Columbia River Project Water Use Plan

Arrow Lakes Reservoir Operations Management Plan

Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Implementation Year 7

Reference: CLBMON-36

Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Study Period: 2014

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June 15, 2015

CLBMON-36: Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations

Year 7, 2014

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Cover photo: Juvenile Yellow Warbler (photo by Lena Ware)

EXECUTIVE SUMMARY

Water Use Planning for the Columbia River provided guidance on the operations of hydroelectric reservoirs to improve ecological and recreational values. During this process, the multi-stakeholder Consultative Committee recognized that impacts of reservoir operations on breeding birds were potentially large, yet poorly understood. As a requirement of their new Water Licence, BC Hydro committed to undertake research in order to quantify the impact or reservoir operations on breeding birds. CLBMON-36 is a 10-year monitoring program designed to determine the effects of reservoir operations on the productivity of birds nesting in the drawdown zone of Kinbasket (KIN) and Arrow Lakes Reservoirs (ALR). This report summarizes field work and analysis conducted in **2014**, **Year 7** of the project.

At KIN, research has focussed on two regions. Canoe Reach (CR), near Valemount, BC, has been monitored annually since project inception (2008); the more remote Bush Arm (BA) region, closer to Golden, BC, was monitored for three years in order to increase knowledge of breeding birds that utilize vegetation communities in the drawdown zone that were not well represented at CR. At ALR, only one study area has been monitored - Revelstoke Reach (RR). All three study areas contain unusually high amounts of vegetated habitat, and appear to constitute the most important areas for breeding birds within the vast drawdown zones of these reservoirs.

<u>PROJECT OVERVIEW</u>

Nest mortality: biogeography and site productivity monitoring

In Years 1-5, a focus of the field research was to document how avian communities were distributed in the drawdown zones of KIN and ALR (i.e., to determine which species were nesting where), and to document how nesting productivity was influenced by reservoir operations. New sites, stratified among habitat classes, were selected and monitored annually. Monitoring generally involved finding nests and observing their outcomes. Sites with active nests were visited regularly (~ every 3 days) to track nest progress.

After field work for Year 5 was completed, an initial examination of biogeographical and productivity data was made, and it was shown that most habitat classes had been monitored sufficiently to gain a decent understanding of biogeography in these drawdown zones. The Year 5 Interim Report (Y5IR) showed that the cumulative increase in species richness levelled off at both reservoirs after Year 3, indicating that knowledge of species nesting in the drawdown zones of both reservoirs was near complete. Nonetheless, nests of additional uncommon species have continued to be located, even in Year 7. To date, 29 species have been discovered nesting in KIN, and 60 species in ALR. While we are confident that all regular species have been documented, additional rarities are likely to be discovered occasionally in the future.

At both reservoirs, nesting was concentrated at higher elevations in the drawdown zones, where there is greater plant species diversity, and a more complex vegetation structure. However, nesting was not restricted to these high elevation habitats, and extended to surprisingly low elevations in the drawdown zones where the habitat is devoid of vegetation. By Year 5, nesting was documented as low as 739.3 m ASL in KIN (~ 16 m below the historic maximum reservoir elevation), and as low as 433.2 m ASL in ALR (~ 8 m below the historic maximum reservoir elevation). The number of nests and diversity of species nesting varied considerably, depending on the habitat classes being monitored. In KIN one habitat class (WS) had a species richness of 13 species with an average of

2.35 nests located per ha of monitored habitat, while other habitats were never observed to be used for nesting. In ALR, one habitat class (BF) had a species richness of 15 species, and an average of 11.86 nests located per ha of monitored habitat. There were also habitat classes in ALR where no nesting was observed (see Y5IR Appendix 1 and 2 for additional detail).

The Y5IR revealed that active nests were submerged annually by reservoir operations in the ALR (mean = 11.7% of monitored nests). Nest submergence was less common in KIN (2.8%), and was not observed every year. Nest predation was the leading cause of nest failure in both reservoirs. Overall, nesting success was greater in KIN, compared with ALR due to lower rates of nest predation and submergence.

A major result presented in the Y5IR was the production of the first empirically derived model of nest activity as a function of elevation and time, allowing nest flooding rates to be modelled. Although this model was conceptually simple, its predictions correlated with field observations.

Focal species research

In addition to the biogeography (community-level) research above, focal species monitoring took place to allow more detailed ecological processes to be explored within particular populations. This research explored how reservoir operations impact all aspects of productivity including both nest survivorship and the survivorship of juveniles post-fledging. Focal species monitoring involved targeted nest searching and monitoring, and the monitoring of juvenile survivorship using radio telemetry. To determine juvenile survivorship, we attached small radio transmitters to nestlings and located them daily to determine their vital status allowing us to determine how reservoir inundation of post-fledging habitat affects their prospect of survival. To determine if juvenile survival is impacted in reservoir drawdown zones, our approach was to contrast survival data in dry versus flooded habitats within the drawdown zone, and in drawdown zone habitats versus non-drawdown zone habitats. Radio telemetry work has been a major focus of CLBMON-36 following the 5YIR.

Over time a considerable dataset of nesting data has emerged for the ground-nesting Savannah Sparrows (SAVS) in KIN, but data are exceptionally limited for this species in ALR, where nesting success was found to be very low. SAVS is therefore the primary focal species in KIN. To date 41 juveniles have been radio tagged for juvenile survivorship monitoring, primarily in KIN.

Another focal species, Yellow Warbler (YEWA) were common at ALR, but not at KIN. This species has been monitored in collaboration with students of Dr. D.J. Green at Simon Fraser University (SFU). Due to the collaboration with SFU, this population has been intensively studied, with most breeding adults and fledged young being colour-banded each year. To date, one peer-reviewed paper has demonstrated that YEWA habitat selection in the ALR drawdown zone is adaptive, indicating that the drawdown zone habitats these birds select are unlikely to function as ecological traps. As of Year 7, 39 juvenile YEWA were tagged for juvenile survivorship monitoring in ALR.

SUMMARY OF YEAR 7 PROGRESS

In Year 7, field work continued in CR and RR. We located 367 nests from 38 species. In RR, nests of six previously unrecorded species were located over a range of elevations within the drawdown zone: Northern Harrier, Lincoln's Sparrow, Tree Swallow, Dark-eyed Junco, Downy Woodpecker, and Northern Waterthrush. We observed 18 cases where monitored nests in the ALR were destroyed by nest inundation, including 5 Virginia Rail nests and 4 Yellow-headed Blackbird nests. In the early breeding season, a census of Canada Goose nests in Revelstoke Reach was made north of 12 Mile; during this census, 42 Canada Goose nests were located, primarily in Airport Marsh and Montana Slough. In Year 7, 13 nestling Savannah Sparrow and 17 nestling Yellow Warbler were tagged for juvenile monitoring.

NEW ANALYSES, RESULTS, AND CONCLUSIONS

The Y5IR presented the very first examination of multiple years of data for CLMBON-36, and should be considered as draft results. In Year 6, minor updates and re-examination of some multi-year analyses were performed, but these updates did not greatly change the preliminary conclusions that could be drawn from the Y5IR. In this Year 7 report, we present one new analysis, and review some updated final results that were written up as an independent paper.

In this report, we explored a physical works project idea designed to mitigate the negative impact of reservoir operations on nesting birds. Specifically, we quantified the benefit of protecting Airport Marsh from reservoir operations. This analysis assumed that habitat inundation presented a net cost to birds nesting in the marsh (via nest flooding), and that there was no upside benefit caused by habitat flooding. Our calculation indicated that as much as 25% (typically 18%) of the nest flooding that occurred historically (1969-2014) in Revelstoke Reach could have been avoided by protecting the Airport Marsh from reservoir impoundment (approximately 2.6% of the Revelstoke Reach drawdown zone). This idea was significant because the Airport Marsh has a high density of nests, and is significant site with respect to regional biodiversity. Our results suggest that this physical works project idea is likely to be one of the most effective options available to BC Hydro for mitigating negative impacts of reservoir operations.

In 2014, we also finalized an analysis of the impact of habitat flooding on nest survivorship of shrub-nesting birds, prepared a manuscript, and submitted it for publication in a peer-reviewed journal. In this paper, we showed that despite considerable costs to productivity observed as a result of nest flooding, YEWA and Willow Flycatcher nests in flooded habitat had similar survivorship as those nesting in non-flooded habitats; in other words, the conditions that lead to nest flooding were of no consequence to nesting productivity. This result indicates that habitat flooding must provide a benefit in addition to a cost; we postulated that the benefit that the reservoir provides by flooding habitats is a reduction in nest predation rates.

RECOMMENDATIONS

- Site selection in 2015 should continue to focus on filling knowledge gaps.
- Radio-telemetry tracking for juvenile survivorship should continue.
- Explore nest survivorship and impacts of nest submersion for nesting guilds that have not yet been examined in detail (e.g., ground nesting birds, and birds nesting in wetlands).

Keywords

reservoir operations, nest mortality, habitat distributions, habitat suitability, habitat selection, flooding, nest monitoring, nest survivorship, juvenile survivorship, Willow Flycatcher, *Empidonax traillii*, Yellow Warbler, *Dendroica petechia*, Savannah Sparrow, *Passerculus sandwichensis*, Arrow Lakes Reservoir, Kinbasket Reservoir, BC Hydro, British Columbia

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CBA collaborates with the Okanagan Nation Alliance (ONA) for delivery of CLBMON-36, with ONA biologists and technicians providing field and technical support, and insight into the perspectives and protocols of the Syilx (Okanagan) people. Bruce Weaver of the Okanagan Indian Band and Alexis Friesen of the ONA contributed to field studies. Al Peatt managed the ONA's involvement and provided a technical review of this report.

Many people contributed to field studies including: Devon Anderson, Corey Bird, Emily Braam, James Bradley, Russell Cannings, Stacey Carnochan, Catherine Craig, Jason Fidorra, Alexis Friesen, Ryan Gill, Michal Pavlik, Vicki Prigmore, Amber Richmond, Harry van Oort, and Lena Ware, and Bruce Weaver. Ryan Gill provided GIS mapping and analysis. Ryan Gill and Harry van Oort planned the 2014 field study program. Suzanne Beauchesne provided overall supervision and monitoring of crews. John Cooper acted as Project Manager and provided a technical review of this report.

CBA worked closely with Simon Fraser University throughout this study. Dr. David Green of Simon Fraser University coordinated some of the Yellow Warbler research in 2014, which was conducted by Lena Ware, Amber Richmond and Matthew Hepp. Dr. David Green provided scientific guidance to CBA.

Lesley-Anne Howes and Louise Laurin (Canadian Wildlife Service Bird Banding Office) processed bird banding and capture permits. All procedures followed in this study were approved by the Simon Fraser Animal Care Committee.

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1 INTRODUCTION

The regulation and impoundment of river basins causes considerable impact to riparian and wetland wildlife, initially through habitat destruction, and continually via the ongoing regulation of water flow (Nilsson and Dynesius 1994). The Columbia River is one of the most modified and regulated large rivers in North America (Nilsson et al. 2005), with multiple dam projects existing in both the USA and British Columbia portions of the basin. Water storage reservoirs along the primary course of the Columbia River in BC include the Kinbasket Reservoir (KIN), Lake Revelstoke and the Arrow Lakes Reservoir (ALR), positioned sequentially along the river's course. The footprint impact of these, and several other reservoir projects has been estimated to cause a loss of 26% of the wetlands, 21% of riparian cottonwood, and 31% of shallow water and ponds in the BC Columbia basin (Utzig and Schmidt 2011). In place of these and other natural habitats that were lost, are the substantial drawdown zones of these reservoirs, typically comprised of steep, barren shorelines, with negligible value as habitat for wildlife.

Yet in some parts of the reservoir drawdown zones in BC, important wildlife habitats remain, with particular significance as nesting habitat for a variety of birds. In particular, the upper 4 m of the drawdown zone in Revelstoke Reach (RR) at the north end of ALR is highly vegetated and known to be used by a diversity birds during the breeding season (Boulanger 2005, Jarvis 2006, Quinlan and Green 2012, CBA 2013). The drawdown zones at Canoe Reach (CR) and Bush Arm (BA), both in KIN, also contain several vegetated areas suitable as nesting habitat (CBA 2010, 2011, 2013). Because these remnant breeding habitats are located in reservoir drawdown zones, the operation of ALR and KIN reservoirs may have significant impacts on the productivity of resident bird populations (CBA 2013). It is possible that some nesting habitats within the reservoir act as ecological traps (Schlaepfer et al. 2002, Robertson and Hutto 2006, Anteau et al. 2012, CBA 2013), and/or that some drawdown zone populations act as population sinks (Pulliam 1988)[1].

During the Columbia River Water Use Planning process (BC Hydro 2007), nest mortality caused by reservoir operations was identified as a critical issue. The primary concern was that the operations of ALR and KIN may reduce the productivity of breeding bird communities due to flooding of active nests. This concern arose from earlier studies in RR that documented a high diversity of birds using drawdown habitats during the breeding season (Boulanger et al. 2002, Boulanger 2005), and pilot surveys that documented nest mortality resulting from reservoir operations (Jarvis 2003, 2006). Furthermore, the discovery of a pair of Short-eared Owl (*Asio flammeus*) nesting within the drawdown zone in 2002 (Jarvis 2003) highlighted the potential for reservoir operations to have negative effects on breeding bird species that are protected under the federal *Species at Risk Act* (SARA). Under the direction of the Columbia River Water Use Plan, and as one of their Water Licence Requirements (WLR), BC Hydro initiated CLBMON-36, a 10-year program designed to determine the effects of reservoir operations (water level management) on breeding success of birds nesting in the drawdown zone of KIN and ALR, and to provide feedback and guidance on the efficacy

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[1] Ecological traps occur when populations prefer/select unnatural habitats where reproduction is compromised. Population sinks are sub-populations in a meta-population with intrinsic productivity that is insufficient to sustain the population size; their existence is sustained by immigration (demographic rescue) from other sub-populations.

of methods used to enhance breeding habitats for birds in reservoir drawdown zones (revegetation and wildlife physical works).

1.1 Objectives

The objectives of CLBMON-36 are as follows:

- Identify how drawdown zone habitats are used by breeding birds in Kinbasket Reservoir and Revelstoke Reach.
- Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nest survival.
- Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence juvenile survival.
- Establish a nest flooding risk model for Kinbasket Reservoir and Revelstoke Reach.
- Assess how habitat management in the drawdown zones can be used to increase productivity, or reduce negative impacts of reservoir operations.

1.2 Management questions

To achieve the above objectives, the Terms of Reference (TOR) for CLBMON-26 list Management Questions that the research should address:

A. Which bird species breed in the drawdown zones and how are they distributed among the drawdown zone habitat classes?

B. What are the seasonal patterns of habitat use by birds nesting in the drawdown zones?

C. Do reservoir operations affect nest survival?

D. What are the causes of nest failure in the drawdown zone, and how do they differ among species, among habitat classes, and across elevation (i.e., position in drawdown zone)?

G. Do reservoir operations affect juvenile survival when water levels inundate post-fledging habitat?

H. How can the operations of the Kinbasket and Arrow Reservoirs be optimized to reduce nest submersions and/or improve avian productivity?

K. Can drawdown zone habitats be managed to improve nest survival and/or site productivity? If so, how?

1.3 Management hypotheses

Further to the Management Questions, several hypotheses were drafted to focus data collection and analysis:

H1: Inundation of nesting habitat caused by reservoir operations does not affect nest survivorship.

H1A: Nest survivorship in the drawdown zone is not different from nest survivorship above the drawdown zone.

H1C: Nest survivorship does not differ across elevations in the drawdown zone.

H1D: Rates of nest flooding do not differ across elevations in the drawdown zone.

