Columbia River Project Water Use Plan

KINBASKET AND ARROW LAKES RESERVOIRS

Reference: CLBMON-36

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

Study Period: Year 10, 2017

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May 3, 2018

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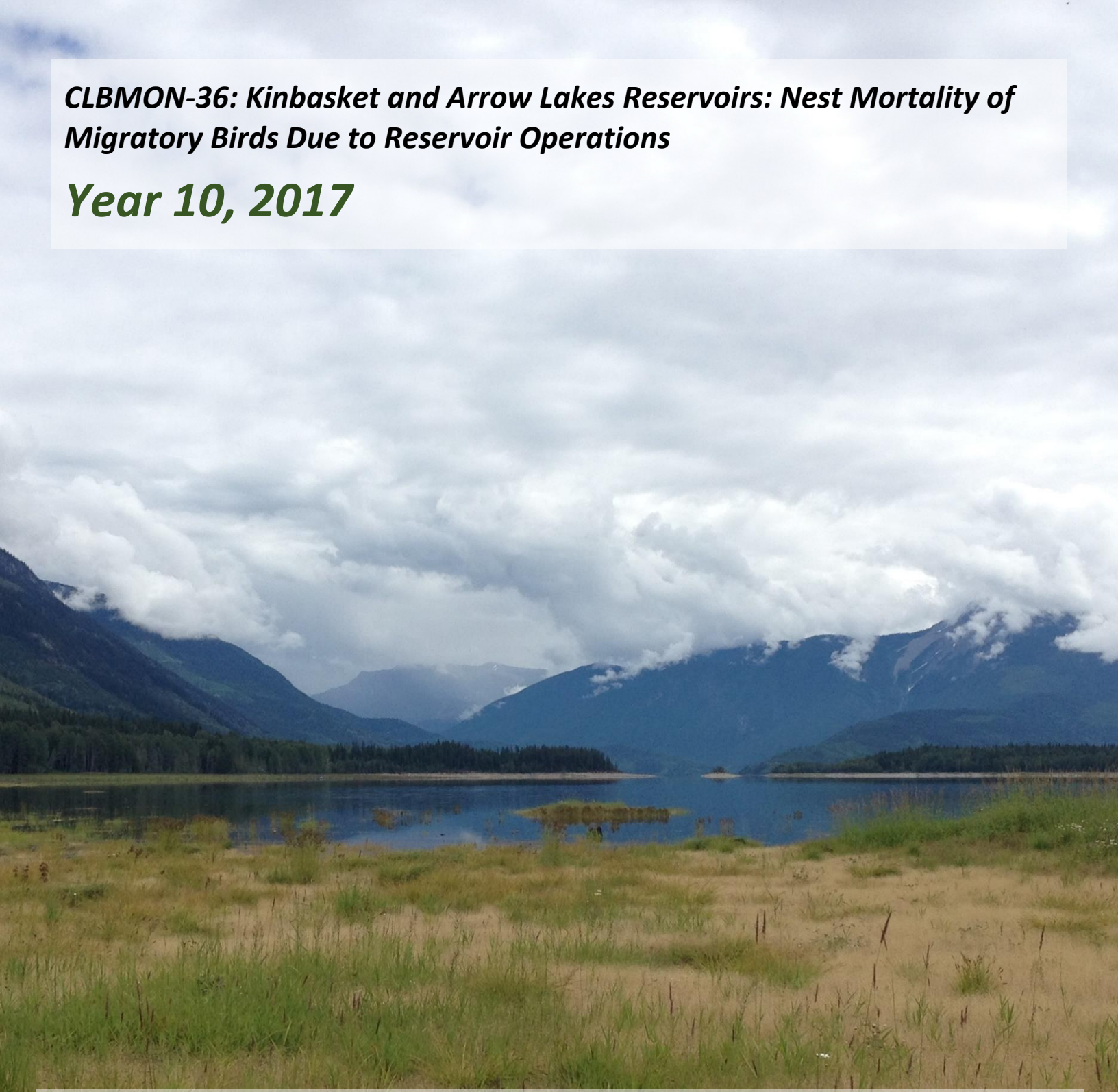

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Report prepared for: BC Hydro, Water Licence Requirements, Burnaby, British Columbia

May 3, 2018

Suggested Citation:

Craig, C., R. Gill, and J.M. Cooper. 2018. CLBMON-36: Kinbasket and Arrow Lakes Reservoirs: nest mortality of migratory birds due to reservoir operations— Year 10, 2017. Unpublished report by Cooper Beauchesne and Associates Ltd., Qualicum Beach, BC, for BC Hydro Generation, Water Licence Requirements, Burnaby, BC. 24 pp. + Apps.

Cover photo: Revelstoke Reach drawdown zone, Arrow Lakes Reservoir, 2017 (photo by Catherine Craig)

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 Water Licence Requirement, BC Hydro committed to research the impacts that reservoir operations have on the productivity of birds breeding in the reservoir drawdown zones of Kinbasket (KIN) and Arrow Lakes Reservoirs (ALR). CLBMON-36 is a 10-year monitoring program designed to fulfill this commitment. This report summarizes field study and analysis conducted in **2017**, **Year 10** of CLBMON-36.

At KIN, research has focussed on two regions. Canoe Reach (CR), near Valemount, BC, was monitored annually during the first eight years of the project (2008-2015). To increase knowledge of breeding birds using vegetation communities within the drawdown zone that were not well-represented at CR, Bush Arm (BA), near Golden, BC, was monitored for five years (2010-2012, 2016, 2017). At ALR, one study area, Revelstoke Reach (RR), has been monitored since project inception (2008). All three study areas contain relatively high amounts of vegetated habitat, and appear to constitute the most important areas for breeding birds within the vast drawdown zones of the two reservoirs.

PROJECT OVERVIEW

Nest mortality: biogeography and site productivity monitoring

In Years 1-5, the focus of field research was to document how avian communities were distributed in the drawdown zones of KIN and ALR, and to document how nesting productivity was influenced by reservoir operations. New, previously unsampled sites were chosen annually, stratified among habitat classes, and monitored during the entire breeding season with the goal of finding all nests within 3 m of the ground at each site.

An initial examination of biogeographical and productivity data completed for the Year 5 Interim Report (Y5IR) showed that the cumulative increase in species richness documented by the study had levelled off at both reservoirs after Year 3, indicating that knowledge of the diversity of species regularly nesting in the drawdown zones of both reservoirs was near complete. Nonetheless, nests of additional uncommon species have continued to be located since that time. To date, 30 species have been discovered nesting in KIN's drawdown zone, and 65 species in ALR's. While we are confident that all regular species have been documented, additional rarities are likely to be discovered occasionally in the future.

It was evident by Year 5 that the project had attained a basic understanding of the biogeography of nesting communities within and among the various drawdown zone habitats of ALR and KIN. 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 (see Y5IR Appendix 1 and 2 for additional details).

The Y5IR revealed that active nests in the ALR drawdown zone were often submerged by annual reservoir operations (mean = 11.7% of monitored nests were observed to have

flooded). 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. At ALR, the reservoir elevation is typically increased to elevations at which there are many nests during the time when these nests are active; whereas, at KIN, the reservoir is raised later in the breeding season, when fewer nests are active. Nest flooding affects species at ALR disproportionately; for some species, nest flooding was the leading cause of nest failure (e.g., Yellow-headed Blackbird, *Xanthocelphalus xanthocephalus*), while for others, it was a relatively unimportant impact, clearly something that is related to species nesting habitat preferences.

A major result presented in the Y5IR was the production of the first empirically derived mechanistic model of nest activity as a function of elevation and time, allowing nest flooding rates to be modelled within the mapped parts of the drawdown zone.

Focal species research

In addition to the biogeography (community-level) study described above, monitoring of focal species allowed specific ecological processes to be explored within certain populations. This research explored how reservoir operations impact aspects of productivity including nest survivorship and the post-fledging survivorship of juveniles. Focal species were monitored by targeted nest searches and subsequent nest inspections, and by using radio telemetry to track juvenile survivorship. This approach allowed us to determine if reservoir inundation of post-fledging habitat affected their survival. To determine if juvenile survival is impacted by reservoir operations 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.

Focal species monitoring has been ongoing since project inception for two species: Savannah Sparrow (*Passerculus sandwichensis*, SAVS) in the CR study area, and the Yellow Warbler (*Setophaga petechia*, YEWA) in RR. SAVS monitoring has been an increasing focus of field study since Year 5.

