of Lesser Snow Geese of the western Canadian Arctic and Wrangel Island, Russia. Occasional Paper Number 98, Canadian Wildlife Service, Environment Canada. 117 pp.

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

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

Mackenzie, W.H., and J.R. Moran. 2004. Wetlands of British Columbia: a guide to identification. Resources Branch, BC Ministry of Forests, Victoria, B.C. Land Management Handbook No. 52.

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.

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.

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 APPENDICES

Appendix 8-1: Site occupancy for each identified (marked) turtle recorded during 2013-2015 monitoring years in Revelstoke Reach.

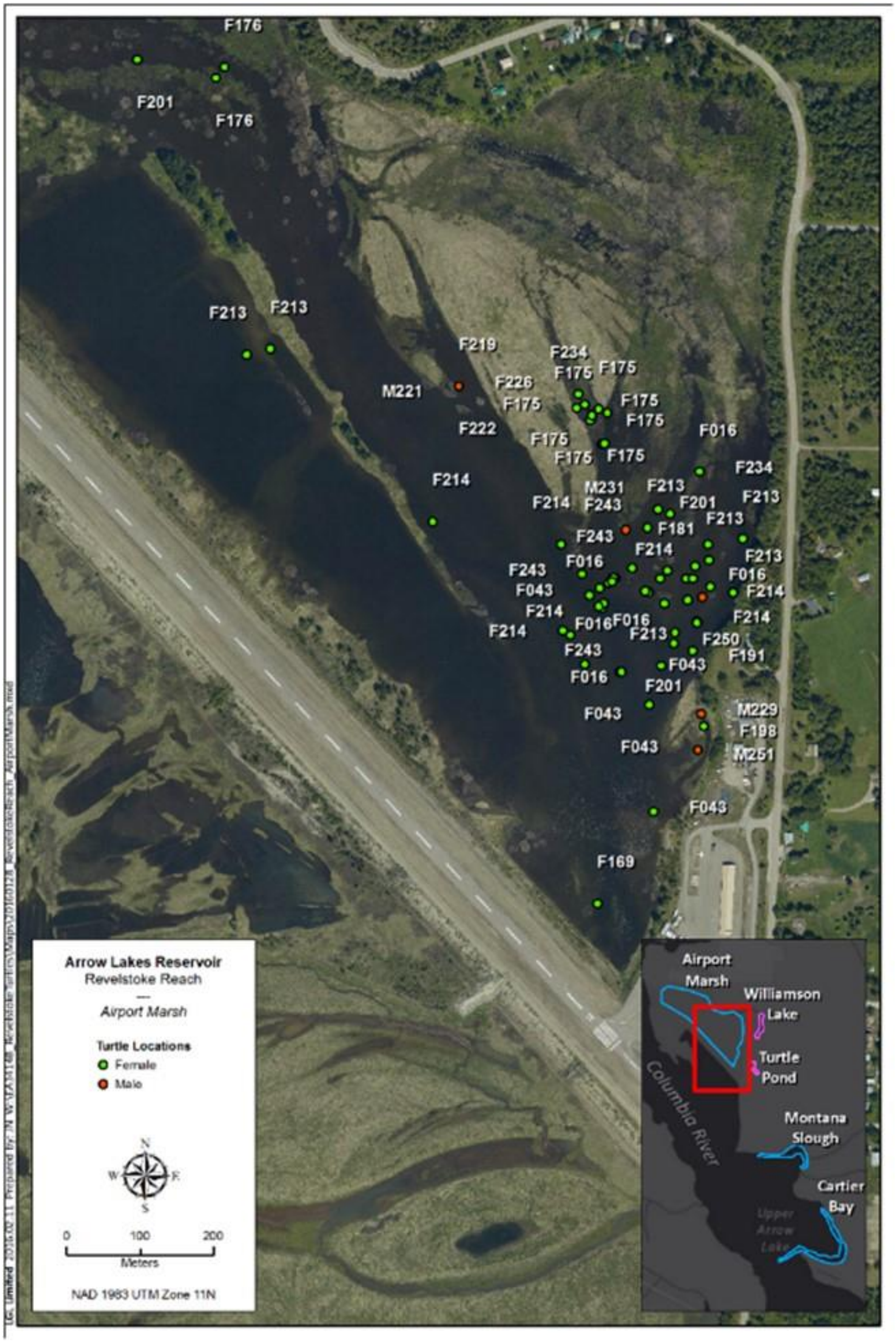
Table 8-1: Site occupancy of individually identified painted turtles at each of the five main study sites, 2013-2015. Blue = female present; green = hatchling present; orange = male present. AP = Airport Marsh, CB = Cartier Bay, MS = Montana Slough, TP = Turtle Pond, WL = Williamson Lake