H2: Inundation of post-fledging habitat does not affect juvenile survival.

H2A: Juvenile survival in the drawdown zone does not differ from juvenile survival above the drawdown zone.

The above **Objectives**, **Management Questions** and **Hypotheses** were refined in the CLBMON-36 TOR revisions in 2014. The TOR re-write addressed several outstanding issues that were highlighted in previous reports (e.g., CBA 2013) and improved clarity. Notably, two Management Questions (E and F) were removed because they were not questions that could be answered by CLBMON-36, and two others (I and J) were amalgamated as one question (K). Similar editing to the objectives and hypotheses also occurred. A table showing how the revised objectives, questions and hypotheses are related is provided in Appendix 6-1.

1.4 Study areas

Field studies in 2014 were conducted at one study area in each of two reservoirs: RR (ALR) and CR (KIN; Figure 1-1).

1.4.1 Canoe Reach, Kinbasket Reservoir

KIN is the upper-most reservoir along the Columbia River. The KIN reservoir impounds a 216-km section of the Columbia and Canoe Rivers, and is operated by BC Hydro for storage (12 MAF), power generation (1805 MW) and flood control downstream (BC Hydro 2007). It extends from Donald, 39 km northwest of Golden, down the Columbia River and north up the Canoe River to 7 km south of Valemount. The reservoir is regulated by outflow at the Mica Dam (input is unregulated), and is licensed to operate between 707.41 m and 754.38 m (BC Hydro 2007). Additional storage may be attained (to an elevation of 754.68 m) with approval from the Comptroller of Water.

KIN drawdown zone habitats have been described and mapped by another WLR project (CLBMON-10; Hawkes et al. 2010) and this work informed the design of the CLMBON-36 monitoring regime (i.e., site selection). The first five years of bird studies under CLBMON-36 documented nesting in 13 of the described habitat types, with annual nest density estimates ranging up to 2.35 nests per hectare (CBA 2013). The habitat with the greatest nest density (WS = Willow-Sedge wetland), had the highest diversity of nesting species (13 species), and had a mapped area of ~35 ha within the KIN drawdown zone.

Situated between the Monashee and Rocky Mountains, CR is the northern arm of KIN (Figure 1-1). CR occurs in the Interior Cedar–Hemlock moist mild (ICHmm) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives moderate precipitation, primarily from Pacific frontal systems that shed snow during the winter. The reservoir is surrounded by steep slopes with managed coniferous forests. The study area is approximately 50 km long and extends from the northern end of the reservoir south as far as Hugh Allen Creek on the east shore, and as far as Windfall Creek on the west shore. The drawdown zone of this area is largely comprised of steep, unvegetated shorelines of sand, gravel and cobble, but includes vegetated habitats near seepage sites, which are characterized by grasses and sedges (Figure 1-2). Extensive remnant peat lands occur at the north end of CR.

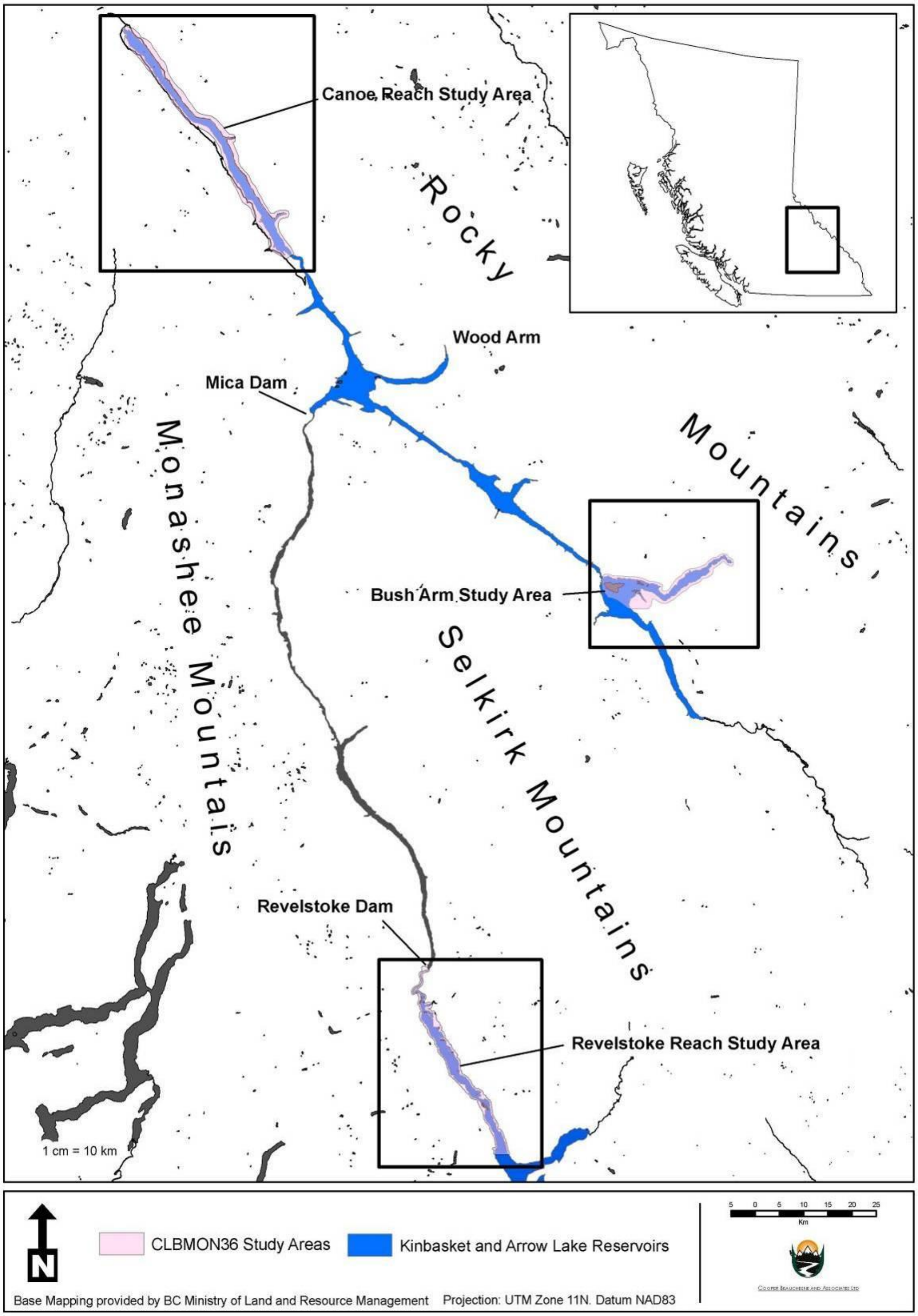


Figure 1-1: **Overview map of the three study areas (lakes are shown in black). Bush Arm was not monitored in 2014.**

Figure 1-2: Relatively well-vegetated drawdown habitat at Hugh Allen Bay, Canoe Reach

1.4.2 Revelstoke Reach, Arrow Lakes Reservoir

The Hugh Keenleyside Dam is located approximately 8 km north of Castlegar. The facility, completed in 1968, is capable of discharging 10,500 m^3/s (BC Hydro 2007), primarily through non-generating ports and spillways. Although the Hugh Keenleyside Dam was created primarily for flood control and water storage for downstream power generation in the U.S. (BC Hydro 2007), a 185-MW generating facility was added in 2002. The completion of the Hugh Keenleyside Dam created the Arrow Lakes Reservoir, which extends approximately 240 km north to Revelstoke and has a licensed storage capacity of 7.1 MAF (BC Hydro 2007). The Arrow Lakes Reservoir is licensed to operate between 418.6 m and 440.1 m ASL. With approval from the Comptroller of Water Rights, the maximum allowable level is 440.75 m (BC Hydro 2007).

Situated between the Monashee and Selkirk Mountain Ranges, and directly below the Revelstoke Dam, RR forms the northernmost section of the Arrow Lakes Reservoir. From the Trans-Canada Highway, RR extends south for approximately 42 km (Figure 1-1). Habitats within the RR drawdown zone vary with topographic elevation. Grasses (e.g., *Phalaris arundinacea*), sedges (*Carex* spp.) and horsetails (*Equisetum* spp.) become well-established at 434 m ASL; willow (*Salix* spp.) and cottonwood (*Poplar balsamifera*) grow as low as 436 m ASL, but become well-established at 438 m, within a matrix of dense graminoid cover (Figure 1-3). Above 439 m, multi-storied mature cottonwood riparian forests have become established in some areas (e.g., Machete Island).

RR occurs in the ICHmm (variants 2 and 3) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives heavy precipitation, primarily from Pacific frontal systems that shed snow during the winter. The drawdown zone is surrounded by steep slopes with managed coniferous forests.

Figure 1-3: Shrub savannah habitat in the drawdown zone of Revelstoke Reach (~438 m ASL)

1.5 Scope of work in 2014

This annual report presents data collected in Year 7 (2014). Similar to Year 6, a concentrated effort was made in Year 7 to conduct productivity and telemetry monitoring of Savannah Sparrow (SAVS) in CR, and Yellow Warbler (YEWA) in RR. In CR we expanded this component to begin monitoring more SAVS above the drawdown zone in order to address H_{2A}. Mist netting of focal species occurred in RR only and focussed on SAVS and YEWA. We continued with community-level nest mortality monitoring with emphasis on the habitat classes less studied to date.

2 METHODS

The methods followed those used in previous years (CBA 2014a).

A large part of the field effort involved ‘Nest Mortality’ monitoring, which is a community-level nest monitoring program aimed at determining biogeographic distributions of communities, the causes of nest failure, and the overall productivity within the reservoir drawdown zones. To accomplish this, field technicians attempted to find and monitor all nests (less than 3 m above ground) in a selection of monitoring sites in the course of the nesting season. Sites were chosen systematically to maximize spatial replication and stratification among habitat types identified in GIS maps.

In addition to the community-level Nest Mortality monitoring, we also focussed on finding and monitoring nests and juvenile survival of several 'focal species'. The purpose of focal species monitoring was to examine factors influencing the survivorship of nests, and the juveniles post-fledging, and field efforts attempted to generate larger sample sizes for particular species for statistical purposes; for focal species monitoring there was reduced emphasis on finding every nest at a site, and site boundaries were of less importance. Focal species monitoring was also conducted over multiple sites, but these were in some cases above the drawdown zone. In 2014, focal species monitoring centred on SAVS in CR, and YEWA in RR. Radio telemetry was implemented for both species to monitor juvenile survival.

2.1 Site selection

Habitat categories for both reservoirs are described in Appendix 6-2. Maps of study sites are provided in Appendix 6-3 and Appendix 6-4. Sites with high concentrations of focal species (SAVS and YEWA) were monitored annually, including 2014.

In CR sites 1, 2, 4, 5, and 16 were monitored at the community level, but were also monitored each year because these plots were occupied by SAVS. In RR, drawdown zone sites 150 (south of Machete Island), and 71663 (9 Mile) were monitored annually for SAVS; however, at these 2 sites, monitoring in 2014 only included repeated census counts to monitor changes to this population, and to provide information on breeding displacement caused by reservoir operations. In RR, colour-banded populations of YEWA were monitored at sites 21 (Drimmie Creek and 12 Mile Island), 28 (Machete Island) and 46 (Illecillewaet riparian shrub) in conjunction with SFU. No other focal species were monitored at dedicated sites.

In RR, two sites were monitored at the community-level annually because they provided particularly interesting time series data, and because the sites are unique. Site 39 (Montana Slough) contained the majority of the floating bog habitat. This habitat is unique, and becomes populated by breeding birds following their displacement by reservoir flooding elsewhere (at lower elevations) in the reservoir drawdown zone. Site 30 (at the Airport Marsh) includes some of the best examples of water sedge, cattail and bullrush habitat, and includes the primary colony of Yellow-headed Blackbirds in ALR. This site is also used by other regionally uncommon species such as Pied-billed Grebe, Virginia Rail, Sora, and Marsh Wren.

Most site selection for community-level monitoring followed a systematic sampling design with new sites chosen and monitored annually. These sites were systematically selected from each of the available habitat types (strata). Site accessibility and habitat patch size/configuration were considered during site selection, but we did not have, or use prior knowledge of the site's suitability for nesting, when delineating the sites. Sites were monitored for at least one full breeding season. In KIN, we stratified the drawdown zone habitats by the vegetation communities identified by CLBMON 10 (Hawkes et al. 2010). In RR, we stratified the drawdown zone by vegetation communities identified by a habitat map developed by CBA (CBA 2012).

2.2 Field procedures

2.2.1 Nest searching

Sites were surveyed by walking slowly and systematically while looking for nests or signs of nesting activity. Birds exhibiting nesting behaviour (e.g., giving warning calls; carrying nest material, fecal sacs or food) were watched for clues of nest locations (Martin and Geupel 1993). In grassland habitats, rope dragging was used to flush birds from nests, especially shortly prior to sites becoming submerged. Nest searching effort was adjusted based on the potential to find additional nests. Sites with many singing birds, but relatively few known nests were prioritized for nest searching. Sites where no birds were detected were searched less frequently. In some cases (e.g., barren sites without any vegetation), nest searching required minimal effort, but multiple visits to the site were made during the season. When active nests were located, sites were visited regularly for nest monitoring. In most cases, site visits included some additional nest searching but sometimes the sites were visited only for the purposes of making nest observations.

2.2.2 Nest monitoring

Standard nest site data were collected at all nests (nest position, nest substrate, habitat, etc.). Active nests were monitored every three or four days until young fledged or the nest failed. Evidence of nest outcome was documented for each nest. A nest was considered to be successful if it fledged one or more young. Nest failure was categorized as being caused by nest predators or reservoir operations, or as failed for unknown reasons. Nest outcomes were designated as "unknown" if it was unclear whether the nest had been successful or had failed. Nests that had well-developed young late in the nestling phase were deemed to be successful if the last observation of the active nest was after the minimum number of days recorded for fledging by that species. Information about fledging periods was obtained from *The Birds of North America* species accounts (Poole 2010).

2.2.3 Focal species capture

Targeted mist netting with call-playback was undertaken in areas with focal species. In 2014, efforts to capture adults focused on SAVS and YEWA. Mist nets were set up near territorial males, and an audio recording of the species' territorial song was played to lure the focal species into the nets. Once captured, all focal species were banded with a metal Canadian Wildlife Service (CWS) leg band inscribed with a unique number. Additionally, unique combinations of coloured plastic leg bands were applied to individuals these two focal species (SAVS and YEWA) to allow field biologists to identify and track individual birds. Nestlings of these species were also colour banded.

2.2.4 Juvenile survivorship and recruitment

We recorded observations of previously colour-banded individuals to determine if any banded juveniles return to the study area.

To study juvenile survivorship, we used radio-telemetry. Lotek PicoPip Aeg 337 transmitters (<0.35 g; YEWA) or Aeg 317 transmitters (<0.45 g; SAVS) telemetry transmitters were attached to one nestling per nest. Tagged birds were monitored daily using a Communications Specialists R-1000 receiver equipped with a three element Yagi antenna until ether the bird died, the transmitter battery expired, or the bird could no longer be found. Radio transmitters were attached with a temporary thin elastic filament designed to drop off shortly following expiry of the transmitter battery.

2.3 Data summary and analysis

Historic reservoir data reported includes all data from KIN (July 1, 1976 to present) and all data from ALR dating from completion of the Revelstoke Dam (January 1, 1985 to present).

All data manipulation, statistical computing and graphing was performed using R (R Core Team 2014). For the analysis presented in section 3.3.1, we implemented the nesting model described previously in detail (CBA 2014). Briefly, the model incorporates habitat-specific information on nest density and nesting community, GIS maps of habitat types, a digital elevation model, species specific information on nest height above ground, and a nesting phenology curve to calculate the number of active nests within each 50 cm elevation band on each day of the breeding season. In the analysis presented here, we removed habitat in the Airport Marsh from the inputs, and calculated the difference between the estimates with and without Airport Marsh included.