Since 2008, we have generated substantive nesting data for ground-nesting SAVS in KIN. Analysis of this nest monitoring and juvenile survival data will be completed for the 10 Year Comprehensive Report. YEWA have been studied in collaboration with Dr. D.J. Green (and students) at Simon Fraser University (SFU). Due to the collaboration, three YEWA populations in the ALR drawdown zone have 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. An additional paper has shown that YEWA (and Willow Flycatcher, *Empidonax traillii*) are buffered from the effect of nest flooding to some degree because they are compensated for nest flooding by reduced predation rates at non-flooded nests within flooded habitat. Our component study of juvenile YEWA survival using telemetry concluded in Year 7 (2014), and had sufficient data to show a negative impact of reservoir operations on juvenile survivorship.

SUMMARY OF YEAR 10

In Year 10, field work continued in BA and RR. Both reservoirs were relatively high throughout the nesting season compared to historic levels, which led to greater nest flooding impacts.

KIN's above average water levels earlier in the season led to four nests being flooded, two fewer than in 2016, but higher than is typical for that reservoir. ALR filled to a relatively high maximum level of 439.5 m ASL on July 27th. Observations of nest flooding in the ALR were higher than in the two previous years (17 nests).

In 2017, we continued to monitor two focal species (YEWA at ALR and SAVS at KIN). Additionally, we conducted targeted searches for Cedar Waxwing (*Bombycilla cedrorum*, CEDW) nests to increase our sample size of nests for that species. To continue documentation of the variation in breeding bird communities, we monitored 116 ha of mapped habitat at KIN and 46 ha of mapped habitat at ALR.

We located 294 nests from a total of 27 species; 51 of these were at BA (5 species), and 243 of were at ALR (27 species). No new species were found nesting at the 2017 study sites; however, two adults and one juvenile Yellow-breasted Chat (*Icteria virens*) were captured post-field season at the Machete Island banding site, suggesting that this species likely bred within ALR in 2017. At ALR, 54% of monitored nests were successful, and 58% were successful at KIN.

In Year 10, 18 SAVS nestlings were tagged for juvenile survival monitoring in the drawdown zone at BA. 44% of the tagged juveniles survived their monitoring period; two of the young drowned in the rising reservoir pool.

With data collection now complete for the CLBMON-36 study, the project is in a solid position to address each objective, Management Question, and hypothesis, and in the 10 Year Comprehensive Report.

KEYWORDS

River regulation, reservoir operations, nest mortality, habitat distribution, habitat suitability, nest flooding, nest monitoring, nest survivorship, juvenile survivorship, Yellow Warbler, *Setophaga petechia*, Savannah Sparrow, *Passerculus sandwichensis*, Arrow Lakes Reservoir, Kinbasket Reservoir, BC Hydro, British Columbia.

ACKNOWLEDGEMENTS

Many people contributed during Year 10 of CLBMON-36. BC Hydro WLR sponsored the project. CBA is very grateful to Trish Joyce, Susan Pinkus, Harry van Oort, and Margo Sadler of BC Hydro for their ongoing support and management of this project.

CBA collaborates with the Okanagan Nation Alliance (ONA) for the delivery of CLBMON-36. ONA biologists and technicians provide field and technical support, and insight into the perspectives and protocols of the Syilx (Okanagan) people. Bruce Weaver of the Okanagan Indian Band, and Mike Dunn and Autumn Solomon of the ONA contributed to field studies. Dave DeRosa managed the ONA's collaboration.

We would like to acknowledge the hard work of James Bradley, Catherine Craig, Mike Dunn, Ryan Gill, Rianne Mariash, Michal Pavlik, Emily Smith, Autumn Solomon, Bruce Weaver, and Emily Williams in collecting field data.

Ryan Gill and Catherine Craig planned the field research program. Catherine Craig conducted all analyses for this report. Ryan Gill provided GIS mapping. Suzanne Beauchesne provided overall supervision and monitoring of field 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, which was conducted by Michal Pavlik and Rianne Mariash in 2017. Dr. David Green provided scientific guidance to CBA. All procedures followed in this study were approved by the Simon Fraser Animal Care Committee.

CBA would also like to thank the community of Revelstoke for providing an enjoyable home base for crews during the field season.

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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 river discharge (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 main stem (other impoundments exist on the tributaries). The footprint impact of Columbia River basin reservoirs has been estimated to cause a loss of 26% of the wetlands, 21% of riparian cottonwood, and 31% of shallow water and ponds in BC portion of the 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 reservoir drawdown zones in BC, important wildlife habitats persist, some with significance as nesting habitat for a variety of birds. In particular, the upper four meters 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 of 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 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]; both situations are a possibility due to potential flooding of nesting habitats, and nests during the breeding season (Wolf 1955, Espie et al. 1998, Anteau et al. 2012).

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 via nest submersion. 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 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 identified in 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

[1] Ecological traps occur when populations prefer/select unnatural habitats where reproduction is compromised (misguided preferences). 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.

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 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-36 list the following Management Questions (MQs) for the research to 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 MQs, 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**, **MQs,** and **Hypotheses** were refined in the CLBMON-36 TOR revisions in 2014. The TOR revision addressed several outstanding issues that were highlighted in previous reports (e.g., CBA 2013) and improved clarity. Notably, two MQs (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, MQs, and hypotheses are related is provided in Appendix 6-1.

1.4 Study areas

Field studies in 2017 were conducted at one study area in each reservoir: RR (ALR) and BA (KIN; Figure 1-1).

1.4.1 Bush Arm, Kinbasket Reservoir

KIN is the upper-most reservoir along the Columbia River. KIN 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, north, down the Columbia River and further north up the Canoe River to ~ 7 km south of Valemount. The reservoir is regulated by outflow at the Mica Dam near the Columbia River's 'Big Bend' (input is unregulated), and is licensed to operate between 707.41 m and 754.38 m elevation (BC Hydro 2007). Additional storage to 754.68 m may be attained with approval from the BC Comptroller of Water Rights.

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 (see Appendix 6-2), with annual nest density estimates ranging up to 2.35 nests per ha (CBA 2013). The habitat with the greatest nest density (WS = Willow-Sedge wetland), had the highest diversity of nesting species (13 species), and a mapped area of ~35 ha within the KIN drawdown zone.

BA is located at the southern end of the reservoir (Figure 1-1) and is formed where the Bush River flows west into the Columbia from the Rocky Mountains. The study area is about 24 km long and extends from Bear Island to the Bush River. Like most of KIN, the drawdown habitats are largely barren. The drawdown zone is rocky in places, but much of the area is comprised of unvegetated silt and old tree stumps are a common feature (Figure 1-2). Sedge wetlands and some shrub habitat occur sporadically along the upper elevations of the drawdown zone, typically near upslope seepages or wetlands (Figure 1-3). Reed canarygrass (*Phalaris arundinacea*), common cattail (*Typha latifolia*) and willow (*Salix* spp.) are established at one location. Some areas include small, rich, remnant wetland habitat, vegetated with willow and skunk cabbage (*Lysichiton americanus*).