Turtle ID	AM	CB	MS	TP	WL	No. Sites
F016	■					1
F043	■					1
F061		■	■			2
F091	■		■	■		3
F106	■					1
F116	■					1
F117		■	■			2
F146			■			1
F148					■	1
F150				■		1
F151				■		1
F155				■		1
F162				■		1
F163				■		1
F169			■	■		2
F175	■					1
F176	■		■			2
F178			■			1
F181	■				■	2
F182	■			■		2
F183						0
F189	■			■		2
F191	■					1
F192	■					1
F194				■		1
F198				■		1
F201	■					1
F213	■					1
F214	■					1
F243	■				■	2

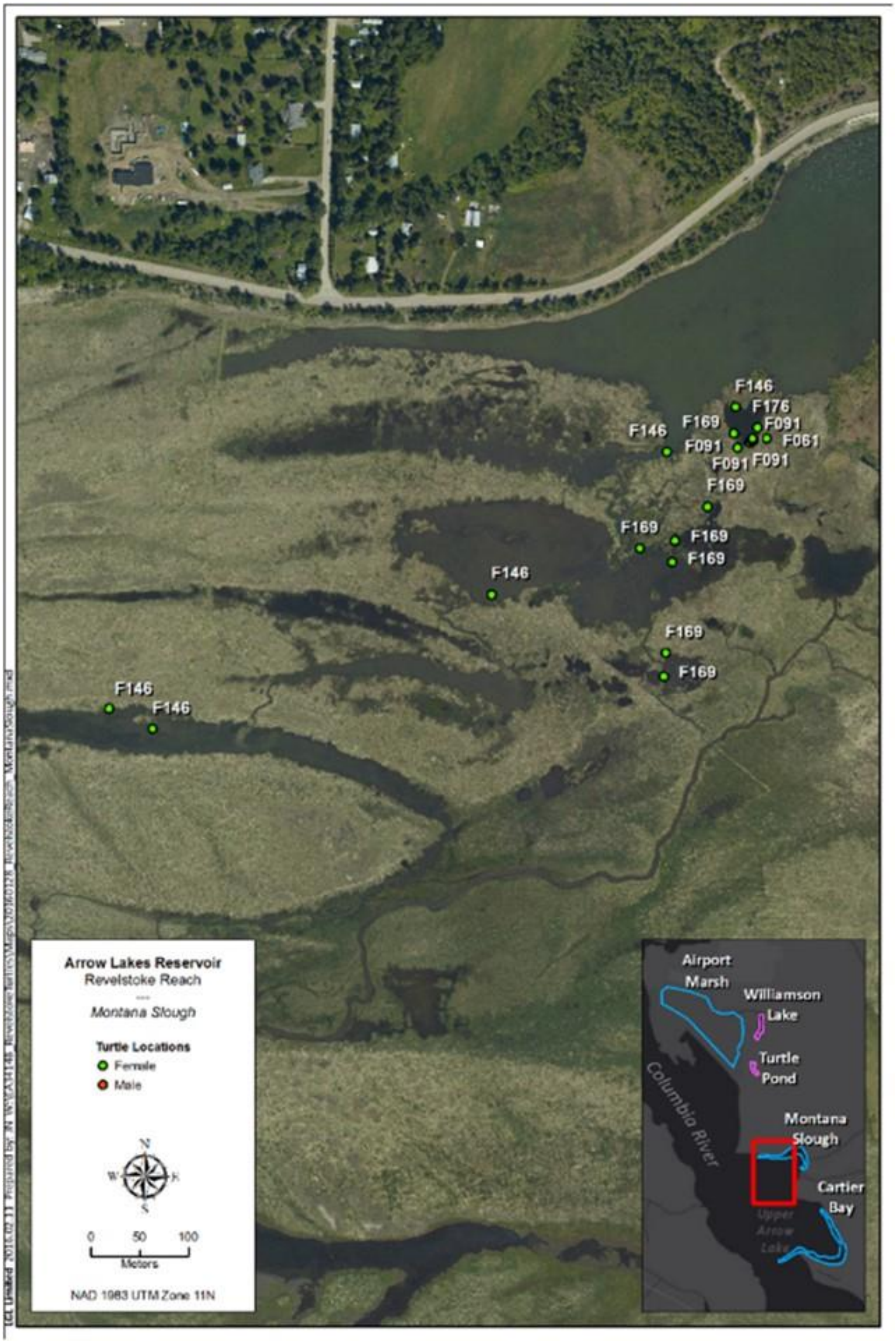
Turtle ID	AM
H.0	■
H.1	■
H.2	■
H.3	■
H11	■
H16	■
H2	■
H3	■
H4	■
H5	■