2.4 Permits

Bird handling and telemetry protocols were approved by the Simon Fraser University Animal Care Committee (1038B-04). Banding was conducted under a Federal Scientific Permits to Capture and Band Migratory Birds issued to Harry van Oort (#10663 F), and Catherine Craig (#10273 Al).

3 RESULTS

3.1 Year 7 summary

3.1.1 Reservoir operations

The KIN water elevation was ~ 725 m ASL in early May, a little lower than average historic levels, but increased over the summer to 753.8 m ASL on August 31 at which time the water was filled to a relatively high level compare with historic operations (Figure 3-1).

The ALR water elevation was relatively high in early May (~ 429 m ASL) compared to historic levels, and remained relatively high throughout spring as the surface elevations increased (Figure 3-1). The maximum elevation in 2014 was ~ 1 m below full pool (maximum elevation = 439.1 m ASL on July 4), after which, reservoir levels dropped rapidly over the remainder of the summer (Figure 3-1).

3.1.2 Other annual conditions

Relatively low rainfall was recorded at Revelstoke airport in June and July, compared to the previous years of the project (Figure 3-2).

At RR, the Airport Marsh and Machete Ponds had normal to deep water levels in 2014 compared with previous years. The abundance of several species in RR differed from previous years:

- Marsh Wren were absent from the Airport Marsh
- Yellow-headed Blackbird were present in very low numbers, and did not occupy their normal breeding area until relatively late in the nesting season (late June)
- Brewer's Blackbird were less abundant in the Revelstoke townsite in 2014
- There was an unusually large population of Clay-coloured Sparrow, and these birds were observed over a wider area in the drawdown zone
- SAVS appeared to be present in higher numbers
- Cedar Waxwing appeared to be present in lower numbers
- Virginia Rail were more abundant

In CR, the drawdown zone had highly reduced ground water; sites that were normally wet and boggy, were exceptionally dry. We noticed the following:

- Spotted Sandpiper were less common
- Killdeer were less common
- Lincoln's Sparrow were less common
- Clay-coloured Sparrow were more common in the region

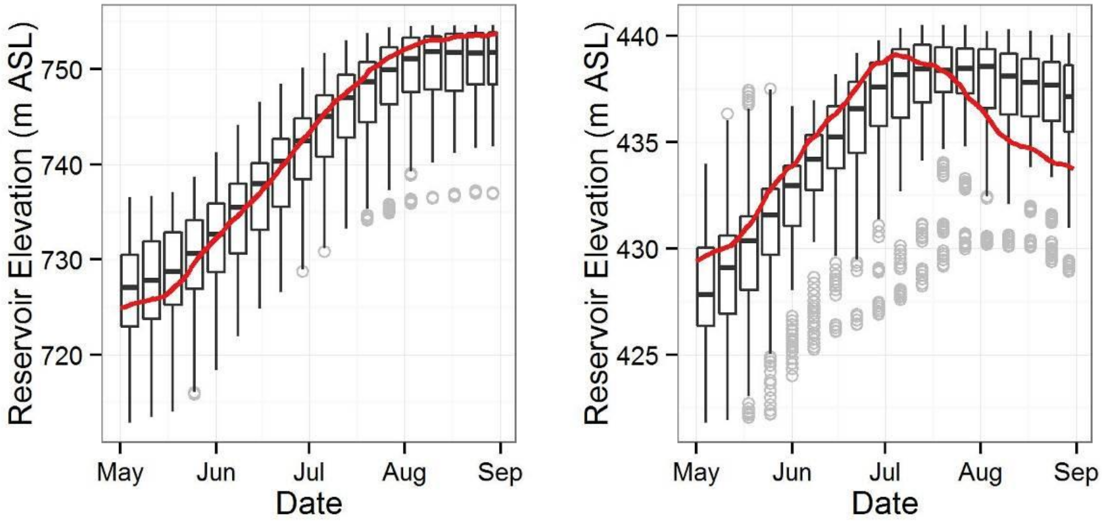


Figure 3-1: **Reservoir elevations at Kinbasket Reservoir (left) and Arrow Lakes Reservoir (right) plotted as weekly boxplots of historical data, with the 2014 elevations plotted in red**

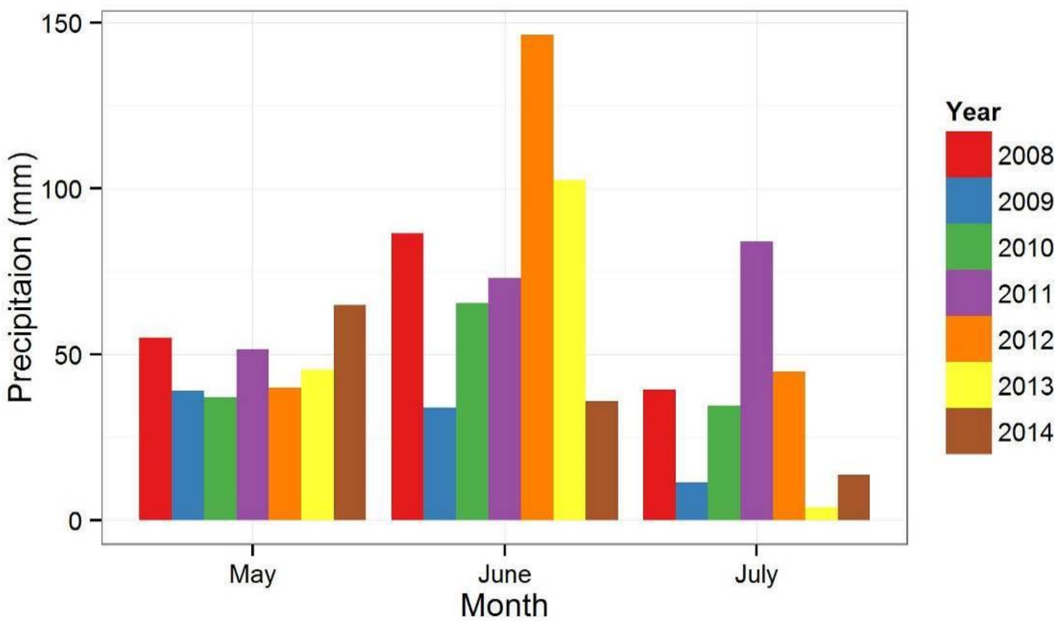


Figure 3-2: **Precipitation measured at the Revelstoke airport weather station over the course of CLBMON-36 monitoring**

3.1.3 Survey effort

In both study areas, crew schedules were coordinated so that surveys were conducted almost daily. Approximately 60% of survey effort was spent searching for nests, and 20% of the time checking nests. The remaining 20% of field effort was primarily spent catching, banding and/or tagging birds with radio transmitters, and monitoring tagged juveniles.

In CR, field sampling was conducted from May 28 to August 1. During this period, we monitored 18 community-level monitoring sites. Additionally, focal species (SAVS) were monitored at four additional areas. In total, there were 457 person-hours of survey effort in CR in 2014.

In RR, field sampling was conducted from May 7 to August 31. During this period, 31 community-level study sites were monitored. Focal species (YEWA) were monitored at three additional areas in RR. To improve knowledge of Canada Goose nesting, specific surveys for nesting geese were conducted during the early nesting season. We attempted to find all nests in the wetlands at the north end of the study area (Montana Slough, Airport Marsh). In total, there were 1755 hours of survey effort in RR in 2014.

3.1.4 Nest records

In 2014, 361 nests from 38 confirmed species[2] were located. Of these, 358 nests from 38 species were monitored until young fledged or the nest failed (Table 3-1).

In CR, 55 nests from six species were found, which accounted for 15% of the 2014 nest records (Table 3-1); 30 (55%) of these nests (5 species) were located in the drawdown zone; the rest were located above the drawdown zone.

In RR, 306 nests from 38 species were found, which accounted for 85% of the total nest records (Table 3-1); 302 (99%) of these nests (38 species) were located in the drawdown zone; the rest were located above the drawdown zone.

3.1.5 Bird Species at risk

No avian species at risk were found breeding in either reservoir.

3.1.6 Nest monitoring results

Of the nests for which outcomes were determined (341 nests, 95% of all monitored nests), 171 (50%) were successful. Of the 170 documented nest failures (also 50% of nest outcomes), 96 (56%) failed due to predation, and 17 nests (10%) failed as a result of reservoir inundation. The cause of failure for the remaining 57 nests (34%) was uncertain.

Within the drawdown zones, nest success rate was highest in CR (60%); RR nests had considerably lower success rate (45%). At RR 6% of all monitored nests failed due to reservoir operations.

[2] The species for one duck nest was not identified.

Table 3-1: Bird species and number of nests found in CR (Kinbasket Reservoir), and in Revelstoke Reach (Arrow Lakes Reservoir)

Common Name	Scientific Name	Above Drawdown Zone		Within Drawdown Zone	
		Canoe Reach	Revelstoke Reach	Canoe Reach	Revelstoke Reach
Common Loon	*Gavia immer*	0	0	0	1
Pied-billed Grebe	*Podilymbus podiceps*	0	0	0	5
Canada Goose	*Branta canadensis*	0	1	0	41
American Wigeon	*Anas americana*	0	0	0	2
Mallard	*Anas platyrhynchos*	0	0	0	6
Unidentified Duck	*Anatinae (gen, sp)*	0	0	0	1
Northern Harrier	*Circus cyaneus*	0	0	0	1
Virginia Rail	*Rallus limicola*	0	0	0	17
Sora	*Porzana carolina*	0	0	0	13
Killdeer	*Charadrius vociferus*	0	0	0	2
Spotted Sandpiper	*Actitis macularius*	1	0	1	1
Wilson's Snipe	*Gallinago delicata*	0	0	1	12
Long-eared Owl	*Asio otus*	0	0	0	1
Downy Woodpecker	*Picoides pubescens*	0	0	0	1
Northern Flicker	*Colaptes auratus*	0	0	0	1
Alder Flycatcher	*Empidonax alnorum*	0	0	0	1
Willow Flycatcher	*Empidonax traillii*	0	0	1	15
Least Flycatcher	*Empidonax minimus*	0	0	0	1
Eastern Kingbird	*Tyrannus tyrannus*	0	0	0	1
Warbling Vireo	*Vireo gilvus*	0	0	0	1
Red-eyed Vireo	*Vireo olivaceus*	0	0	0	2
Tree Swallow	*Tachycineta bicolor*	0	0	0	1
Black-capped Chickadee	*Poecile atricapillus*	0	0	0	1
Veery	*Catharus fuscescens*	0	0	0	8
American Robin	*Turdus migratorius*	0	0	0	2
Gray Catbird	*Dumetella carolinensis*	0	0	0	3
Cedar Waxwing	*Bombycilla cedrorum*	0	0	0	28
Yellow Warbler	*Dendroica petechia*	0	1	0	67
American Redstart	*Setophaga ruticilla*	0	1	0	22
Northern Waterthrush	*Parkesia noveboracensis*	0	0	0	1

Common Name	Scientific Name	Above Drawdown Zone		Within Drawdown Zone	
		Canoe Reach	Revelstoke Reach	Canoe Reach	Revelstoke Reach
MacGillivray's Warbler	*Oporornis tolmiei*	0	0	0	1
Common Yellowthroat	*Geothlypis trichas*	0	1	0	14
Chipping Sparrow	*Spizella passerina*	0	0	0	1
Clay-colored Sparrow	*Spizella pallida*	2	0	0	8
Savannah Sparrow	*Passerculus sandwichensis*	22	0	26	1
Song Sparrow	*Melospiza melodia*	0	0	0	10
Lincoln's Sparrow	*Melospiza lincolnii*	0	0	1	1
Dark-eyed Junco	*Junco hyemalis*	0	0	0	1
Yellow-headed Blackbird	*Xanthocephalus xanthocephalus*	0	0	0	6

3.1.7 Nest submersion in 2014

Reservoir operations flooded 17 monitored nests from seven species (Appendix 6-5). None of these were nests of species at risk; all were located at RR. The majority of these records were from Virginia Rail (5 nests, 29%) and Yellow-headed Blackbird (4 nests, 24%). Nesting by these species was largely confined to Airport Marsh. Most nests (15; 83%) were located in the low shrub layer (e.g., within 0.3 m from the ground), or near the ground in grasses, emergent vegetation, or other ground cover. One ground nest (Long-eared Owl), and one shrub nest (YEWA) were observed to be submerged.

3.1.8 Canada Goose population at Revelstoke Reach

During the blitz census of Canada Goose nests in May, 42 nests were located. Most (81%) were located in the Airport Marsh wetland complex; 8 nests (19%) were located in the Montana Slough area (Figure 3-3). Nesting success was high for Canada Goose; 76% of the nests were successful (32 nests) while predation was determined to cause the failure of 17% of the nests (7 nests). The first observation of a fledged brood occurred on May 12.

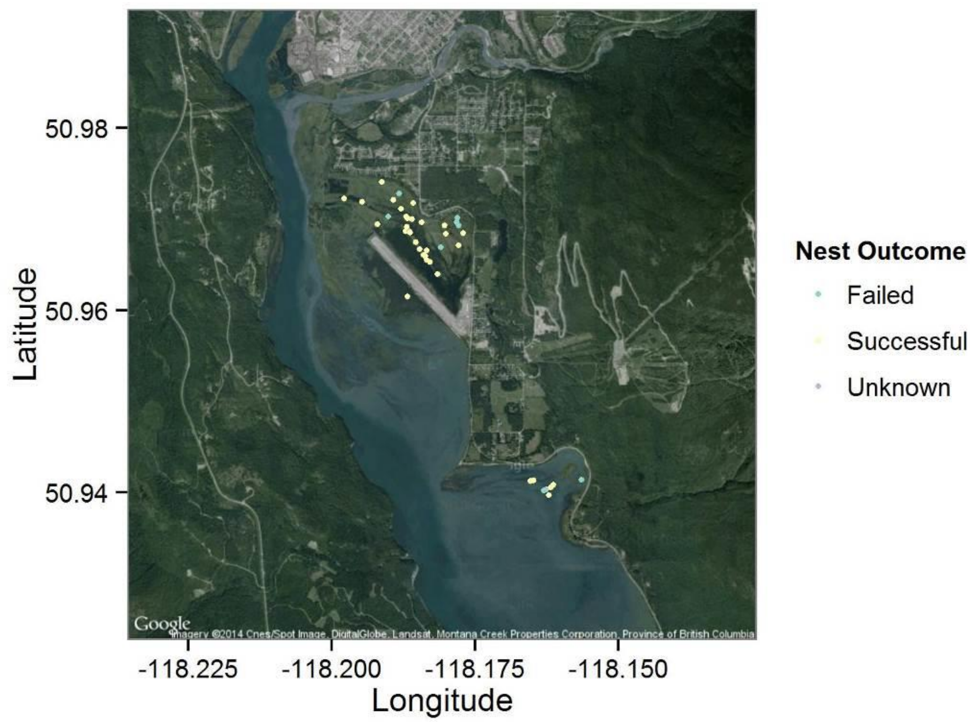


Figure 3-3: Locations of Canada Goose nests located during May. These nests likely represent the majority of goose nests in Revelstoke Reach

3.1.9 Juvenile survival

At Canoe Reach, 13 nestling SAVS were tagged for juvenile survival study: four from nests above the drawdown zone, and nine from nests within the drawdown zone. Of 13 radio-tagged young, 10 fledged, and six survived the post-fledging period until the transmitters faded (10-22 days).