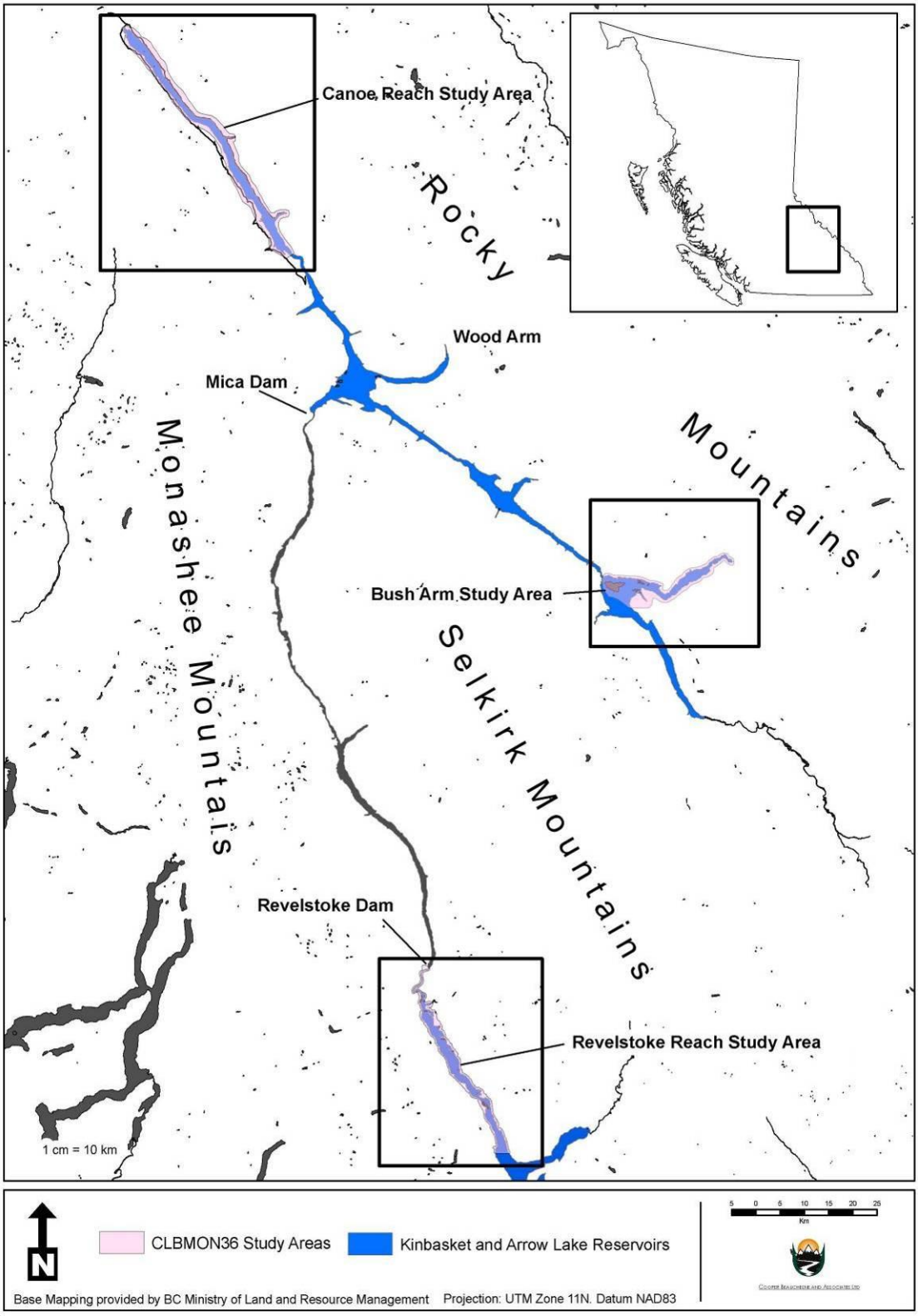

Figure 1-1: Overview map of the three CLBMON-36 study areas (lakes are shown in black). Canoe Reach was not monitored in 2017

BA occurs in the Moist Mild Interior Cedar Hemlock (ICHmm, variant 1) biogeoclimatic subzone (Meidinger and Pojar 1991), and receives moderate precipitation, primarily from Pacific frontal systems that shed snow during the winter. As with Canoe Reach, the reservoir in Bush Arm is surrounded by steep slopes with managed coniferous forests.

Figure 1-2: **Bush Arm drawdown zone is commonly unvegetated with stumps. This example of such habitat is classified as LL (Lady's Thumb–Lamb's Quarter)**

Figure 1-3: **At certain locations in Bush Arm drawdown zone where there are sources of ground water, a rich wetland vegetation community can exist. The unique drawdown zone habitat in this picture is classified as WS (Willow–Sedge Wetland)**

1.4.2 Revelstoke Reach, Arrow Lakes Reservoir

The Hugh Keenleyside Dam is located approximately 8 km north of Castlegar. The completion of the dam in 1968 created ALR, which extends approximately 240 km north to Revelstoke and has a licensed storage capacity of 7.1 MAF (BC Hydro 2007). The facility 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. ALR is licensed to operate between 418.6 m and 440.1 m elevation. 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 ALR. 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 above 434 m ASL; willow (*Salix* spp.*)* and cottonwood (*Poplar balsamifera*) grow as low as 436 m ASL, but become well-established at 438 m (Figure 1-4), within a matrix of dense graminoid cover (Figure 1-4). 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 1-4 **Shrub savannah habitat in the drawdown zone of Revelstoke Reach (~438 m ASL). This habitat is often subjected to as much as 2 m of habitat flooding in the mid to late breeding season**

1.5 Scope of work in 2017

This annual report presents data collected in Year 10 (2017). As in Years 6-9, a concentrated effort was made in Year 10 to conduct productivity and telemetry monitoring. In Year 10, work focused on Savannah Sparrow (*Passerculus sandwichensis*, SAVS) in BA and continued with regular nest monitoring in RR. On-going multi-year analysis projects continued in Year 10 and these results will be presented in the 10 Year Comprehensive Report.

2 METHODS

The methods followed those used in previous years (CBA 2016).

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.

In addition to the community-level nest mortality monitoring, we also focussed on finding and monitoring nests, and the juvenile survival of, several focal species. The purpose of focal species monitoring was to examine factors influencing the survivorship of nests and of juveniles post-fledging. Field efforts attempted to generate larger sample sizes of nests of selected species for statistical purposes; there was reduced emphasis on finding every nest at a given site, and site boundaries were of less importance. Focal species monitoring was also conducted at multiple sites, including some above the drawdown zone. In 2017, focal species monitoring centred on SAVS in CR, and Yellow Warbler (*Setophaga petechia*, YEWA) and Cedar Waxwing (*Bombycilla cedrorum*, CEDW) in RR. Radio telemetry was used on SAVS in BA to monitor post-fledging 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 in 2017. In BA, six sites were monitored for the SAVS juvenile survival study (four at the Bush Arm Causeway, km 69, and km 87). 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. In 2017, we also monitored sites 113404 (CEDW Jordan River) and 112402 (Rob's Willows CEDW) specifically to increase our sample size of CEDW nests both within and outside of the drawdown zone.

In RR, two unique sites have been monitored at the community-level annually because they provide particularly important time series data. Site 39 (Montana Slough) contains most of the floating bog habitat. This habitat is unique and becomes populated by breeding birds following their displacement by reservoir flooding elsewhere in the drawdown zone. Site 30 (at Airport Marsh) includes some of the best examples of water sedge, cattail and bulrush habitat, and contains the only colony of Yellow-headed Blackbird (*Xanthocelphalus xanthocephalus*) in ALR. This site also provides nesting habitat for other regionally uncommon species such as Pied-billed Grebe (*Podilymbus podiceps*), Virginia Rail (*Rallus limicola*), Sora (*Porzana carolina*), and Marsh Wren (*Cistothorus palustris*) (CBA 2015b).

Site selection for community-level monitoring followed a systematic sampling design with new sites chosen annually. Sites were chosen to maximize spatial replication and stratification among each of the available habitat types identified in GIS maps. 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. At 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 to nest locations (Martin and Geupel 1993). In grassland habitats, rope dragging was used strategically to flush birds from nests, especially prior to sites becoming submerged. Nest searching effort was adjusted based on the potential to find additional nests. For example, sites populated by numerous breeding adult birds but with relatively few known nest sites were prioritized for nest searching over sites where birds were not detected, or where all nests were known for most detected birds. 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 due to lack of nesting habitat and lack of birds, but multiple visits to the site were made during the season. When active nests were located, sites were re-visited regularly for nest monitoring. In most cases, site visits included some additional nest searching but sometimes the sites were visited only to monitor active nests. Field technicians attempted to find and monitor all nests (less than 3 m above ground) at selected sites throughout the entire nesting season.

2.2.2 Nest monitoring

Standard nest site data were collected at all nests (nest position, nest substrate, habitat description, 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 successful if it fledged one or more young. Nest failure was categorized as being caused by nest predators, reservoir operations, abandonment, 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).

2.3 Focal species capture and monitoring

Targeted mist netting with call-playback was undertaken in areas with focal species. 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, birds 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 allow field biologists to identify and track these individual birds. Re-sighting colour

banded birds assisted in mapping territories, monitoring juvenile survivorship, and documenting local recruitment and dispersal.

To study juvenile survivorship of SAVS, we used radio telemetry. Lotek PicoPip Ag 317 (≤0.39 g) 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 either the bird died, the transmitter battery expired, or the bird could no longer be found. Transmitters were attached with a fine elastic filament designed to drop off following expiry of the transmitter battery using a leg-loop harness (Rappole and Tipton 1991).

2.4 Data summary and analysis

Historic reservoir data 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 2017).

2.5 Permits

Bird handling and telemetry protocols were approved by the SFU Animal Care Committee (1038B-04). Banding was conducted under Federal Scientific Permits to Capture and Band Migratory Birds issued to John Cooper (#10663), Catherine Craig (#10663G), and Michal Pavlik (#10841).