Turtle ID	AM	CB	MS	TP	WL	No. Sites
M082	■					1
M084	■					1
M090		■	■			2
M099	■					1
M147	■		■			2
M149			■			1
M152			■			1
M153					■	1
M154			■			1
M157	■					1
M158				■		1
M159				■		1
M160				■		1
M161				■		1
M167	■					1
M174			■			1
M177				■		1
M179	■					1
M180	■					1
M184			■			1

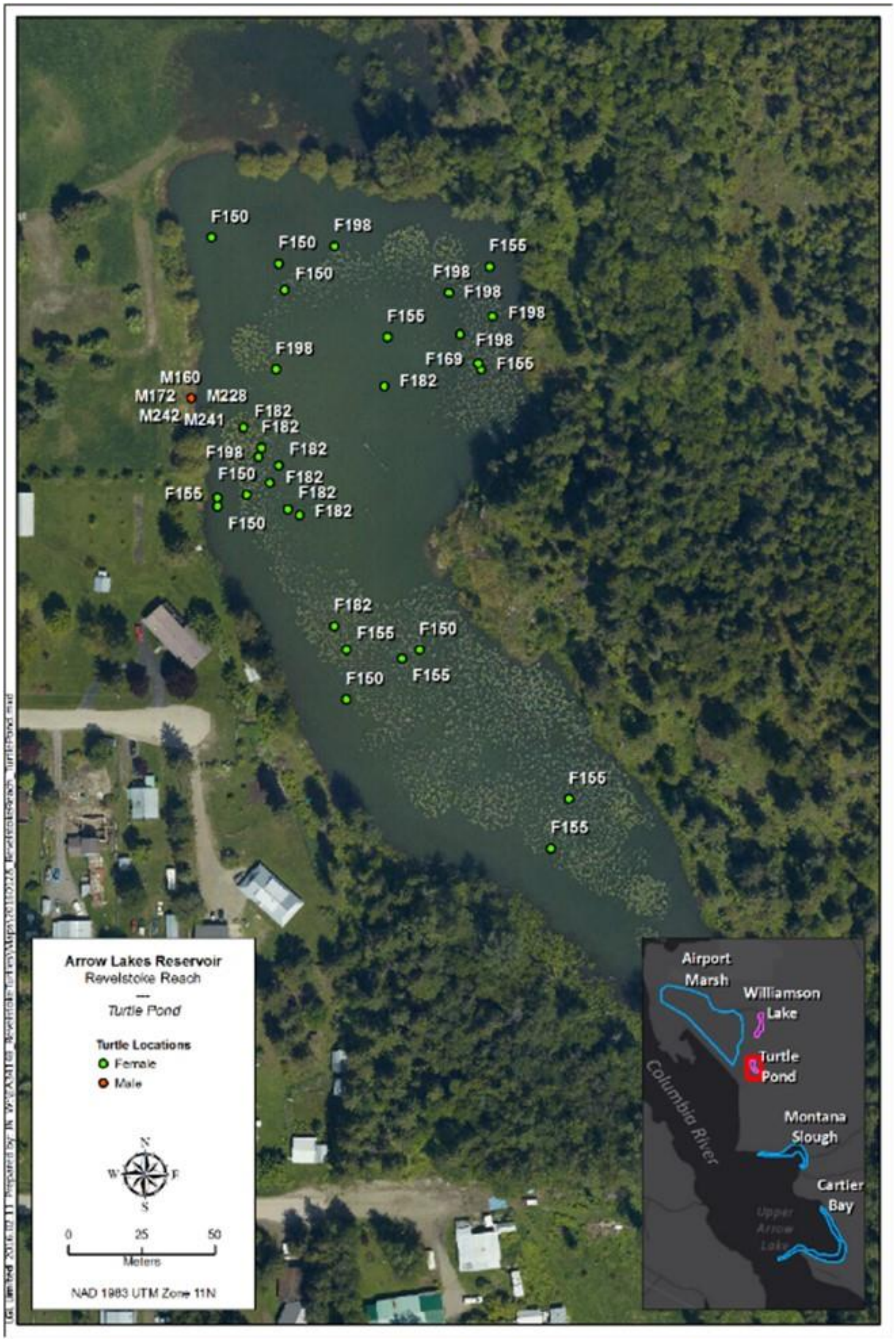
Appendix 8-2: Locations of Western Painted Turtles determined by telemetry surveys at Revelstoke Reach in 2015 by season. The following maps identify the locations of individual turtle observations (marked with turtle IDs) in each study area