At Revelstoke Reach, 17 nestling YEWA were tagged; 11 of these birds were tagged on dry territories and six were tagged in territories that were inundated with water, or partially so. Of the 17 tagged nestlings, 10 fledged successfully, and four of these survived the post-fledging period until the transmitters faded (10-24 days).

3.2 Multi-year progress

3.2.1 Community-level monitoring

In 2014, 40 ha of mapped habitat was monitored at KIN and 54 ha of mapped habitat was monitored in ALR. This progress is summarized in Table 3-2 and Table 3-3. At KIN, one new habitat type was monitored (RD), and effort was increased at previously monitored habitats (Table 3-2). At ALR, monitoring improved coverage of several habitats with low levels of previous monitoring (e.g., GR, CK, CT, CW, and SW) in addition to increasing monitoring effort over most common habitat classes.

Table 3-2: Habitats monitored in Kinbasket Reservoir (CR and BA) from 2008 through 2014

Code	Category	Total Area[1]	Monitored Area[2]	Effective 2013[3]	Effective 2014[3]
BR	Bluejoint Reedgrass	41.6	13.8	13.8	13.8
BS	Buckbean–Slender Sedge	12.0	7.5	7.5	7.5
CH	Common Horsetail	287.6	54.2	62.4	62.4
CO	Clover–Oxeye Daisy	136.5	34.6	75.7	79.8
CT	Cottonwood – Trifolium	20.3	4.2	6.1	6.1
DR	Driftwood	36.9	16.3	20.3	20.8
FO	Forest	159.6	1.7	1.9	1.9
KS	Kellogg's Sedge	210.7	36.3	69.8	76.4
LH	Lodgepole Pine–Annual Hawksbeard	0.5	0.5	0.5	0.5
LL	Lady's Thumb–Lamb's Quarter	1299.7	44.0	78.5	82.6
MA	Marsh Cudweed–Annual Hairgrass	140.3	10.3	10.3	10.3
MC	Mixed Conifer	0.2	0.0	0.0	0.0
RC	Reed Canarygrass	31.5	12.1	12.1	12.1
RD	Common Reed	0.6	0.6	0.0	0.6
SH	Swamp Horsetails	52.4	36.0	82.5	90.5
TP	Toad Rush–Pond Water-starwort	310.0	101.4	108.4	109.2
WB	Wool-grass–Pennsylvania Buttercup	128.9	55.6	102.4	112.4
WD	Wood Debris	70.0	26.0	26.0	26.0
WS	Willow–Sedge wetland	34.5	11.3	38.5	44.2
	Total	2973.7	466.3	716.8	757.0

1. 'Total Area' is the sum of mapping for each habitat type within the reservoir.
2. 'Monitored Area' indicates the sum of the mapped area that has been monitored (2008 – 2014).
3. Some sites have been monitored more than one time. Considering sites that have been repeatedly monitored over time, the effective monitored area increases, which is summarised for 2013 and 2014 in 'Effective 2013' and 'Effective 2014' respectively.

Table 3-3: Habitats monitored in Arrow Lakes Reservoir (Revelstoke Reach) from 2008 through 2014.

Code	Category	Total Area[1]	Monitored Area[2]	Effective 2013[3]	Effective 2014[3]
BE	Steep bedrock	5.8	0.0	0.0	0.0
BF	Floating bog	2.6	2.5	12.2	14.6
BR	Bullrush	12.7	7.6	41.3	48.8
BS	Submerged bouyant bog	4.2	5.1	14.3	17.1
CK	Creek	25.1	5.7	4.9	5.7
CR	Coarse Rocks	0.1	0.0	0.0	0.0
CT	Cattail	4.3	3.1	5.8	6.3
CW	Shrub wetland complex	12.2	7.1	6.4	7.1
EG	Equisetum grassland	56.6	17.9	15.9	17.9
GR	Gravel	193.5	2.9	1.7	3.0
LD	Low elevation draw	189.0	41.9	58.9	61.8
MG	Mixed grassland	1019.3	74.6	124.4	128.8
PG	Sparse grassland	372.4	40.6	41.1	42.7
PO	Pond	127.5	37.5	59.6	64.2
RB	Rocky bank	57.6	4.7	6.3	6.5
RC	Reed canarygrass	109.9	38.8	50.9	50.9
RF	Riparian Forest	77.1	29.5	54.0	57.7
SA	Sand	474.1	24.0	22.7	24.1
SB	Sand bank	10.4	2.5	3.4	3.4
SG	Sedge grassland	364.1	70.7	88.4	91.8
SH	Shrub savannah	323.5	70.8	94.6	102.4
SI	Silt	710.1	10.3	10.3	10.3
SR	Riparian shrub	25.8	8.2	11.2	12.8
SW	Swamp	1.2	2.1	1.7	2.1
TH	Thalweg	2068.6	1.2	0.8	1.2
UC	Upland conifer	43.1	0.5	0.5	0.6
UM	Upland mixed	109.8	5.8	9.3	10.5
UR	Urban	1.2	0.0	0.0	0.0
WM	Wet meadow	25.8	8.3	12.7	13.5
WS	Water Sedge	26.0	5.3	9.0	11.0
	Total	6453.6	529.3	762.2	816.5

1. 'Total Area' is the sum of mapping for each habitat type within the reservoir.
2. 'Monitored Area' indicates the sum of the mapped area that has been monitored (2008 – 2014).
3. Some sites have been monitored more than one time. Considering sites that have been repeatedly monitored over time, the effective monitored area increases, which is summarised for 2013 and 2014 in 'Effective 2013' and 'Effective 2014' respectively.

3.2.2 Nesting species detections

In 2014, no new species were detected in KIN; the total known to nest in the KIN drawdown zone is 29. Six bird species were found nesting in the ALR drawdown zone which had not previously been recorded (Lincoln's Sparrow, Northern Harrier, Dark-eyed Junco, Tree Swallow, Northern Waterthrush, Downy Woodpecker). These new species were found nesting over a range of elevations in the ALR drawdown zone, increasing the number of species known to nest in the ALR drawdown zone to 60 (Figure 3-4).

1. A Lincoln's Sparrow nest was found at the floating bog at Montana Slough, which is likely the most suitable habitat for this species in RR. A Lincoln's Sparrow was detected at this site in 2013, but did not appear to be nesting.
2. A Northern Harrier nest was located 2.37 m below the registered full pool elevation (440.1 m ASL) at 437.73 m ASL. Since 2008, we have not suspected that Northern Harriers nested, although a few are regularly seen during migration each year. Nesting by this species was previously suspected in 2002 (Jarvis 2003).
3. A Dark-eyed (Oregon) Junco nest was located at 438.6 m ASL (1.54 below full pool) at site 56388 in the Cartier Bay area. This species likely nests annually in the upper elevations of the drawdown zone in low densities, in uncommon types of drawdown zone habitat.
4. A Tree Swallow nest was found in a nest box (site 74772), located just 40 cm below the full pool elevation of the reservoir. Tree Swallow likely nests annually at low densities near the full pool elevation.
5. A Northern Waterthrush nest was found above the official full pool elevation at 440.77 m ASL (site 74751), which is technically within the drawdown zone as this elevation has previously been flooded during surcharge conditions. This species is a rarity in the Revelstoke region.
6. A Downy Woodpecker nest (site 74775) was located within 40 cm of the full pool elevation.

Downy Woodpecker, Dark-eyed Junco and Tree Swallow likely nest annually at low densities near the full pool elevation (spatially uncommon). The other nests are likely present in some years, and not in others.

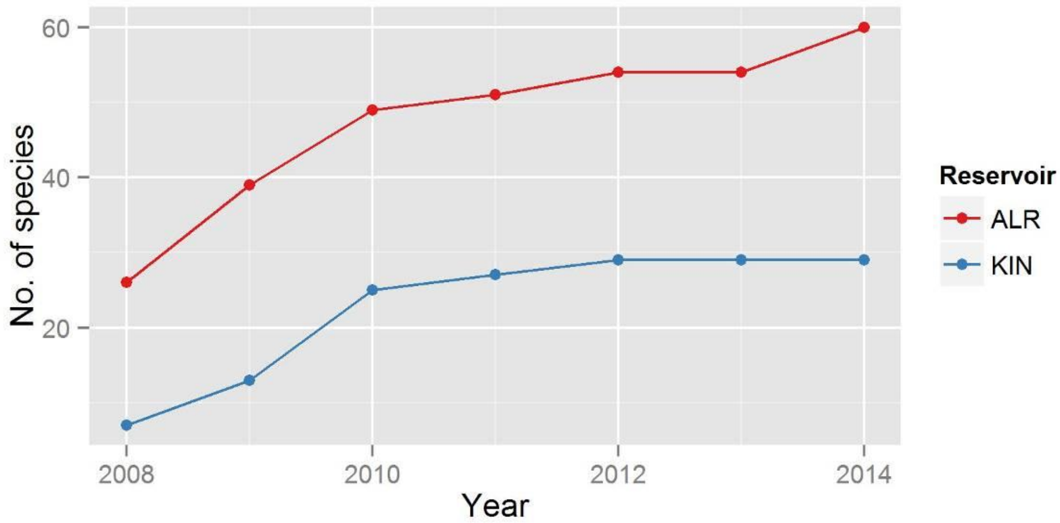


Figure 3-4: **Cumulative count of species detected in the drawdown zones of the Arrow Lakes Reservoir (ALR) and the Kinbasket Reservoir (KIN) from 2008 to 2014.**

3.2.3 Nest submergence

Since 2008, there have been 174 nests (of 34 species) observed to have failed as a direct consequence of reservoir operations (Table 3-4); 13 nests (6 species) in KIN, and 161 nests (32 species) in ALR. At KIN, nest inundation was observed in 2010, 2011, 2012, and 2013. At ALR, nest inundation has been observed in each year of the study (Figure 3-5).

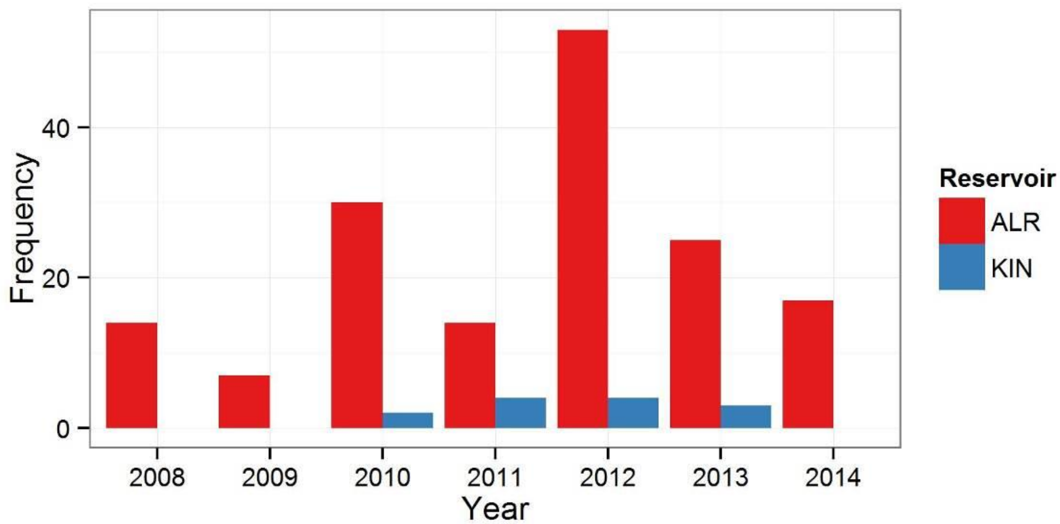


Figure 3-5: **Annual number of observations of nest flooding observed for Kinbasket (KIN) and Arrow Lakes Reservoir (ALR)**

Table 3-4: Observations of nest submergence since 2008 by species in Kinbasket (KIN) and Arrow Lakes (ALR) Reservoirs

Type of Nest Location	Common Name	ALR	KIN
Ground Nests (27.8%)	Common Loon	2	0
	American Wigeon	6	0
	Mallard	8	0
	Green-winged Teal	3	0
	Killdeer	4	0
	American Avocet	1	0
	Spotted Sandpiper	2	3
	Wilson's Snipe	3	0
	Wilson's Phalarope	1	0
	Long-eared Owl	1	0
	Short-eared Owl	1	0
	Savannah Sparrow	7	6
In Low Shrub Layer (e.g., <0.5 m) or in Ground Cover (37.6%)	Pied-billed Grebe*	2	0
	Virginia Rail*	5	0
	Sora*	2	0
	Marsh Wren*	1	0
	Veery	2	0
	MacGillivray's Warbler	1	0
	Common Yellowthroat	15	1
	Chipping Sparrow	6	0
	Clay-colored Sparrow	2	0
	Song Sparrow	4	0
	Red-winged Blackbird*	9	0
	Yellow-headed Blackbird*	15	0
In Shrubs (33.0 %)	“Traill's” Flycatcher	2	0
	Willow Flycatcher	15	1
	Dusky Flycatcher	1	0
	Eastern Kingbird	1	0
	Unidentified Flycatcher	2	0
	Gray Catbird	8	0
	Cedar Waxwing	7	0
	Yellow Warbler	20	0
In Canopy (1.2%)	American Robin	0	1
	American Redstart	1	0
Cavity Nest (0.6%)	Mountain Bluebird	0	1

* these species are confined, or largely confined, to nesting in the Airport Marsh

3.2.4 Juvenile survival monitoring

Since Year 5 (2012) 41 SAVS and 39 YEWA nestlings have been tagged with radio-telemetry transmitters to monitor juvenile survival. Of these 80 tagged young, 59 nestlings were known to have fledged (33 SAVS; 29 YEWA).

In the KIN drawdown zone (n = 23), 35% of the fledged SAVS young survived their monitoring period, similar to what was observed in other (non-drawdown) habitats (30%, n = 10).

In the ALR drawdown zone (n = 18), 33% of the monitored YEWA fledglings survived when their post-fledging habitat was inundated, whereas 50% of the fledged young survived when their post-fledging habitat remained dry (n = 8). Accordingly, a draft Cox proportional hazards analysis of the YEWA telemetry data indicated that inundation is likely an important variable impacting post fledge survival, and that fledging from an inundated habitat decreases juvenile DSR (Matthew Hepp *unpublished results*).

3.3 New Analyses

3.3.1 Physical Works Projects to mitigate negative impacts of reservoir operations: What benefit would accrue by protecting the Airport Marsh from reservoir operations?

By protecting the Airport Marsh from reservoir operations (e.g., using a dyke), several rare and productive habitats that are confined to this wetland would be protected. We calculated that the Airport Marsh contains the majority of habitat for five different habitat types, all of which are regionally important breeding habitat for birds (Figure 3-6).

Using the nesting model for ALR, and looking back to 1985, we calculated that by protecting the Airport Marsh from reservoir operations, a maximum of 274 nests per year (predicted for 1997) would have been saved from being submerged (Figure 3-7). The maximum percent reduction in nest flooding was 26%, which was predicted for 1987. Not surprisingly, the benefit was realized in years of high impact, particularly when the nest flooding impact was above the middle-point (Impact ≥ 0.5) in terms of historic nest flooding impacts (1985-2014; Figure 3-7). In high impact years (Impact ≥ 0.5), our calculations predicted 176 nests (18%) would have been saved on average.