3 RESULTS

3.1 Year 10 summary

3.1.1 Reservoir operations

Both reservoirs were relatively high throughout the nesting season compared to historic levels; however, the pattern of increase and decrease was typical.

At KIN, the water level was higher than usual in May (as was also the case in 2015 and 2016) and increased throughout the breeding season, reaching a maximum elevation of 752.1 m during August 19 to 25.

At ALR, the water level increased in the spring, reached a maximum elevation in July, and then decreased throughout August. Like 2011 and 2012, the reservoir was close to its annual maximum for several weeks (in July this year), rather than having a steady increase followed immediately by a steady decrease in elevation. The ALR reached a maximum elevation of 439.57 m on July 27 (Figure 3-1).

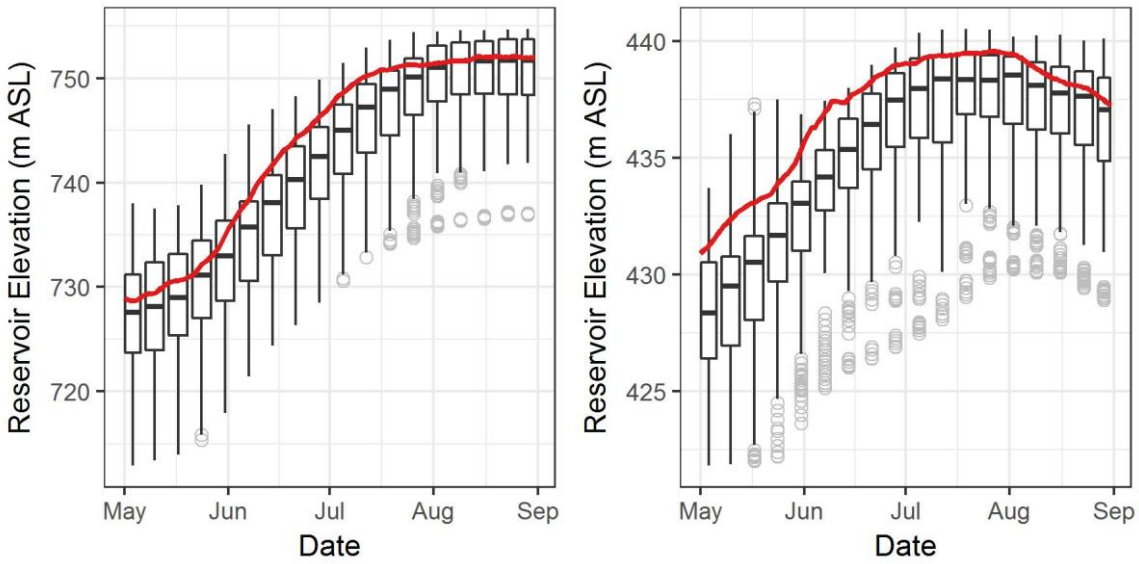

Figure 3-1: **Reservoir elevations at Kinbasket Reservoir (left) and Arrow Lakes Reservoir (right) during the nesting season, showing weekly boxplots of historical data and the 2017 elevations in red.**

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). Except for in early May, temperatures were warmer than usual in Revelstoke throughout the nesting season (Figure 3-3).

On July 23 there was an unusually strong windstorm at RR, with wind speeds topping 96 km/h. The high winds are believed to have caused the failure of four nests.

At RR, notable bird observations relation to previous years included the following:

- Brewer's Blackbird continued to have low abundance compared with what was normal at the initiation of the project
- Yellow-headed Blackbird were less abundant than in previous years
- Greater numbers of Spotted Sandpiper (*Actitis macularius*) nests were found
- Fewer observations of Short-eared Owl (*Asio flammeus*) than in 2016 and there were no nests for this species in 2017
- An uncommon species, Northern Mockingbird (*Mimus polyglottos*), was seen to the west of the airport runway on June 9

In BA, the bird populations were similar to previous years. Two uncommon species were observed on the causeway: Chestnut-collared Longspur (*Calcarius ornatus*) on June 8 and 9, and Yellow-breasted Chat (*Icteria virens,* YBCH) on June 13. Both were only seen on those 1-2 days, thus are not suspected to have bred in the area.

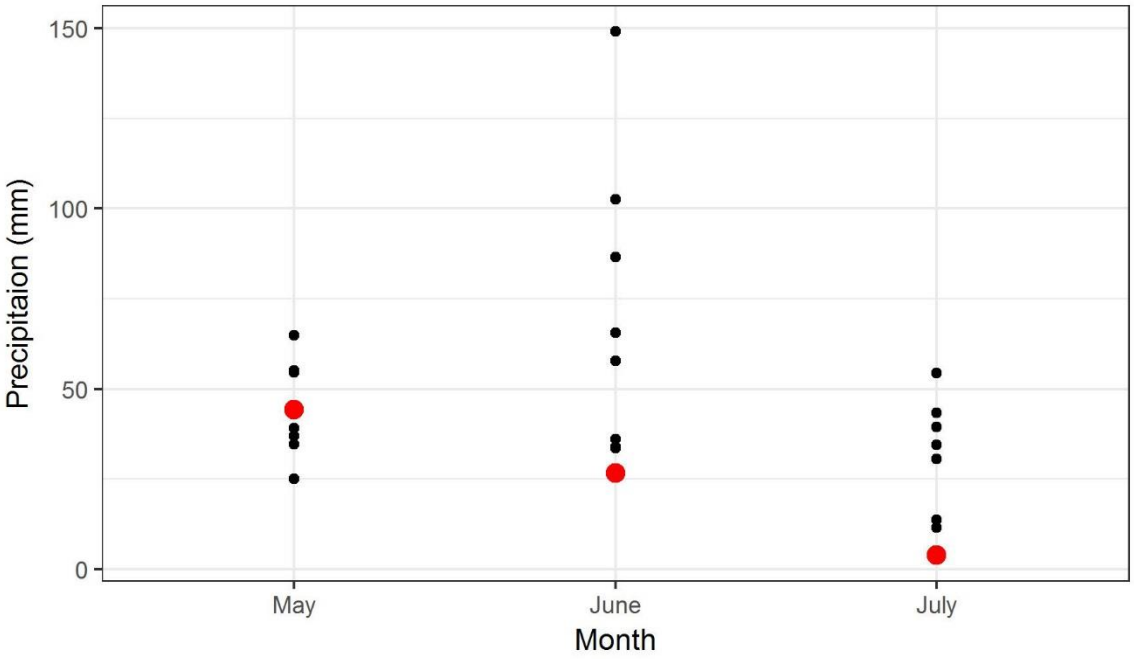

Figure 3-2: **Cumulative precipitation measured at the Revelstoke airport weather station during each year of CLBMON-36 monitoring, with 2017 values in red.**

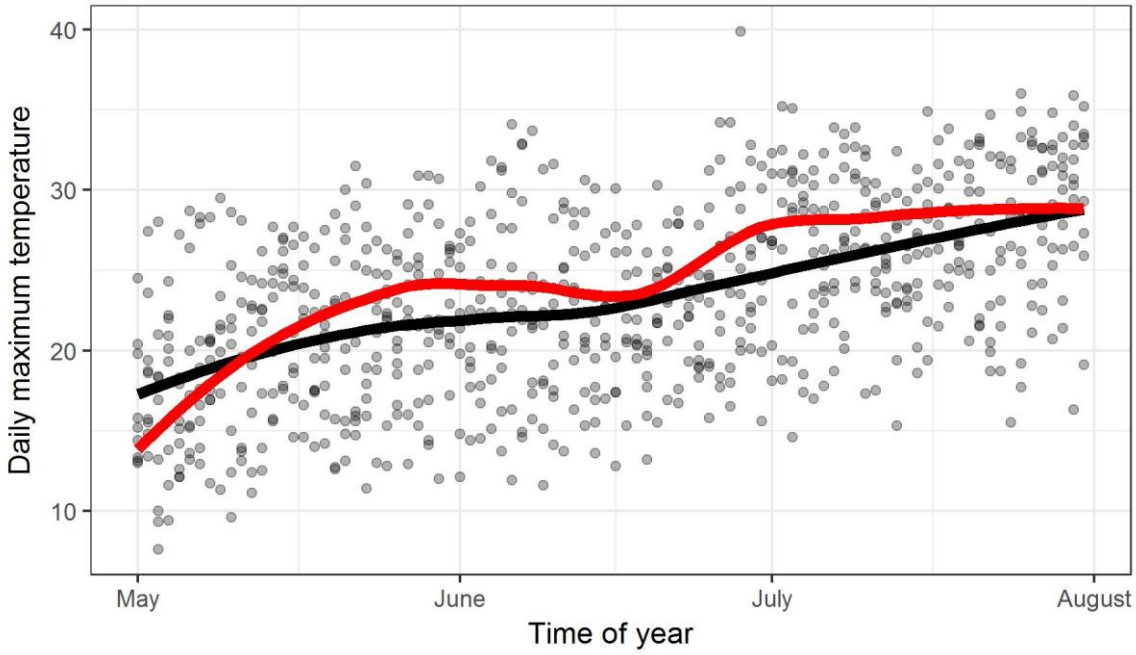

Figure 3-3: **Maximum daily temperatures measured at the Revelstoke airport weather station during CLBMON-36 monitoring. The red line represents maximum daily temperatures in 2017, and the black line represents typical maximum temperatures averaged over all years of the study.**

3.1.3 Survey effort

In both study areas, field crew schedules were coordinated so that surveys were conducted almost daily.