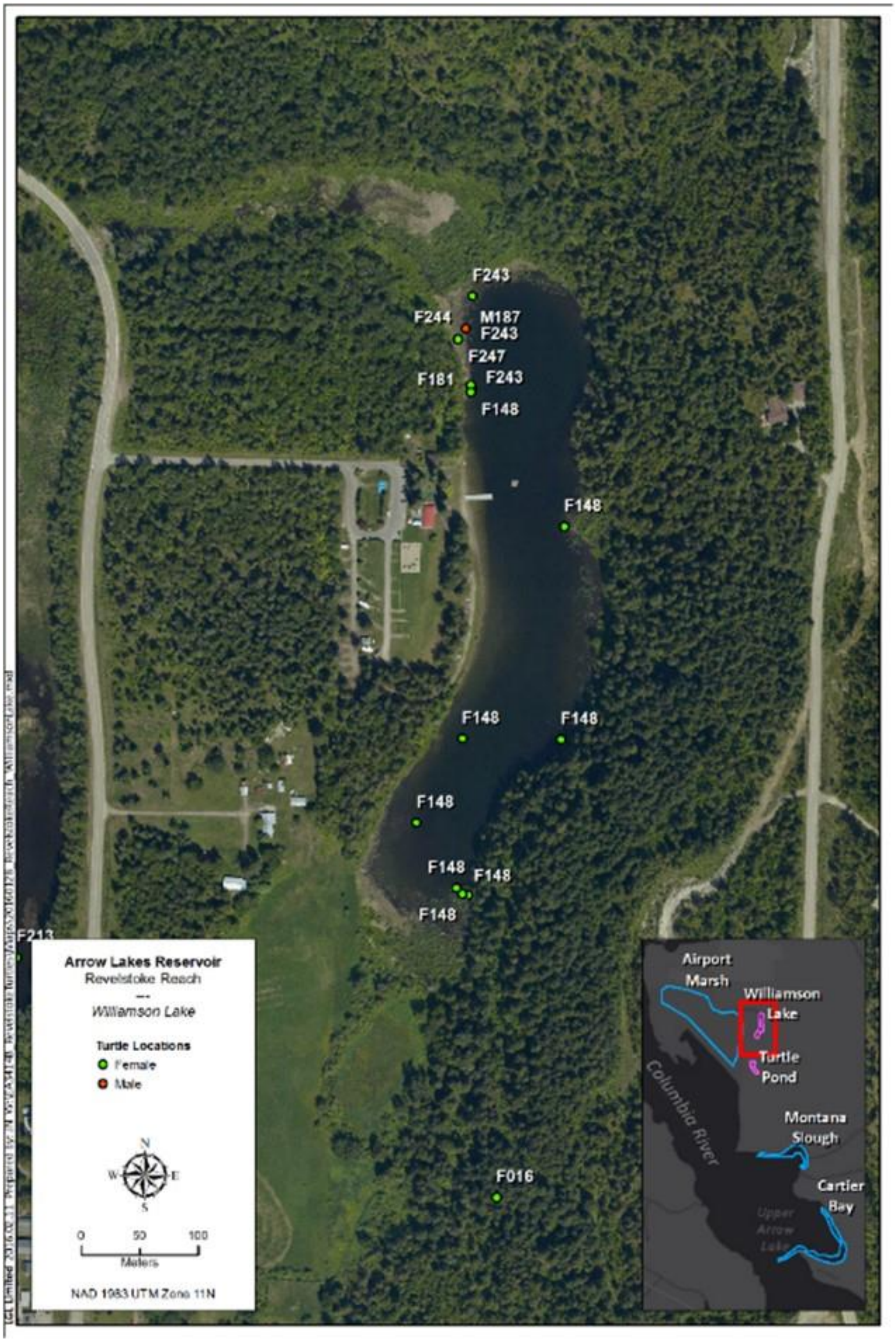
Map 8-1: **The location of Western Painted Turtle at Airport Marsh, detected during telemetry surveys in 2015.** Point labels identify individual turtles (F= female, M= male); triangulation points were excluded due to low accuracy