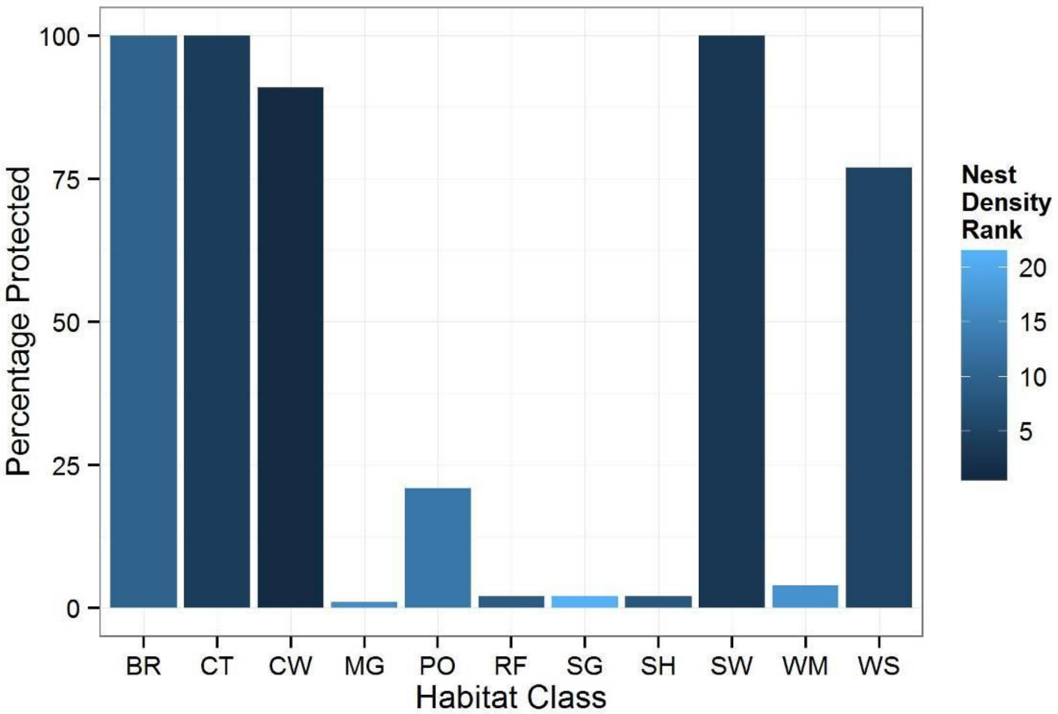


Figure 3-6: **The percentage of available habitat that would be protected from reservoir operations if a dyke were installed at Airport Marsh. Nest density rank indicates nest densities calculated for each habitat type (1 = the highest density). Only habitats located within the Airport Marsh are plotted**

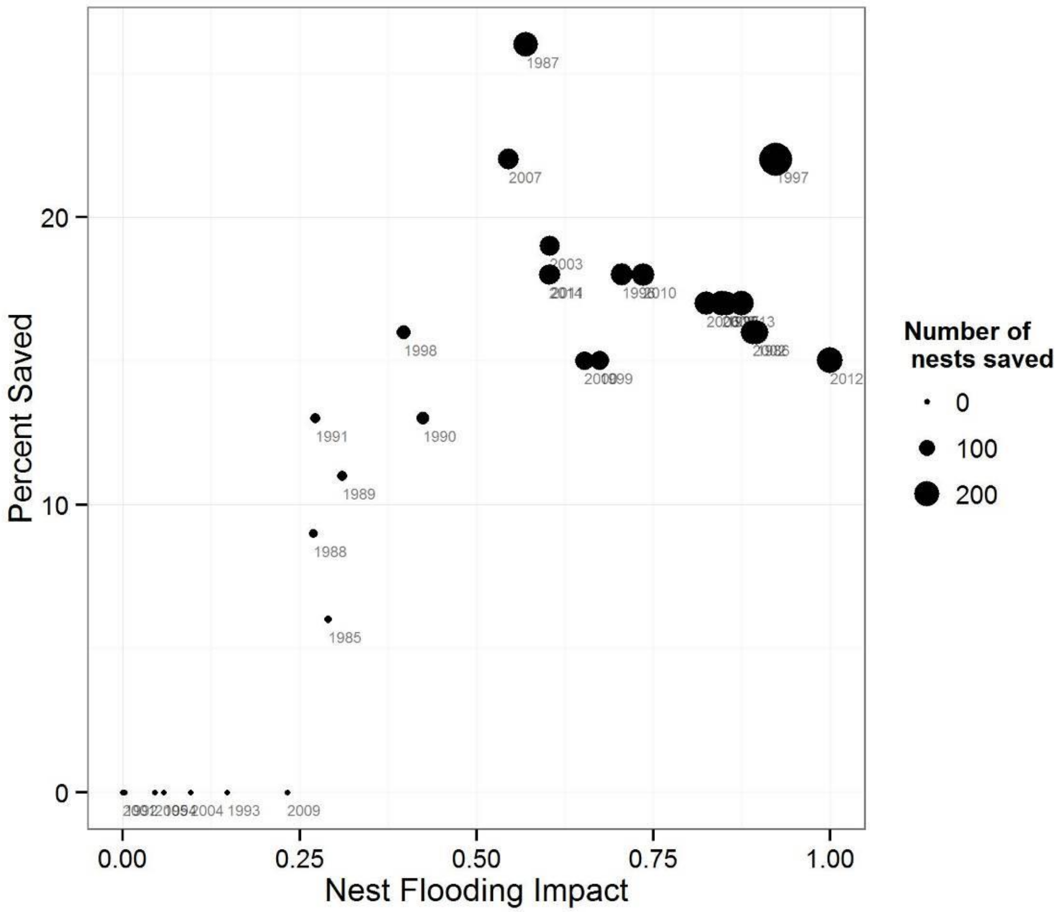


Figure 3-7: **Comparison of an index of the predicted severity of historic nest flooding impact versus the percentage of nests predicted to be saved by protecting the Airport Marsh from reservoir operations**

4 DISCUSSION

CLBMON-36 is a 10-year project addressing knowledge gaps related to the management of reservoirs (their habitat and operation) to enhance avian productivity and minimize the incidental take of nests caused by reservoir operations. This report summarizes progress made in the CLBMON-36 project in 2014, the 7th year of research on this project.

A strategic initial focus of study during the first five years was to establish a relatively complete and robust knowledge of which avian breeding communities exist in the drawdown zones of Kinbasket and Arrow Lakes Reservoirs, as this knowledge underpins all of the project's objectives (listed in Section 1.1). One of the major outcomes of the first five years was the production of a nest flooding model built using GIS maps of drawdown habitat communities, digital elevation models, and empirical knowledge of nesting phenology and habitat-specific nesting patterns (nesting species, densities, and nest heights). While there is room to enhance the nesting model's complexity, it represents an enormous improvement over what was previously available (AXYS 2002, Korman 2008). Our nest flooding model can now predict with a high degree of accuracy how many nests and species are at risk of flooding on any date and reservoir level.

Following the five-year analysis, the field study program was modified to reduce allocation of effort towards Nest Mortality study, and greater emphasis was placed on focal species work and analysis. Specifically, we expanded our field study of juvenile survival using radio telemetry in Years 6 and 7, and we refined analyses of nest survivorship for two focal species, and prepared a manuscript to be published in a peer-reviewed journal (van Oort et al. *in press*).

In this report, we briefly review salient aspects of data collection in 2014, reviewed multi-year progress in data collection, and presented new analyses. The format of this report differs from previous annual reports, reflecting the more advanced stage of this study.

Below we (1) discuss notable aspects about the Year 7 field season, (2) review progress and remaining data gaps in the biogeographical components of this study, (3) discuss the newly presented analyses, and (4) summarize a final analyses that has now been drafted for publication.

4.1 Year 7 (2014)

In general, 2014 had a relatively dry and hot summer. At Revelstoke, where there are good weather records available, May has had relatively invariable levels of precipitation during the course of the study, but 2014 was the wettest May observed to date. June was the wettest month during most years, but in 2014, precipitation was minimal by comparison with previous years. It was the third driest July since 2008.

At Canoe Reach, two factors resulted in a relatively low number of nest records in 2014. First, effort was split between focal species sites above the drawdown zone, and sites within the drawdown zone. This was the first time that monitoring occurred above the drawdown zone to such a high degree in the CR area, and will allow comparisons to be made between SAVS populations within each reservoir drawdown zone and elsewhere. This comparison will be made for both nest and juvenile survivorship.

The second factor that affected nest records in CR in 2014 was a relatively low abundance of birds. CBA field crews noted that habitats were very dry in 2014, with very low ground water in the CR peatlands. Working on other WLR studies, LGL field crews concurred, noting that ponds throughout the KIN (CR and Bush Arm, within and above the drawdown zone) were 10-20 cm lower than in previous years (Doug Adama and Virgil Hawkes *personal communication*). This likely accounted for a decline in Spotted Sandpiper, Killdeer and Lincoln's Sparrow in the 2014 nest records.

Monitoring at RR was similar to what occurred previously, with two additions: (1) a concurrent study on secretive marsh birds in the area provided an injection of nest records to the database (CBA 2015); and (2), early in the field season, we conducted a census of Canada Goose nests in the northern part of the study area because records for this important, but early-nesting species were lacking in the database.

In addition to the outcome that the known diversity of nesting species at Revelstoke Reach was increased by six species, notable aspects of the 2014 nest records included a high number of Canada Goose nest records, a high number of Virginia Rail and Sora nest records (due to a collaboration with another project), a high number of Clay-coloured Sparrow (due to a population increase), a high number of Common Yellowthroat nests, a high number of Wilson's Snipe nests, an absence of Marsh Wren and Red-winged Blackbird nests, and a Long-eared Owl nest (second record). Of the new species observed, the Northern Harrier nest, and the Northern Waterthrush nest were both highly notable additions to the dataset.

4.2 Multi-year progress and data gaps

4.2.1 Nest mortality - biogeography

All but one of the drawdown zone habitat classes have been monitored at KIN.

The one habitat that has not been monitored is MC (Mixed Cottonwood) and given the circumstances, this habitat should be omitted from the habitat stratification of CLBMON-36. MC habitat classification is represented by only one small polygon (0.18 ha) located at a remote region of KIN, north of Sullivan Arm. The MC habitat is primarily located above the drawdown zone.

In Year 7, nine drawdown zone habitats were monitored in KIN; one of these had never previously been monitored (RD: Common Reed). This latter habitat is uncommon, but is present in the CR area. In Year 8, site selection for KIN should aim to monitor RD, FO, LH and CT where possible.

At ALR, all but three habitat types (BE, CR, UR) have been monitored.

BE (steep bedrock) is relatively challenging to access, and potentially challenging to monitor safely. Much of this habitat consists of angled slabs of bed rock along the western bank of the Columbia River. This habitat is unlikely to support nests, and an assumption that nest density is near zero in this habitat is reasonable in our opinion. There is 5.8 ha of habitat classified as BE.

CR (coarse rocks) is a habitat class that has only been mapped for 0.1 ha in RR. It would likely be best to amalgamate this habitat class with another similar type prior to future analyses (e.g., RB, GR).

UR (urban) habitat is mapped as 1.2 ha in RR. This habitat consists mainly of paved areas. We suggest it is reasonable to assume a nest density of zero for this habitat type.

A habitat type that has been lightly monitored is the TH (thalweg) habitat. We suggest this habitat does not need further monitoring (this habitat delineates the Columbia's main channel, which is flooded regularly throughout the year).

In Year 7, 24 habitat classes in RR were monitored to some degree. In Year 8 we suggest that GR, CK, CW, CT, SW, RB, UC, and SB be prioritized for monitoring in addition to monitoring the common suite of habitats.

4.2.2 Nest mortality - species detection

In Year 7, six new species were recorded breeding in the drawdown zone of ALR. All are uncommon species in the ALR drawdown habitats, but four species likely breed regularly in very low densities. The remaining two species are unlikely to nest regularly: Northern Harrier and Northern Waterthrush. In Year 7 we monitored a relatively large amount of the less abundant high elevation habitats in the ALR drawdown zone (forests, swamps etc), and this likely contributed to our success in finding nests for these species.

It is likely that the detection of new breeding species will continue into the future, but the curve of species discovery is certainly approaching its maximum/asymptote, and we expect the number of years where no new species are found to increase. In Year 7, half of the new species were common upland species (Downy Woodpecker, Tree Swallow and Dark-eyed Junco) and are generally not attracted to drawdown zones.[1]

In the future, we expect that additional species will either be rarities, or those that typically do not select drawdown zone-like habitats (e.g., at upper elevations of drawdown zone). We are confident that all species that commonly nest in the drawdown zones have been documented.

4.2.3 Nest mortality – nest submergence

The nest submergence records were relatively high in 2014, partially due to the collaborative effort between CLBMON-36 and a concurrent Fish and Wildlife Compensation Program project documenting marsh birds in the Airport Marsh (CBA 2015). This collaboration increased nest records from the Airport Marsh and, consequently, Virginia Rail, a species that nests in marsh vegetation just at the water line, was the leading species for flooded nests in 2014.

Over the course of CLBMON-36, nest flooding has been documented annually in ALR, and in four of seven years in KIN. At ALR, 2009 and 2012 represent the extreme (minimum and maximum respectively) years of nest flooding. In ALR, the observed rates of nest flooding correlated with the predicted impact (HvO *unpublished data*).

Assessing the impact associated with nest flooding requires careful attention to reservoir ecology. The impact to productivity caused by nest flooding will vary depending on the species, and their nesting behaviour. Additionally, rates of nest flooding will vary among species, and across reservoir elevations. These factors need to be controlled for, before any interpretation of nest submersion data can be made. As an example, we show below that nest flooding can be of low consequence to productivity of shrub nesting species, even when the rates of nest flooding are high (see sections 4.3 and 4.4 below).

The list of species that suffer from nest flooding has increased over time; for example, in Year 7, we documented nest flooding at a Long-eared Owl nest, which was new to the list. To date we have documented nest flooding for 36 species in ALR and six species in KIN. While the empirical data will obviously increase with additional years of study, a modelled approach is the most direct way to assess the vulnerability of species to nest flooding. This is something that should be addressed in future analysis.

4.2.4 Focal species - juvenile survival

To date, we have tagged a large number of nestlings for monitoring juvenile survival (80 individuals). For illustrative purposes, the data summarized in this report reviewed only data from tagged young that fledged, which entails a reduction in sample size (n = 59 in this report). We omitted data from young that died before leaving the nest or if their transmitters failed. In reality, not all censoring of unfledged data is unnecessary, and data from unfledged young will likely be used for final analysis, thereby maximizing sample size. We define fledging as the act of leaving the nest for the first time. However, for SAVS, the act of fledging is a somewhat fuzzy concept; young may stay in the nest for a day or two after they normally fledge (and are fully capable of walking), and some even return to the nest after fledging; because SAVS nest on the ground, leaving the nest does not necessarily impart a large change to the young's situation as they remain on the

[1] Tree Swallows could be a common drawdown zone species if nest boxes were installed; the nest found in 2014 was in a nest box on private land in the drawdown zone.

ground, flightless, and similarly well hidden within the ground cover. The impact resulting from reservoirs flooding SAVS nesting habitat will be similar for nestlings and newly fledged young, because neither age groups are able to fly to escape water in their nest/post-fledging area. In the future, when survivorship is modelled, we suspect that the best approach would be to combine nest and juvenile survivorship in one model for SAVS. This approach would incorporate a much larger sample size, allowing nestlings, and those for which fledging status was unknown to be included.

Currently, there is a suggestion that habitat inundation may negatively influence the survivorship of YEWA juveniles. A draft analysis conducted by Matthew Hepp (SFU) confirmed that habitat inundation is likely an important factor limiting juvenile survivorship. Models of daily survivorship will provide a more robust method for comparing survivorship for this analysis, and will allow seasonal effects and other nuisance variables to be assessed.

With three more years of monitoring and further refinement of analysis, we expect that sample sizes will be large enough to assess conclusively if there are biologically important (population level) impacts of habitat flooding on YEWA young, and to compare how daily survivorship in the drawdown zone of Kinbasket Reservoir compares with other more 'normal' habitats outside the drawdown zone, and as may be reported elsewhere in available literature.