In BA, field sampling was conducted from May 28 to July 26. During this period, we monitored two community-level study sites. Sampling in BA was focused on SAVS and that species was monitored at six additional sites. In total, there were 346 person-hours of survey effort in BA in 2017.

In RR, field sampling was conducted from April 22 to August 23. During this period, 13 community-level study sites were monitored. YEWA was monitored at three additional sites and CEDW was monitored at two additional sites. Additional surveys specifically targeting Canada Goose (*Branta canadensis*) and shorebird nests also occurred throughout RR. In total, there were 987 hours of survey effort in RR in 2017.

3.1.4 Nest records

In 2017, 294 nests from 27 species were located. Of these, 285 nests from 25 species were monitored until young fledged or the nest failed (Table 3-1).

In BA, 51 nests from 5 species were found which accounted for 17% of the nest records (Table 3-1); all nests located and monitored in BA, except for one (the only CEDW nest), were within the KIN drawdown zone.

In RR, 243 nests from 27 species were found, which accounted for 83% of the total nest records (Table 3-1). 226 (93%) of these nests (24 species) were in the ALR drawdown zone; the rest were located above the drawdown zone.

3.1.5 Species at risk

The Southern Mountain population of Yellow-breasted Chat (*Icteria virens auricollis*, YBCH) in British Columbia is designated as ‘Endangered’ under the federal *Species at Risk Act* (COSEWIC 2011). Since 2014, a male YBCH has been observed annually, singing throughout the breeding season at Machete Island; however, this year, a male, female, and one juvenile were caught together at Machete Island during migration banding, strongly suggesting that a pair nested there this year. Unfortunately, this area was not included in our study plots this year so was not surveyed, thus we do not know the exact nest location.

Short-eared Owls (*Asio flammeus*, SEOW) were seen foraging within the drawdown zone this year, but no nests were found (four nests were found in 2016). SEOW is designated as a species of ‘Special Concern’ under the federal *Species at Risk Act* (COSEWIC 2008).

3.1.6 Nest monitoring

Of the nests for which outcomes were determined (280 nests, 98% of all monitored nests), 151 (54%) were successful. Of the 129 documented nest failures, 85 (66%) failed due to predation and 21 (16%) failed due to reservoir inundation. Four nests (one American Robin (*Turdus migratorius*), two CEDW, and one Willow Flycatcher (*Empidonax traillii*)) failed due to nest or nest substrate damage caused by a windstorm on July 23. The cause of failure for the remaining 19 non-flooded nests was uncertain.

Within the drawdown zones, nest success rate was higher in BA (58%) than in RR (54%). At both BA and RR, 8% of monitored nests with known outcomes failed due to reservoir operations.

3.1.7 Nest submersion

Reservoir operations flooded 21 monitored nests from 10 species (Appendix 6-5), although almost half of them were Spotted Sandpiper (10 nests). All flooded nests in 2017 were either on the ground or low in a shrub. The majority (17) of these nests were in the ALR drawdown zone; the other four nests were in the KIN drawdown zone.

3.1.8 Juvenile survival

At BA, 18 nestling SAVS were tagged to study juvenile survival in the KIN drawdown zone. Eight juveniles survived their observation period, although observation was cut short on three birds (due to the end of the field season in BA and one possible transmitter battery failure). Two juveniles drowned due to reservoir flooding; one was killed by predators after fledging; and two were killed when their nest was depredated. The cause of death for two additional juveniles was unknown. One tagged young appeared to have been killed by its parents. We suspect that one transmitter may have failed the day after attachment; another was removed the day after attachment because it seemed to be attached too tightly.

3.2 Multi-year progress

3.2.1 Community-level monitoring

In 2017, 116 ha of mapped habitat was monitored at KIN and 46 ha of mapped habitat was monitored in ALR (Table 3-2 and Table 3-3). At both KIN and ALR, we improved monitoring coverage across many vegetation communities in addition to also expanding monitoring effort over the most common habitat classes (Table 3-2 and Table 3-3).

Table 3-1: Number of nests for each species in Bush Arm (Kinbasket Reservoir) and Revelstoke Reach (Arrow Lakes Reservoir)

		Above Drawdown Zone		Within Drawdown Zone	
Common Name	**Scientific Name**	**Bush Arm**	**Revelstoke Reach**	**Bush Arm**	**Revelstoke Reach**
Pied-billed Grebe	*Podilymbus podiceps*	0	0	0	1
Canada Goose	*Branta canadensis*	0	0	0	39
American Wigeon	*Mareca americana*	0	0	0	4
Mallard	*Anas platyrhynchos*	0	0	0	10
Blue-winged Teal	*Spatula discors*	0	0	0	2
Unidentified Duck	*Anatinae (gen, sp)*	0	0	0	1
Virginia Rail	*Rallus limicola*	0	0	0	2
Sora	*Porzana carolina*	0	0	0	1
Killdeer	*Charadrius vociferus*	0	1	0	0
Spotted Sandpiper	*Actitis macularius*	0	0	13	15
Wilson's Snipe	*Gallinago delicata*	0	0	1	13
Willow Flycatcher	*Empidonax traillii*	0	1	0	9
Eastern Kingbird	*Tyrannus tyrannus*	0	0	0	1
Red-breasted Nuthatch	*Sitta canadensis*	0	1	0	0
Marsh Wren	*Cistothorus palustris*	0	0	0	7
Swainson's Thrush	*Catharus ustulatus*	0	1	0	0
American Robin	*Turdus migratorius*	0	0	0	8
Gray Catbird	*Dumetella carolinensis*	0	0	0	5
Cedar Waxwing	*Bombycilla cedrorum*	1	11	0	31
Yellow Warbler	*Setophaga petechia*	0	1	0	45
Common Yellowthroat	*Geothlypis trichas*	0	0	0	7
Chipping Sparrow	*Spizella passerina*	0	0	0	6
Clay-colored Sparrow	*Spizella pallida*	0	0	0	1
Savannah Sparrow	*Passerculus sandwichensis*	0	0	31	2
Song Sparrow	*Melospiza melodia*	0	1	0	12
Lincoln's Sparrow	*Melospiza lincolnii*	0	0	5	2
Red-winged Blackbird	*Agelaius phoeniceus*	0	0	0	1
Yellow-headed Blackbird	*Xanthocephalus*	0	0	0	1

Table 3-2: Habitats monitored in Kinbasket Reservoir (Canoe Reach and Bush Arm) from 2008 through 2017

Habitat Category	Total Area[1]	Monitored Area[2]	Effective 2016[3]	Effective 2017[3]
Bluejoint Reedgrass	41.6	15.3	15.3	15.3
Buckbean–Slender Sedge	12.0	14.4	14.4	20.5
Common Horsetail	287.6	70.4	77.2	85.1
Clover–Oxeye Daisy	136.4	61.2	110.4	136.1
Cottonwood – Trifolium	20.3	6.6	8.5	10.3
Driftwood	36.9	20.5	25.6	28.2
Forest	159.6	2.4	2.6	2.6
Kellogg's Sedge	210.7	52.0	95.3	104.2
Lodgepole Pine–Annual Hawksbeard	0.5	0.5	0.5	0.5
Lady's Thumb–Lamb's Quarter	1299.7	54.9	96.2	102.2
Marsh Cudweed–Annual Hairgrass	140.3	20.1	14.9	23.2
Mixed Conifer	0.2	0.0	0.0	0.0
Reed Canarygrass	31.5	28.8	28.8	45.4
Common Reed	0.6	0.6	1.2	1.2
Swamp Horsetails	52.4	53.8	116.3	132.4
Toad Rush–Pond Water-starwort	310.0	110.8	119.5	120.4
Wool-grass–Pennsylvania Buttercup	128.9	68.3	134.6	144.8
Wood Debris	70.0	27.7	27.7	27.7
Willow–Sedge wetland	34.5	20.5	61.2	66.0

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 – present).
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 summarized for the present year and the previous year.