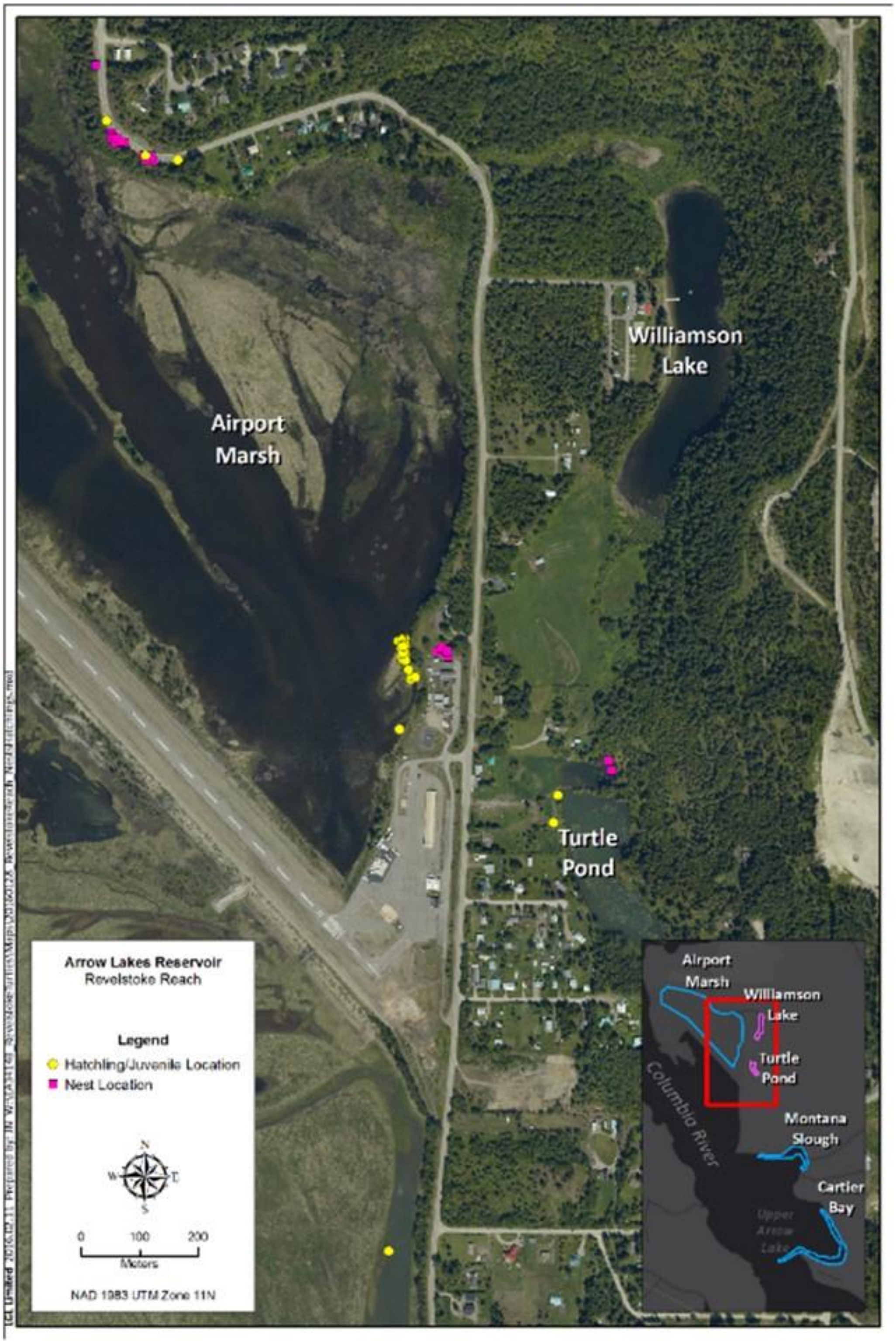
Map 8-2: The location of Western Painted Turtle at Montana Slough, detected during telemetry surveys in 2015. Point labels identify individual turtles (F= female, M= male); triangulation points were excluded due to low accuracy



Map 8-3: The location of Western Painted Turtle at Turtle Pond detected during telemetry surveys in 2015. Point labels identify individual turtles (F= female, M= male); triangulation points were excluded due to low accuracy



Map 8-4: The location of Western Painted Turtle at Williamson Lake detected during telemetry surveys in 2015. Point labels identify individual turtles (F= female, M= male); triangulation points were excluded due to low accuracy



Map 8-5: The location of Western Painted Turtle nests (pink) and hatchlings (yellow) In Revelstoke Reach detected during visual encounter surveys and telemetry surveys in 2015