It is unclear if there will be sufficient data to assess how reservoir operations impact the survivorship of SAVS. To date there has been minimal observation of juveniles of this species in flooded habitats. We have observed mortality of tagged young that took place when the young were at the fledging stage (similar to nest mortality). We have also recorded a fledged juvenile SAVS drowning in a natural ponded area. Clearly reservoir inundation poses a serious threat to juvenile SAVS given that they cannot fly for up to a week after fledging; however, our ability to empirically observe the extent of this threat will depend on the reservoir operations that we experience in the remaining three years of study. On the other hand, radio-telemetry will provide helpful information on how old the birds need to be before they are capable of sustained flight (and are thus able to relocate as waters rise).

4.3 New analyses (2014)

4.3.1 MQ-K: Mitigating negative reservoir impacts through a physical works project

One avenue to address MQ-K is to provide a robust recommendation for a physical works that will mitigate negative impacts of reservoir operations. Our new analysis focuses on the potential to mitigate nest flooding impacts via the protection from inundation of Airport Marsh. Protecting Airport Marsh from inundation is appropriate for at least three reasons.

First, Airport Marsh is locally and regionally a very important breeding habitat for a number of bird species (and other species such as Western Painted Turtle). The regional significance of this site to birds is due to the presence of nesting species that are rarely found elsewhere in the BC Columbia Basin. These regionally uncommon species include Pied-billed Grebe, Virginia Rail, Marsh Wren and Yellow-headed Blackbird. Improving the productivity of Airport Marsh by protecting the nests of these and other species from inundation would have high ecological significance at a regional scale.

Second, Airport Marsh contains unique habitat types within the RR, and these rank very high in terms of nest density compared with other drawdown zone habitats.

Consequently, protecting Airport Marsh from inundation would result in a very high ratio of nests saved per unit area protected (i.e. physical works would be highly effective).

The third reason is that nest flooding is a major issue for species nesting in Airport Marsh, including regionally rare species. In Table 3-4 (above), several species are listed which are typically confined to nesting in the Airport Marsh; most notably, we observed 15 Yellow-headed Blackbird nests being flooded since 2008 (Table 3-4). This is a serious cause of nest failure for this important population: the number of nests that failed due to flooding was more than twice the number that failed due to predation.

Our analysis indicated that by protecting the ~125 ha Airport Marsh from reservoir operations (~2.6% of RR; 0.24% of ALR), typically 18% of the nest flooding in RR would be prevented in a year of high impacts; in an extreme year, our analysis indicated that as much as 26% of the nest flooding would be prevented.

We do not suspect that there are any benefits that reservoir operations bring to birds nesting in the Airport Marsh with respect to diminishing predation, because they already nest over standing water (see section 4.4 below); hence we suspect that protecting Airport Marsh from inundation would result in notable improvements to the productivity of the Marsh, the ALR, and the whole region. However, the assumption that nest flooding negatively impacts productivity should be assessed with a formal nest DSR analysis for marsh nesting birds, if possible, and other aspects of the wetland ecology would need to be assessed.

To protect the Airport Marsh, it would be necessary to regulate the flow of water through the Revelstoke Airstrip, and to build new dykes at the northwest end of the marsh. However, these potentially major works would also provide notable ancillary benefits to the Revelstoke community; the physical works would also allow development of walking trails that would allow public enjoyment of the marsh and drawdown zone even when reservoir is at full pool.

4.4 Final analyses

One final analysis was written up in Year 7 as a stand-alone manuscript (van Oort et al. in press), which is summarized below.

4.4.1 Do reservoir operations affect daily survival rate of nests in shrubs?

The impact of reservoir operations on nest survival will differ among species. Birds nesting on the ground will suffer ~100% nest loss when their nesting habitat becomes flooded. Birds with floating nests suffer from exposure to predators (floating nests are pulled up out of cover as water levels rise) or nest stranding, as water levels rise and recede respectively. Birds that nest in shrubs may suffer nest flooding, but the elevation of their nests above the ground increases the nest’s chance of survival. Species that nest high in the drawdown zone will be less impacted than those that nest low in the drawdown zone. As such there will be no single answer regarding the impacts of reservoir operations on nesting birds.

In 2014 we finalized an analysis to quantify how nest survivorship of shrub-nesting birds was impacted by reservoir operations. Shrub nesting birds are commonly impacted by nest flooding in RR, and the impact could potentially be managed by modifying habitat configuration. The impact of reservoir operations surely amounts to more than just nest flooding, given that their nesting habitat is transformed severely prior to nest flooding as water levels swamp what was previously a terrestrial habitat. Our goal was to document the net impact of habitat flooding on nest survivorship.

The question of how reservoir operation impacts nest survivorship (MQ-C) was studied for two shrub nesting species: YEWA and Willow Flycatcher (WIFL). The study considered data from RR where reservoir operations commonly affect nesting birds. The study was a follow up to initial analyses presented in the Year 5 Interim Report, where it was identified that there may be partial benefits to the inundation of nesting habitats, which compensate for the costs caused by nest flooding (CBA 2013). In 2014, the analyses were improved upon, finalized and written up as a separate paper (van Oort et al. in press).

The importance of studying shrub-nesting species are three-fold: (1) the impacts of reservoir operations on shrub-nesting species has not been assessed previously; (2) the impacts are difficult to predict, because there is potential for multiple effects of reservoir operations, beyond nest flooding; and (3) shrub distribution can be manipulated easily to enhance productivity. In the review of nest flooding impacts (see section 3.2.3) 33% of nest submergence observations were for shrub-nesting species in the RR study area. This paper directly tested Hypothesis H1, and addresses MQ-C, MQ-D and MQ-K (see section 1.2 or Appendix 6-1). By examining YEWA and WIFL, the study considered a species that experienced moderate and high levels of nest flooding, respectively (see section 3.2.3, Table 3-4).

We concluded that, for shrub-nesting species, the inundation of nesting habitat resulted in no net impact to nest survivorship (i.e., nesting success). For WIFL, there was a benefit to nesting on the floating bog habitat at Montana Slough. The draft paper was submitted to BC Hydro along with the current report. The primary lesson learned from this study was that for shrub-nesting species, rates of nest flooding is an unreliable measure of reservoir operations impacts on nesting success.

It should be noted that the study, alone, only considers nesting success, and does not consider juvenile survival, which could be subject to altered predation, and drowning impacts. If flooded habitats have low impact to nesting, as found in this study, it is possible that habitat flooding is unfavourable because the juveniles are likely to drown after fledging. A second study looking at YEWA juvenile survivorship and recruitment as a function of habitat condition during the natal period will clarify these aspects.

Our study did not directly monitor the nest predator community, and it remains unclear which nest predator pressures are most influenced by reservoir operations. This remains a worthy question that will not be addressed by CLBMON-36, but should be considered in future research programs.

With respect to MQ-C, the results from our shrub nest survivorship study indicated that there is no impact of reservoir operations on nesting success for shrub-nesting species. Further analysis is required for ground-nesting birds, and a different approach will be warranted. Additionally, further analysis for birds nesting over water in wetlands is warranted.

With respect to MQ-D, the results indicated that the various factors that influence nesting success may simultaneously be impacted by reservoir operations. It is clear that nest predation is the single most important factor for shrub-nesting birds, but predation appears to be reduced as shrub habitats are progressively flooded by reservoir operations, even though the probability of nest submergence increases.

With respect to MQ-K, the study suggests that in general, shrub habitat in the reservoir drawdown zone does not represent an ecological trap during the nesting stage. This conclusion is counter to what was suggested by the earlier analysis of WIFL (CBA 2013). The earlier analysis used a different type of nest survival analysis, where individual nests constituted data points; the current analysis considers nest observations as data points. Closer inspection of the former results indicated that the classification of nests according to conditions (in flooded habitat or not), was a process that introduced bias leading to spurious results.

It is too early to draw conclusions regarding the overall value of shrub savannah; analyses of juvenile survivorship will allow us to determine if total productivity is highly influenced by reservoir operations via low juvenile survival.

4.5 Recommendations for the Year 8 work plan, and future analyses

- Site selection for the 2015 (Year 8) season should review and be informed by section 3.2.1, Table 3-2, and Table 3-3, and attempt to fill knowledge gaps.
- The telemetry study should continue. SAVS nests above the drawdown zone need to be targeted, and young SAVS from nests in danger of being flooded should be tagged when such opportunities arise. Telemetry work should commence in second or third week of June in Kinbasket.
- To complement the study of how reservoir operations impact shrub-nesting species, analyses should attempt to determine how marsh birds, ground nesting species, and species that nest very low in shrubs are impacted, where data are sufficient for conclusive results.

4.6 Conclusions

We conclude that the rate of nest flooding cannot be used alone to assess the impacts of reservoir operations on the productivity of shrub-nesting birds (van Oort et al. *in review*). Furthermore, we conclude that there must be a compensatory process caused by reservoir operations that counters the negative impact of nest flooding, such as a reduction of nest predation (i.e. nests over water may be less likely to be predated). Until more information is available from the juvenile survival study, we cannot be certain about the value of drawdown zone shrubs. Currently, preliminary results suggests that there may be a negative consequence for juvenile birds fledging from shrub nests in flooded habitats.

We also conclude that a physical works project to protect the Airport Marsh from reservoir operations would be highly effective at mitigating impacts of reservoir operations on nest flooding because it would protect a high density of nests, a high diversity of species, and regionally rare species from this impact.

5 ADDITIONAL REPORTING REQUIREMENTS

5.1 Banded birds

Birds were banded in accordance with national permit regulations. Only focal species were targeted, although incidental captures of a few non-focal species did occur, so these birds were also banded. All data were entered into Bandit 2.01 software and were submitted to the Bird Banding Office of the Canadian Wildlife Service. No mortalities or injuries occurred.

5.2 Provincially- and SARA-listed species

No Species at Risk nests were located.

5.3 Species with provincial jurisdiction

All nest records were reported to the Ministry of Environment following the Wildlife Species Inventory standards.

6 LITERATURE CITED

Anteau, M., T. L. Shaffer, M. Sherfy, M. Sovada, J. Stucker, and M. Wiltermuth. 2012. Nest survival of piping plovers at a dynamic reservoir indicates an ecological trap for a threatened population. Oecologia 170:1167–1179 pp.

AXYS. 2002. Mica-Revelstoke-Keenleyside water use plan: breeding bird and migratory shorebird use of the Revelstoke wetlands. Report for Water Use Planning, BC Hydro, Burnaby, BC. 86 pp.

BC Hydro. 2007. Columbia River Project Water Use Plan, BC Hydro, Burnaby, BC.

Boulanger, J. 2005. Land birds in a high human use riparian zone: Revelstoke Reach wetlands, Columbia Basin Fish and Wildlife Compensation Program, Nelson, BC.

Boulanger, J., G. J. Woods, and J. Jarvis. 2002. Songbird use of four floodplain vegetation types in the Revelstoke Reach, Upper Arrow Reservoir, British Columbia, Canada, BC Hydro, Burnaby, B.C.

Cooper Beauchesne and Associates Ltd (CBA). 2010. CLBMON36: Kinbasket and Arrow Lakes Reservoirs, nest mortality of migratory birds due to reservoir operations, Year 2, BC Hydro Water Licence Requirements, Castlegar, BC.

Cooper Beauchesne and Associates Ltd (CBA). 2011. CLBMON36: Kinbasket and Arrow Lakes Reservoirs, nest mortality of migratory birds due to reservoir operations, Year 3, BC Hydro Water Licence Requirements, Castlegar, BC.

Cooper Beauchesne and Associates Ltd (CBA). 2012. CLBMON 40: Arrow Lakes Reservoir shorebird and waterbird monitoring program, Year 4, 2011. Supplemental winter report., BC Hydro Water Licence Requirements, Castlegar, BC.

Cooper Beauchesne and Associates Ltd (CBA). 2013. CLBMON-36: Kinbasket and Arrow Lakes Reservoirs: Nest Mortality of Migratory Birds Due to Reservoir Operations. 5 Year Interim Review Report: 2008-2012, BC Hydro Water Licence Requirements, Burnaby, BC.

Cooper Beauchesne and Associates Ltd (CBA). 2014a. Monitoring protocols for CLBMON36 Kinbasket and Arrow Lakes Reservoirs: nest mortality of migratory birds due to reservoir operations, Year 6, 2013, BC Hydro Water Licence Requirements, Castlegar, BC.

Cooper Beauchesne and Associates Ltd (CBA). 2014b. CLBMON36: Kinbasket and Arrow Lakes Reservoirs, nest mortality of migratory birds due to reservoir operations, Year 6, BC Hydro Water Licence Requirements, Castlegar, BC.

Cooper Beauchesne and Associates Ltd (CBA). 2015. Marsh bird productivity and conservation in Revelstoke Reach. FWCP Project Number W-F15-08, Fish and Wildlife Compensation Program, Burnaby, BC.

Hawkes, V. C., P. Gibeau, and J. D. Fenneman. 2010. Kinbasket and Arrow Lake Reservoir revegetation management plan; CLBMON-10 Kinbasket Reservoir inventory of vegetation resources, BC Hydro Water Licence Requirements, Castlegar, BC.

Jarvis, J. 2003. Preliminary evaluation of the impact of reservoir operations on nesting birds in the Revelstoke Reach, Upper Arrow Lakes Reservoir, Revelstoke, British Columbia, Canada, BC Hydro, Burnaby, B.C.

Jarvis, J. 2006. Impact of reservoir operations on nesting birds in the Revelstoke Reach, BC Hydro, Burnaby, B.C.

Korman, J. 2008. Historic analysis of flooding statistics and bird habitat/nesting success in the Revelstoke Reach of the Arrow Lakes Reservoir, BC Hydro Water Licence Requirements, Castlegar, B.C.

Martin, T. E., and G. R. Geupel. 1993. Nest-monitoring plots: methods for locating nests and monitoring success. Journal of Field Ornithology 64:507–519 pp.

Meidinger, D., and J. Pojar. 1991. Ecosystems of British Columbia, BC Ministry of Forests, Victoria, B.C.

Nilsson, C., and M. Dynesius. 1994. Ecological effects of river regulation on mammals and birds: a review. Regulated Rivers: Research and Management 9:45–53 pp.

Nilsson, C., C. A. Reidy, M. Dynesius, and C. Ravenga. 2005. Fragmentation and flow regulation of the world's large river systems. Science 308:405–408 pp.

Van Oort, H., D. J. Green, M. Hepp, and J. M. Cooper. in press. Do rising water levels alter nest survivorship in reservoir drawdown zone shrubs?

Poole, A. (Ed.). 2010. Birds of North America Online, Cornell Laboratory of Ornithology, Ithica, NY. Retrieved from http://bna.birds.cornell.edu/BNA/.

Pulliam, H. 1988. Sources, sinks, and population regulation. American Naturalist 132:652–661 pp.

Quinlan, S. P., and D. J. Green. 2012. Riparian habitat disturbed by reservoir management does not function as an ecological trap for the Yellow Warbler (Setophaga petechia). Canadian Journal of Zoology 90:320–328 pp.

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

Robertson, B. A., and R. L. Hutto. 2006. A framework for understanding ecological traps and an evaluation of existing evidence. Ecology 87:1075–1085 pp.

Schlaepfer, M. A., M. C. Runge, and P. W. Sherman. 2002. Ecological and evolutionary traps. Trends in Ecology and Evolution 17:474–480 pp.

Utzig, G., and D. Schmidt. 2011. Dam footprint impact summary; BC Hydro dams in the Columbia Basin, Fish and Wildlife Compensation Program, Columbia Basin, Nelson, B.C.