Table 3-3: Habitats monitored in Arrow Lakes Reservoir (Revelstoke Reach) from 2008 through 2017

Habitat Category	Total Area[1]	Monitored Area[2]	Effective 2016[3]	Effective 2017[3]
Steep bedrock	5.8	0.0	0.0	0.0
Floating bog	2.6	4.8	37.7	42.4
Bulrush	12.7	10.8	96.7	107.4
Submerged buoyant bog	4.2	6.2	35.6	39.5
Creek	25.1	6.8	6.8	6.8
Coarse Rocks	0.1	0.0	0.0	0.0
Cattail	4.3	4.0	12.4	13.5
Shrub wetland complex	12.2	7.5	7.5	7.5
Equisetum grassland	56.6	17.9	17.9	17.9
Gravel	193.5	5.4	5.4	5.4
Low elevation draw	189.0	43.7	63.6	63.6
Mixed grassland	1019.3	92.8	139.8	147.2
Sparse grassland	372.4	45.1	45.5	47.2
Pond	127.5	45.8	87.2	89.3
Rocky bank	57.6	5.7	7.5	7.6
Reed Canarygrass	109.9	38.8	50.9	50.9
Riparian Forest	77.1	32.3	60.4	60.4
Sand	474.1	27.8	24.1	27.9
Sand bank	10.4	2.5	3.4	3.4
Sedge grassland	364.1	72.8	93.3	93.8
Shrub savannah	323.5	91.8	117.3	124.4
Silt	710.1	10.3	10.3	10.3
Riparian shrub	25.8	8.7	13.4	13.4
Swamp	1.2	2.4	2.4	2.4
Thalweg	2068.6	1.4	1.3	1.4
Upland conifer	43.1	0.5	0.6	0.6
Upland mixed	109.8	5.8	10.5	10.5
Urban	1.2	0.0	0.0	0.0
Wet meadow	25.8	8.4	13.6	13.6
Water Sedge	26.0	7.9	32.5	35.6

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 – present).
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 summarized for the present year and the previous year.

3.2.2 Nesting species detections

In 2017, no new species were detected nesting in the KIN or ALR drawdown zones (Figure 3-4), leaving the cumulative species counts at 30 and 65, respectively. A complete list of the number of nests for each species found nesting in the reservoir drawdown zones over the course of the study is in Appendix 6-6.

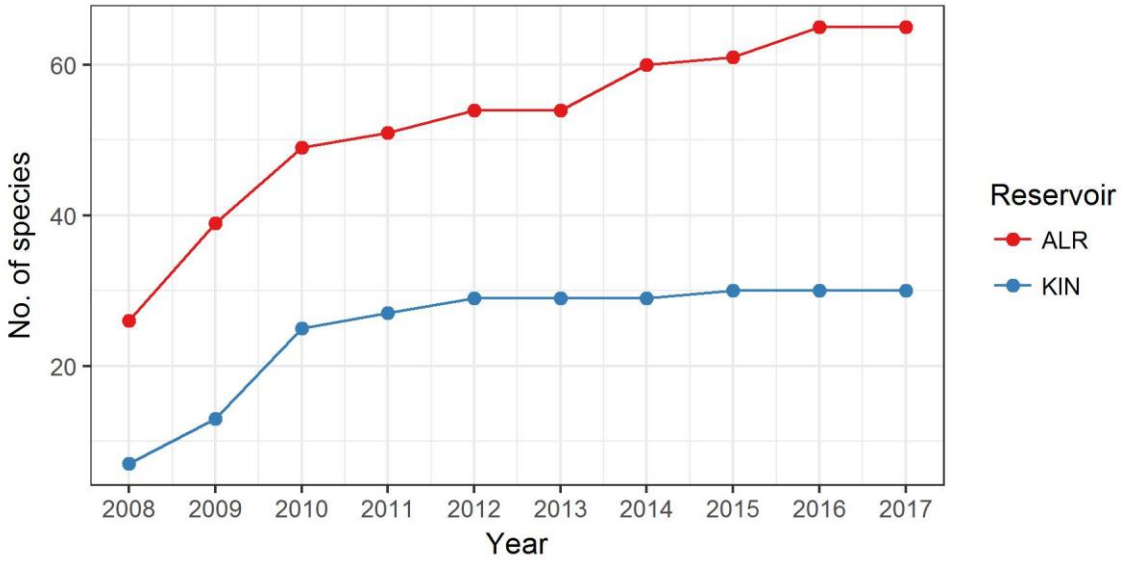

Figure 3-4: Cumulative count of species detected nesting in the drawdown zones of the Arrow Lakes Reservoir (ALR) and the Kinbasket Reservoir (KIN)

3.2.3 Nest submersion

Since 2008, there have been 209 nest failures (of 36 species) observed as a direct consequence of reservoir operations (Table 3-4); 26 nests (8 species) in KIN, and 183 nests (35 species) in ALR. At KIN, nest inundation was observed in every year except 2008, 2009, and 2014; at ALR, nest inundation was observed in every year except 2015.

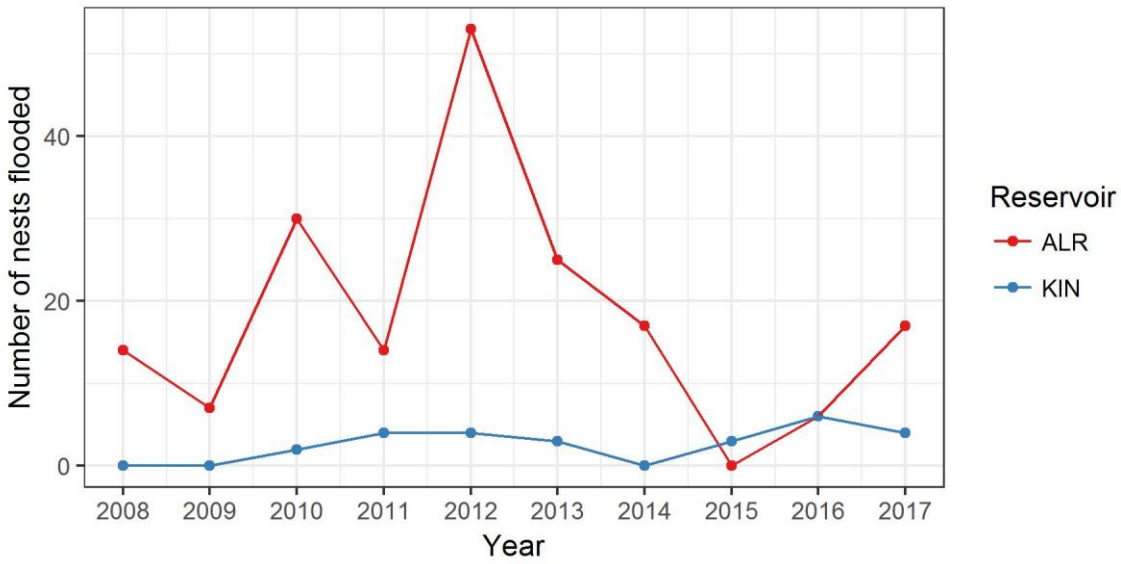

Figure 3-5: Annual number of observations of nest flooding at Kinbasket Reservoir (KIN) and Arrow Lakes Reservoir (ALR)

Table 3-4: Observations of nest submersion since 2008 by species at Kinbasket Reservoir (KIN) and Arrow Lakes Reservoir (ALR)

Nesting Location	Common Name	ALR	KIN
Ground	Common Loon	2	
	American Wigeon	7	
	Mallard	10	
	Blue-winged Teal	1	
	Green-winged Teal	3	
	Northern Harrier	1	
	Killdeer	4	1
	American Avocet	1	
	Spotted Sandpiper	11	8
	Wilson's Snipe	5	
	Wilson's Phalarope	1	
	Long-eared Owl	1	
	Short-eared Owl	3	
	Savannah Sparrow	7	12
	Lincoln's Sparrow		1
Low shrub or emergent vegetation	Pied-billed Grebe	2	
	Virginia Rail	7	
	Sora	2	
	Marsh Wren	1	
	Veery	2	
	MacGillivray's Warbler	1	
	Common Yellowthroat	16	1
	Chipping Sparrow	7	
	Clay-colored Sparrow	3	
	Song Sparrow	4	
	Red-winged Blackbird	9	
	Yellow-headed Blackbird	15	
Shrub	Traill's Flycatcher	2	
	Willow Flycatcher	15	1
	Dusky Flycatcher	1	
	Eastern Kingbird	1	
	Unidentified Flycatcher	2	
	Gray Catbird	8	
	Cedar Waxwing	7	
	Yellow Warbler	20	
Canopy	American Robin		1
	American Redstart	1	
Cavity	Mountain Bluebird		1

4 DISCUSSION

CLBMON-36 is a 10-year project addressing knowledge gaps related to the management of reservoirs (their drawdown zone habitat and their operations) to enhance avian productivity and minimize incidental destruction of nests caused by reservoir operations. This report summarizes progress made in the CLBMON-36 project in 2017, the 10th year of research. Below, we briefly review progress and observations made in 2017, and cumulative progress since 2008. More in-depth analysis of the multi-year data will be provided in the upcoming 10 Year Comprehensive Report.