Appendix 6-1: Status of management objectives, questions and hypotheses

STATUS OF OBJECTIVES, MANAGEMENT QUESTIONS AND HYPOTHESES

OBJECTIVES	MANAGEMENT QUESTIONS	HYPOTHESES	YEAR 7 STATUS AND SUMMARY
Identify how drawdown zone habitats are used by breeding birds in Kinbasket Reservoir and Revelstoke Reach.	A. Which bird species breed in the drawdown zones and how are they distributed among the drawdown zone habitat classes? B. What are the seasonal patterns of habitat use by birds nesting in the drawdown zones?		• These MQ's have been addressed adequately. Additional rare or uncommon species will undoubtedly be observed with additional work, but the we believe that the regularly nesting species are well documented • Additional monitoring will improve knowledge of (1) birds nesting in uncommon habitat types, and (2) uncommon birds within habitat types, in addition to improving precision of density estimates. • Densities do appear to vary among years, so there is a benefit to monitoring for an extended period of time • Additional work can be done to summarize the data in new ways (e.g., elevational profiles for each species) • Additional information on seasonal patterns will be beneficial for uncommon species
Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence nest survival.	C. Do reservoir operations affect nest survival? D. What are the causes of nest failure in the drawdown zone, and how do they differ among species, among habitat classes, and across elevation (i.e., position in drawdown zone)?	H1: Inundation of nesting habitat caused by reservoir operations does not affect nest survivorship. H1A: Nest survivorship in the drawdown zone is not different from nest survivorship above the drawdown zone. H1C: Nest survivorship does not differ across elevations in the drawdown zone. H1D: Rates of nest flooding do not differ across elevations in the drawdown zone.	• H1 has been addressed with a final analysis for shrub nesting species • H1A was addressed in the Interim report, but models need to be re-assessed and fit with new data.
Evaluate how the operations of the Kinbasket and Arrow Lakes Reservoirs influence juvenile survival.	G. Do reservoir operations affect juvenile survival when water levels inundate post-fledging habitat?	H2: Inundation of post-fledging habitat does not affect juvenile survival. H2A: Juvenile survival in the drawdown zone does not differ from juvenile survival above the drawdown zone.	• All data to address H2 for YEWA are now collected, and final analyses and write-up are underway. • Data to address H2 for SAVS are still being collected (success of gaining adequate data will depend on reservoir operations). • Data to address H2A for SAVS are still being collected, and this component study is progressing well.
Establish a nest flooding risk model for Kinbasket Reservoir and Revelstoke Reach.	H. How can the operations of the Kinbasket and Arrow Reservoirs be optimized to reduce nest submersions and/or improve avian productivity?		• Draft models have been created and presented previously. • Improvements and updating will occur prior at Year 10
Assess how habitat management in the drawdown zones can be used to increase productivity, or reduce negative impacts of reservoir operations.	K. Can drawdown zone habitats be managed to improve nest survival and/or site productivity? If so, how?		• One well-supported suggestion for a physical works project has been delivered • The productivity and propensity of drawdown zone shrubs to function as ecological traps is still being assessed (see H1A-D).

Appendix 6-2: Habitat classes / vegetation communities used in Kinbasket Reservoir and Revelstoke Reach

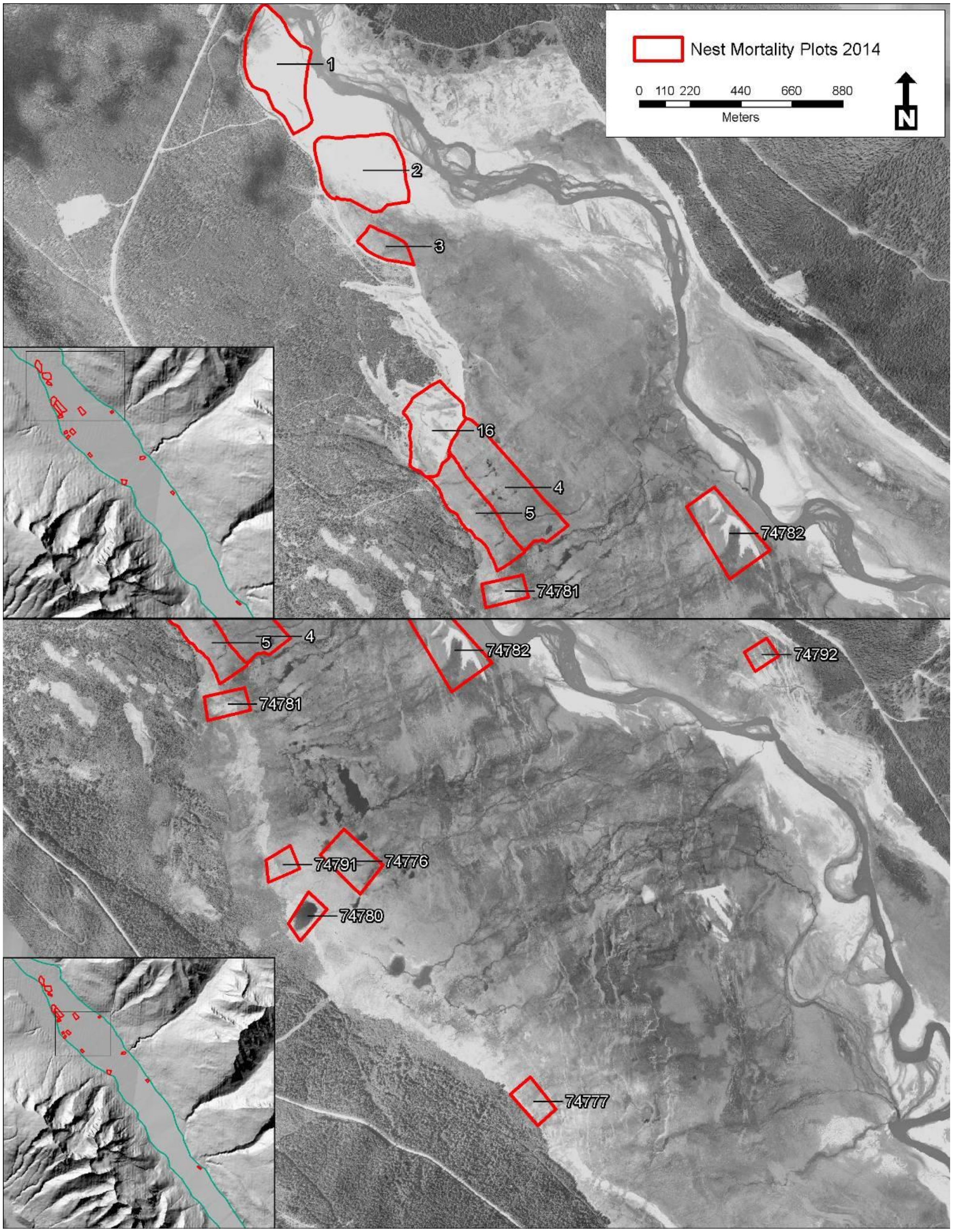
Vegetation communities within the Kinbasket Reservoir drawdown zone mapped by CLBMON 10 (Hawkes et al. 2010)

Code	Vegetation Community	Description
BR	Bluejoint Reedgrass	Above CH, often above KS
BS	Buckbean–Slender Sedge	Very poorly drained, wetland association
CH	Common Horsetail	Well drained, above LL or lower elevation on sandy, well-drained soil
CO	Clover–Oxeye Daisy	Well drained, typical just below shrub line and above KS
CT	Cottonwood – Trifolium	Imperfectly to well drained, above CO, below MC and LH
DR	Driftwood	Long, linear bands of driftwood, very little vegetation
FO	Forest	Any forested community
KS	Kellogg's Sedge	Imperfectly to moderately well drained, above CH
LH	Lodgepole Pine–Annual Hawksbeard	Well drained, above CT along forest edge, very dry site
LL	Lady's Thumb–Lamb's Quarter	Imperfectly to moderately well drained; the lowest vegetated elevations
MA	Marsh Cudweed–Annual Hairgrass	Imperfectly to moderately well drained; common in the Bush Arm area
MC	Mixed Conifer	Well drained, above CT along forest edge
RC	Reed Canarygrass	Imperfectly to moderately well drained; similar elevation to CO community
RD	Common Reed	*Phragmites australis*
SH	Swamp Horsetail	Poorly drained, wetland association
TP	Toad Rush–Pond Water-starwort	Imperfectly drained, above LL, wet sites
WB	Wool-grass–Pennsylvania Buttercup	Poorly drained, wetland association
WD	Wood Debris	Thick layers of wood debris, no vegetation
WS	Willow–Sedge wetland	Very poorly drained, wetland association

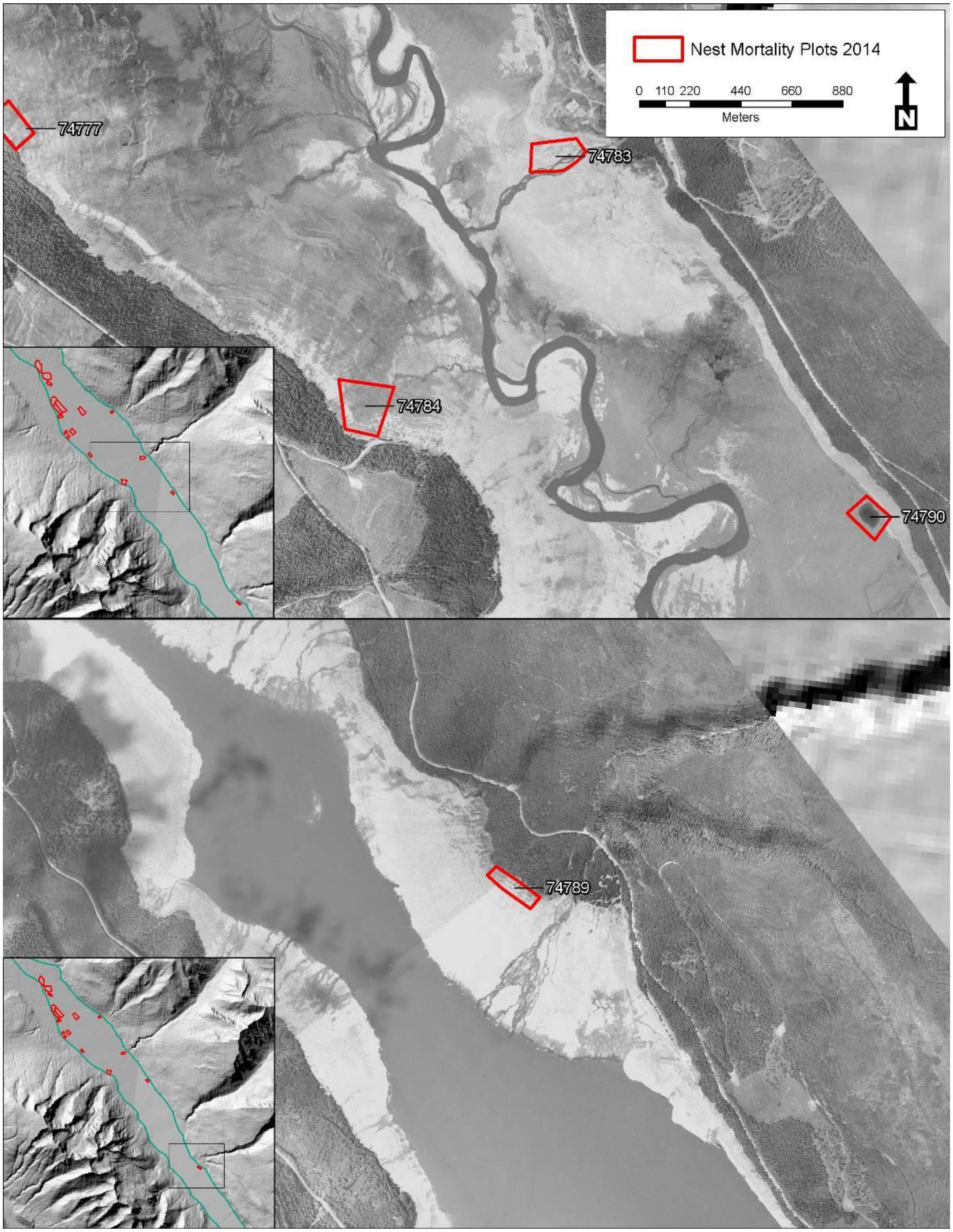
Vegetation communities within the Revelstoke Reach drawdown zone

Code	Category	Description
RF	Riparian forest	Riparian forest with cottonwoods and shrubs, with variable conifer component
UC	Upland conifer	Conifer-dominated upland forest
UM	Upland mixed	Upland forests typically containing high amounts of birch and white pine
EG	Equisetum grassland	Horsetail-dominated grassland
MG	Mixed grassland	Grasslands with variable mixture of graminoids
PG	Sparse grassland	Grasslands with sparse/low graminoid cover
RC	Reed canarygrass	Grasslands dominated by well-developed reed canarygrass cover
SG	Sedge grassland	Sedge-dominated grassland
SH	Shrub savannah	Shrub-savannah
SR	Riparian shrub	Riparian shrub
BE	Steep bedrock	Bluffy steep banks comprised of bedrock slabs or cliffs. Variable vegetation and coarse woody debris
RB	Rocky bank	Steep banks comprised of boulders, talus, and loose rocks. Variable vegetation and coarse woody debris
SB	Sand bank	Sand banks - usually failing. Variable vegetation and coarse woody debris
TH	Thalweg	Columbia River channel
CR	Coarse rocks	Coarse rocks, cobbles, boulders, etc.
GR	Gravel	Gravel, pebbles, etc.
SA	Sand	Sand
SI	Silt	Silt
UR	Urban	Residential, industrial, etc.
BF	Floating bog	Floating peat bog that provides island habitat
BR	Bulrush	Pond habitat with large stands or patches of bulrush
BS	Submerged buoyant bog	Peat bog that rises with water but becomes flooded
CK	Creek	Gravel/rocky creek channel or estuary
CT	Cattail	Cattail-dominated wetland
CW	Shrub wetland complex	Transitional, containing a mixture of wetland components, often with shrubs
LD	Low elevation draw	Muddy/clay depression or channel
PO	Pond	Open water pond habitat with variable amounts of submergent vegetation
SW	Swamp	High in the drawdown zone. Beaver ponds, skunk cabbage, alders, etc.
WM	Wet meadow	Sedge, grass, seasonally flooded area with depressions
WS	Water Sedge	Sedge-dominated marsh of fen

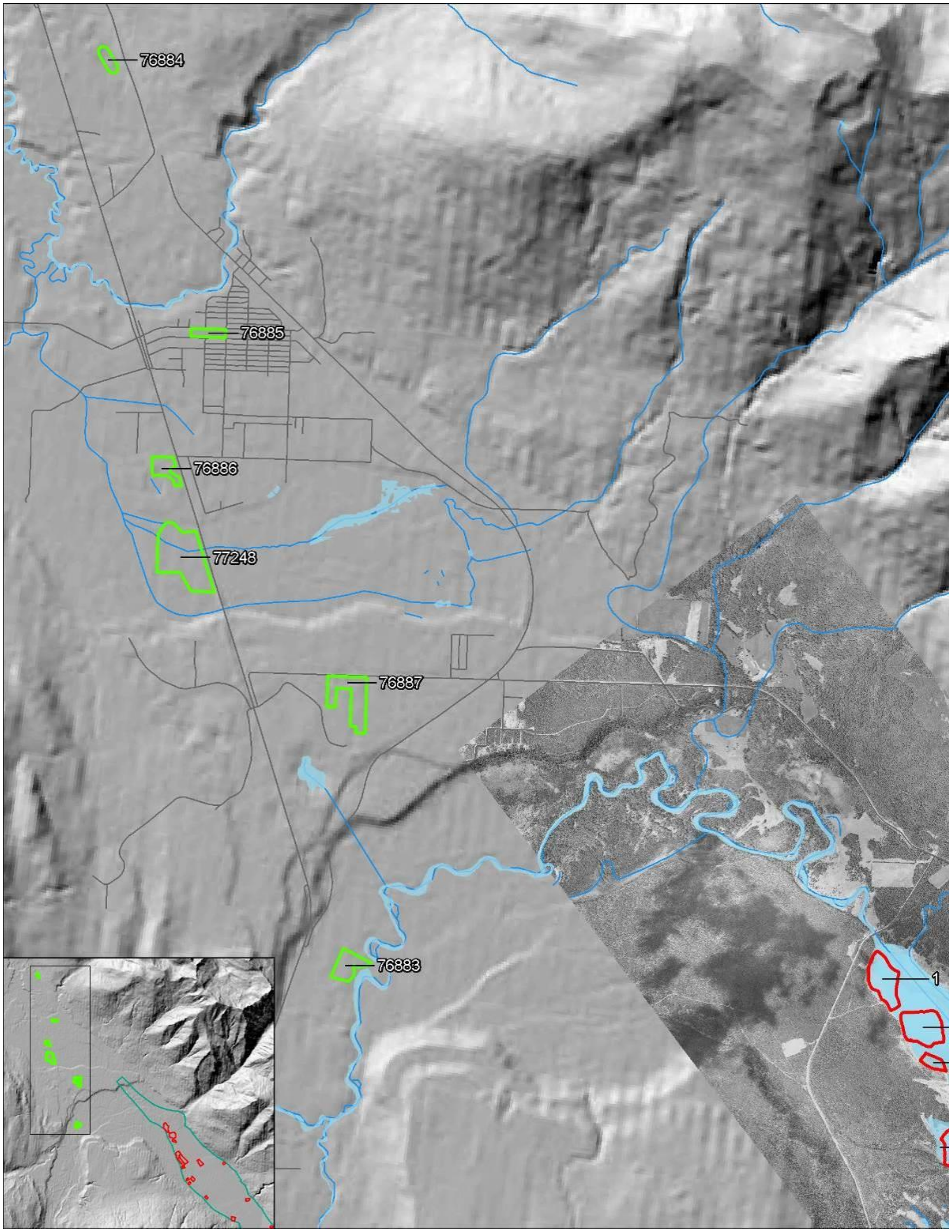
Appendix 6-3: Locations of study sites at Canoe Reach



Northern Canoe Reach

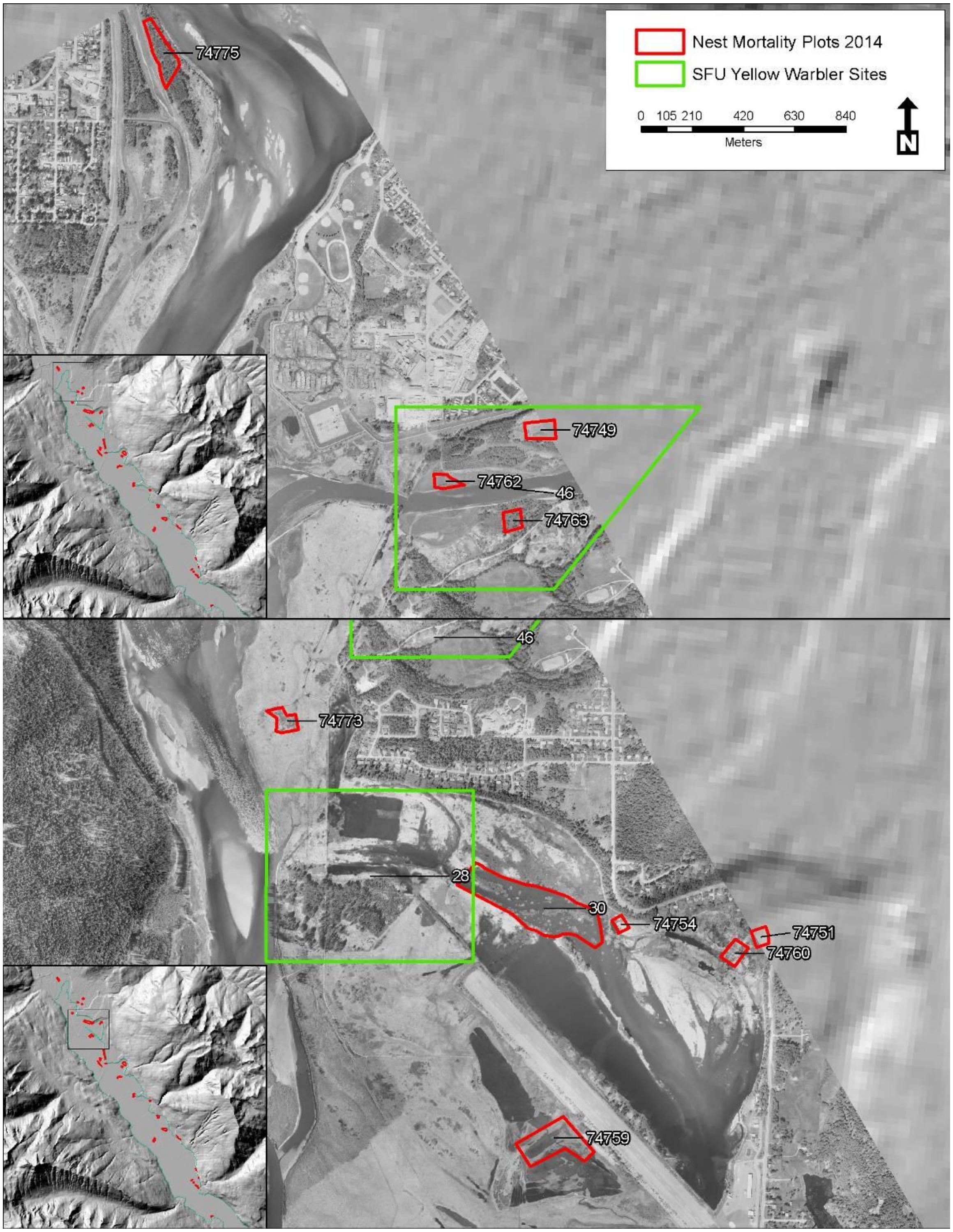


Southern Canoe Reach

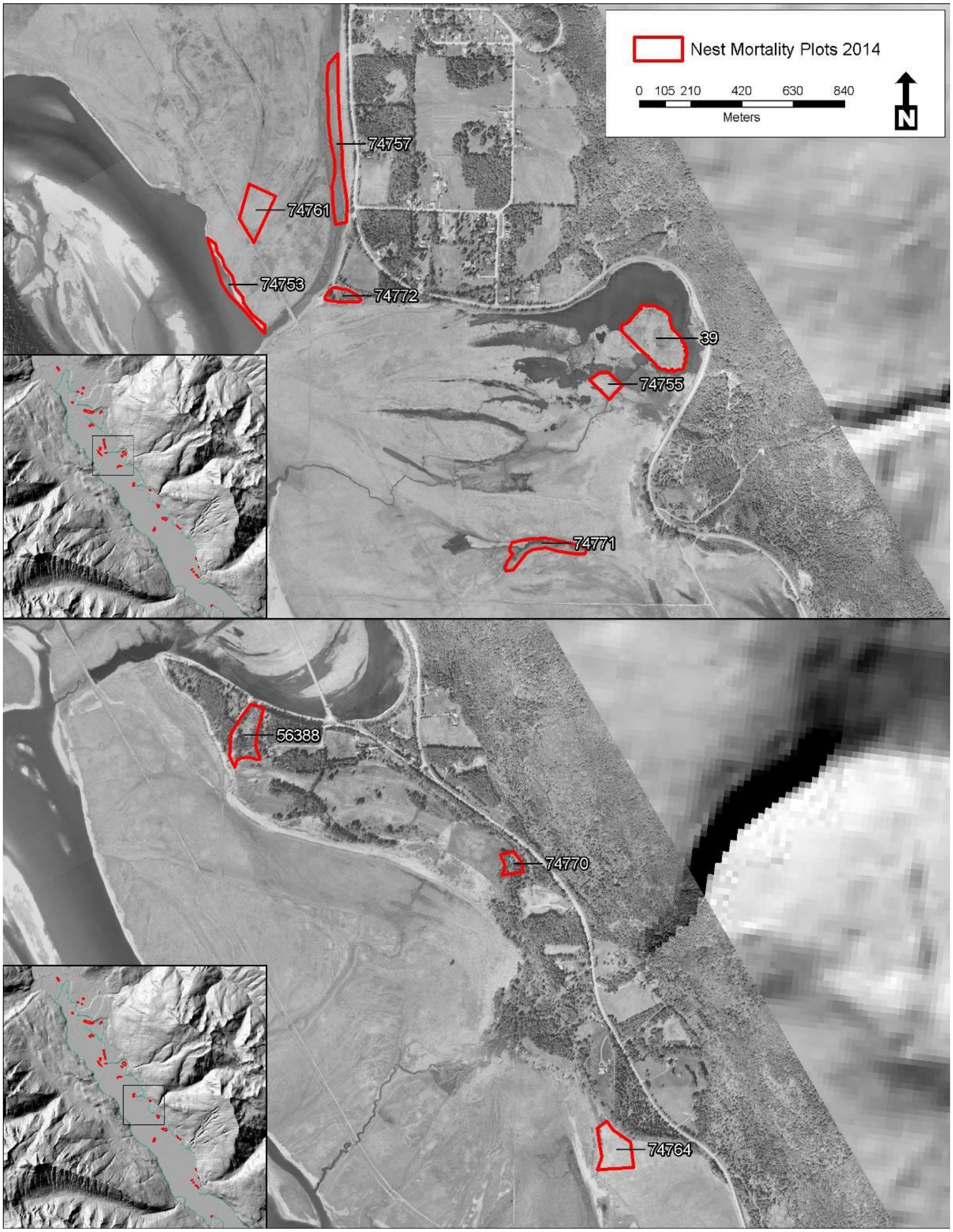


Focal species monitoring sites above the drawdown zone (SAVS)

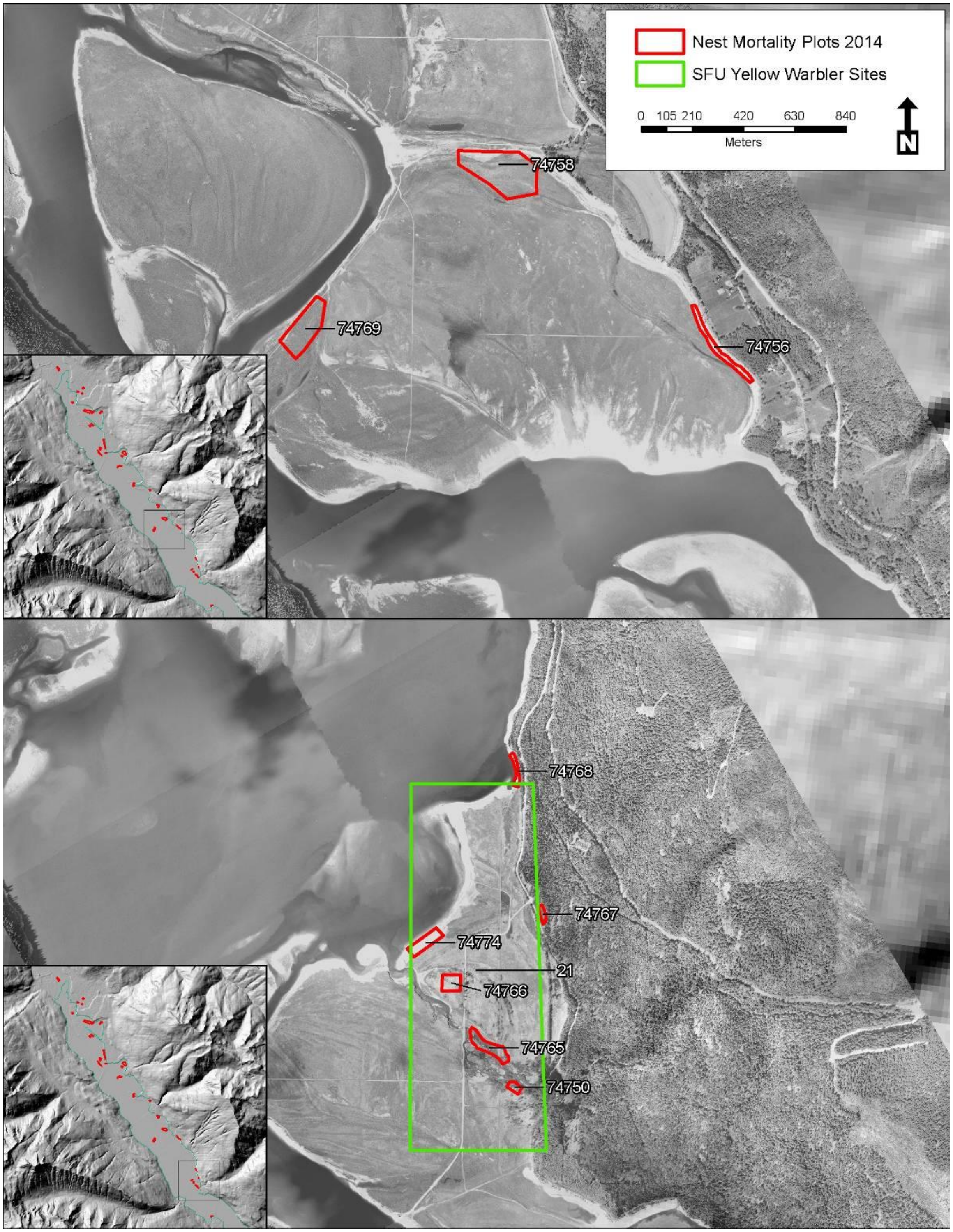
Appendix 6-4: Locations of study sites at Revelstoke Reach



Northern Revelstoke Reach - Near Town (top); Airport Marsh (bottom)



Northern Revelstoke Reach. Locke's Creek - Montana Slough (top); Cartier - Greenslide (bottom).



Revelstoke Reach. 9 Mile (top); 12 Mile (bottom).

Appendix 6-5: **Nest mortalities due to reservoir operations (e.g., flooding) in 2014 in each study area (RR = Revelstoke Reach, CR = Canoe Reach)**

Area	Nest ID	Nest Position	Species	Elevation (m ASL)	Nest Height (m)
RR	78534	Low in Shrub	Clay-colored Sparrow	438.2	0.34
RR	78930	Low in Shrub	Clay-colored Sparrow	438.2	0.48
RR	79458	Low in Shrub	Common Yellowthroat	438.2	0.51
RR	78039	Low in Shrub	Common Yellowthroat	438.2	0.35
RR	77241	Low in Shrub	Common Yellowthroat	438.4	0.2
RR	78019	Ground	Long-eared Owl	438.0	0
RR	78037	Low in Shrub	Song Sparrow	438.3	0.4
RR	78213	Low in Shrub	Virginia Rail	438.2	0.25
RR	78872	Low in Shrub	Virginia Rail	438.2	0.25
RR	78003	Low in Shrub	Virginia Rail	438.3	0.14
RR	78016	Low in Shrub	Virginia Rail	438.2	0.13
RR	78309	Low in Shrub	Virginia Rail	438.3	0.25
RR	77442	Shrub	Yellow Warbler	437.2	1.0
RR	78900	Low in Shrub	Yellow-headed Blackbird	438.2	0.68
RR	78894	Low in Shrub	Yellow-headed Blackbird	438.2	0.67
RR	78902	Low in Shrub	Yellow-headed Blackbird	438.2	0.75
RR	78528	Low in Shrub	Yellow-headed Blackbird	438.2	0.7