4.1 Year 10 (2017)

For the tenth and final year of CLBMON-36, both reservoirs were at relatively high water-levels throughout the breeding season.

Being positioned near the head of the Columbia River and having a huge capacity for storage, the KIN water level traditionally reaches its annual maximum later in the year compared with the ALR. However, as in 2015 and 2016, KIN filled unusually early in 2017, leading to greater nest flooding impacts than in earlier years.

In the summer of 2017, ALR's peak elevation was comparatively high, at 439.57 m ASL, though it reached this peak a bit later in the season than in other high-water years such as 2008, 2012, and 2013. The higher water levels in 2017 results in greater nest flooding impacts than in the two previous years. At ALR we have observed a high variability in annual maximum water elevation during the study.

4.2 Multi-year progress

4.2.1 Biogeography

As recommended in Year 9, we continued monitoring at BA in Year 10, where we improved representation among habitat types in our dataset. We were successful in monitoring additional sites containing the target vegetation communities, as well as continuing the SAVS juvenile survival research.

4.2.2 Species detection

The high diversity and complexity of habitat in the RR drawdown zone provides potential nesting habitat for many species. During CLBMON-36, we have progressively detected new species nesting within the drawdown zone. In the first three years of the study, we had sufficient knowledge of the common species and their habitat distributions, but the years following allowed us to confirm nesting of many less common species.

No new species were detected nesting at the study plots in 2017, however, during banding for CLBMON-39, we captured a YBCH family (two adults and one juvenile) and suspect they nested at Machete Island. A singing male has been detected at Machete Island every year since 2014, but this was the first confirmation of breeding. We also found two Blue-winged Teal (*Anas discors*) nests in 2017, a species first confirmed nesting within the ALR drawdown zone only last year.

There are likely some other species which could be nesting within the drawdown zone that were not detected during the study. Three species of cavity-nesting ducks that we have observed with broods include Common Merganser (*Mergus merganser*), Hooded Merganser (*Lophodytes cucullatus*), and Wood Duck (*Aix sponsa*). Common Merganser likely breed above the drawdown zone frequently but could potentially nest at Machete

Island. Two woodpecker species that we have not detected nesting within ALR include Red-naped Sapsucker (*Sphyrapicus nuchalis*) and Hairy Woodpecker (*Picoides villosus*); both would find excellent nest-building habitat at Machete Island, but the low abundance of coniferous trees may give this habitat low foraging suitability for these species. Other species that may nest within the drawdown zone include American Coot (*Fulica americana*), Northern Pintail (*Anas acuta*), Gadwall (*Anas strepera*), Western Kingbird (*Tyrannus verticalis*) and Barn Swallow (*Hirundo rustica*). Regardless, the community of species that nest regularly in the Revelstoke Reach drawdown zone has been well documented.

From a habitat perspective, nesting opportunities are limited in the KIN drawdown zone due to the reduced complexity in the vegetation communities. As such, it is not surprising that we detected most of this smaller nesting community early in the study.

The general breeding bird communities in both reservoirs have been well-documented and MQ-A (Which bird species breed in the drawdown zones and how are they distributed among the drawdown zone habitat classes?) has been adequately addressed (Appendix 6-1).

4.2.3 Nest submersion

Like Year 9, Year 10 was marked by higher than normal nest flooding in both KIN and ALR. Although we have witnessed relatively high nest flooding impacts in KIN for the past three years, the impact is still relatively low compared to ALR.

To date, we have observed that nest flooding is a factor affecting productivity for 37 species, mostly in ALR. Qualitatively, our impression at the ALR is that species that nest in low elevation habitats in the reservoir drawdown zone (e.g., SAVS, Western Meadowlark (*Sturnella neglecta*), SEOW), and those nesting directly on the ground (e.g., dabbling ducks and shorebirds), have higher chances of nest submersion, and are uncommon. These populations may be limited by reservoir operations and could increase if nest flooding was not an issue. We have previously shown that nest flooding is also an important issue for species nesting in emergent vegetation (e.g., rails, grebes, blackbirds (CBA 2013, 2015a, 2015b)). Species nesting in shrubs commonly suffer from nest flooding in the ALR, but this impact is compensated to some degree by reduced nest predation for nests positioned over water (van Oort et al. 2015).

4.2.4 Focal species

In 2017, focal species research included YEWA and CEDW monitoring in RR and SAVS monitoring in BA. The YEWA (general productivity) research is currently being conducted by Michal Pavlik and Dr. David Green (Simon Fraser University). For CEDW, we selected a few plots this year to deliberately increase our sample size of CEDW nests. This included some habitat outside the drawdown zone, with the aim of collecting additional data to address H1A (The hypothesis that nest survivorship in the drawdown zone is not different from nest survivorship above the drawdown zone).

The SAVS research focuses on whether juvenile survival in the reservoir drawdown zone differs from survival rates in other habitats (i.e., above drawdown zone) and the causes of juvenile mortality within the drawdown zone. At BA, we located SAVS nests within the drawdown zone primarily in two areas, which were monitored throughout the breeding season. The first area was the Bush River causeway and it was split into four sites by location relative to the causeway and the Bush River (e.g., the region to the west of the causeway and north of the river was one site, and the region to the west of the causeway

and south of the river was another site). The second area (km 87) near Bear Island was one site, with habitat located along one side of the reservoir. We also monitored one additional site (km 69), but no nests were found here. In 2017, we were able to increase the sample sizes for both SAVS nests located and juveniles tagged.

4.2.5 Adequacy of data

At the end of the 2017 field season, it is our view that CLBMON-36 has generated adequate data to meet the objectives, address the MQs, and test the hypotheses of this study (See Appendix 6-1). We expect to be able to provide these results in the 10 Year Comprehensive Report.

4.3 Recommendations

Since 2017 was the final field season for CLBMON-36, we do not have any recommendations regarding upcoming field seasons. Any recommendations emerging from final analysis of the ten-year dataset will be included in the 10 Year Comprehensive Report.

5 ADDITIONAL REPORTING REQUIREMENTS

5.1 Banded birds

Birds were banded in accordance with national permit regulations. Only YEWA and SAVS were targeted. All data were entered and submitted to the Bird Banding Office of the Canadian Wildlife Service using Bandit software. No mortalities or injuries occurred.

5.2 Provincially- and SARA-listed species

The Southern Mountain population of Yellow-breasted Chat (*Icteria virens auricollis*, YBCH) in British Columbia is designated as ‘Endangered’ under the federal *Species at Risk Act* (COSEWIC 2011). Since 2014, a male YBCH has been observed annually, singing throughout the breeding season at Machete Island; however, this year, a male, female, and one juvenile were caught together at Machete Island during migration banding, strongly suggesting that a pair nested there this year.

5.3 Species with provincial jurisdiction

All nest records were reported to the BC Ministry of Environment following the Wildlife Species Inventory standards (BC Ministry of Environment 2017).

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Appendix 6-1: Status of objectives, Management Questions, and hypotheses

OBJECTIVES	MANAGEMENT QUESTIONS	HYPOTHESES	YEAR 10 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 MQs have been adequately addressed. Additional rare or uncommon species would undoubtedly be observed with additional work, but we believe that the regular nesting species are well documented. • Additional work could be done to summarize the data in new ways (e.g., elevational profiles for each 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 (van Oort et al. 2015). • H1A was addressed in the 5 Year Interim report, but models could be re-assessed and fit with new data. • H1C and H1D will be addressed in the 10 Year Comprehensive Report.
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 and SAVS have been collected and the analysis is underway. • All data to address H2A for SAVS have been collected and the analysis is underway. • Results for both H2 and H2A will be presented in the 10 Year Comprehensive Report.
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?		• Models have been created and presented previously (Y5IR) – these may be updated for the 10 Year Comprehensive Report.
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). • Improving nesting habitat in the upper KIN drawdown zone would be ecologically valuable, given the low nest flooding impact of its operation.

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

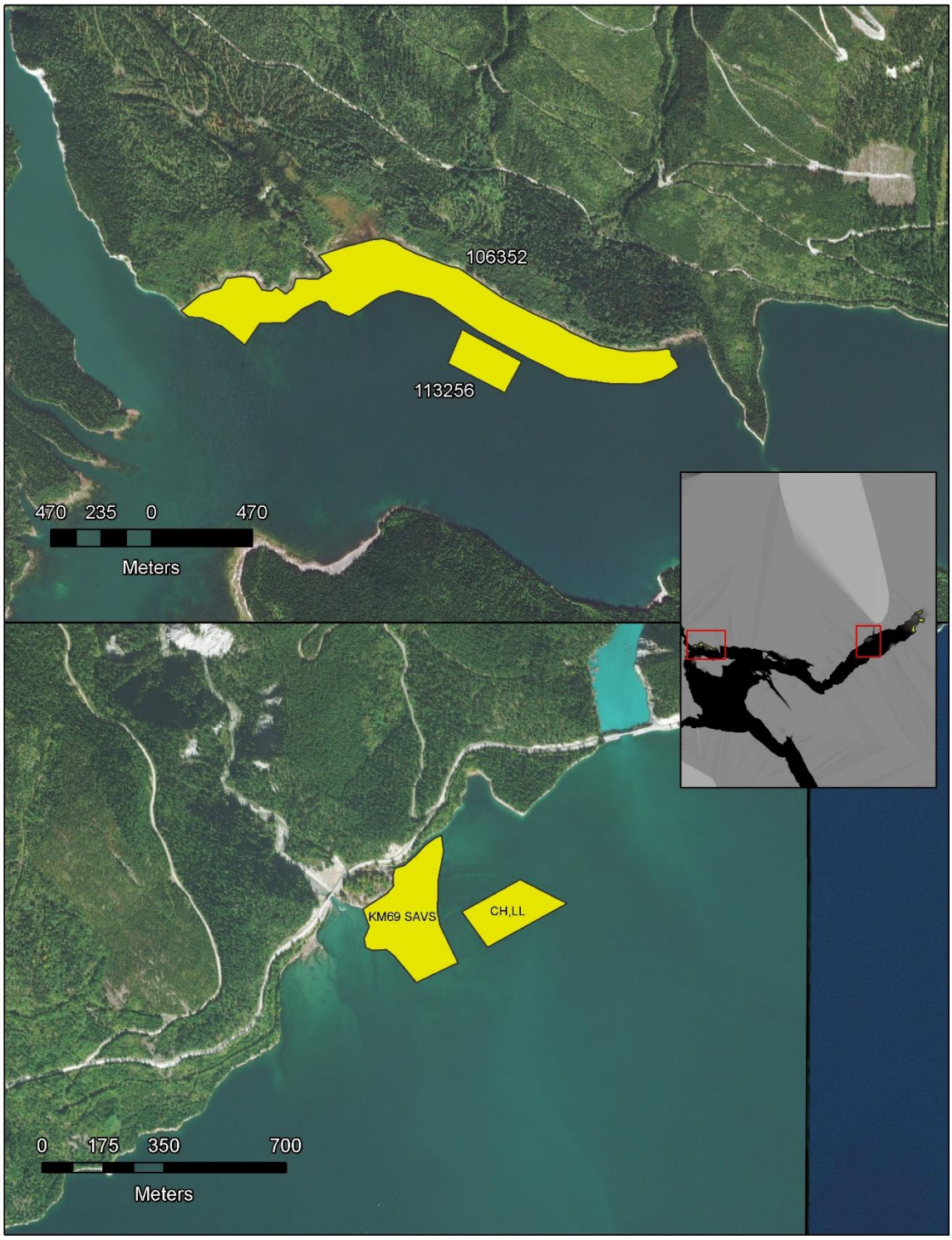
Vegetation communities within the Kinbasket Reservoir drawdown zone mapped by CLBMON-10 (Hawkes et al. 2010)

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

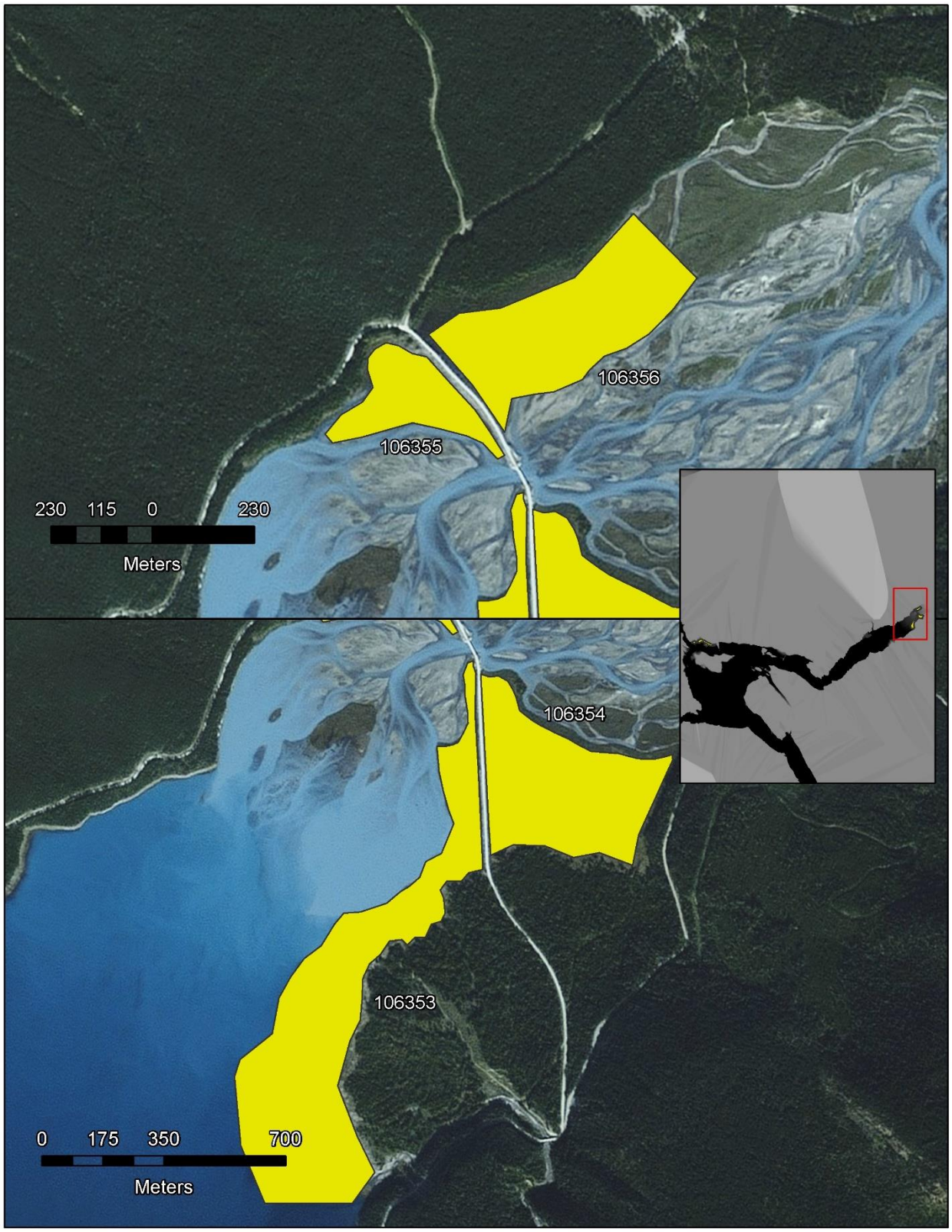
Vegetation communities within the Revelstoke Reach drawdown zone

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 or fen

Appendix 6-3: Locations of nest mortality and SAVS study sites at Bush Arm, Kinbasket Reservoir

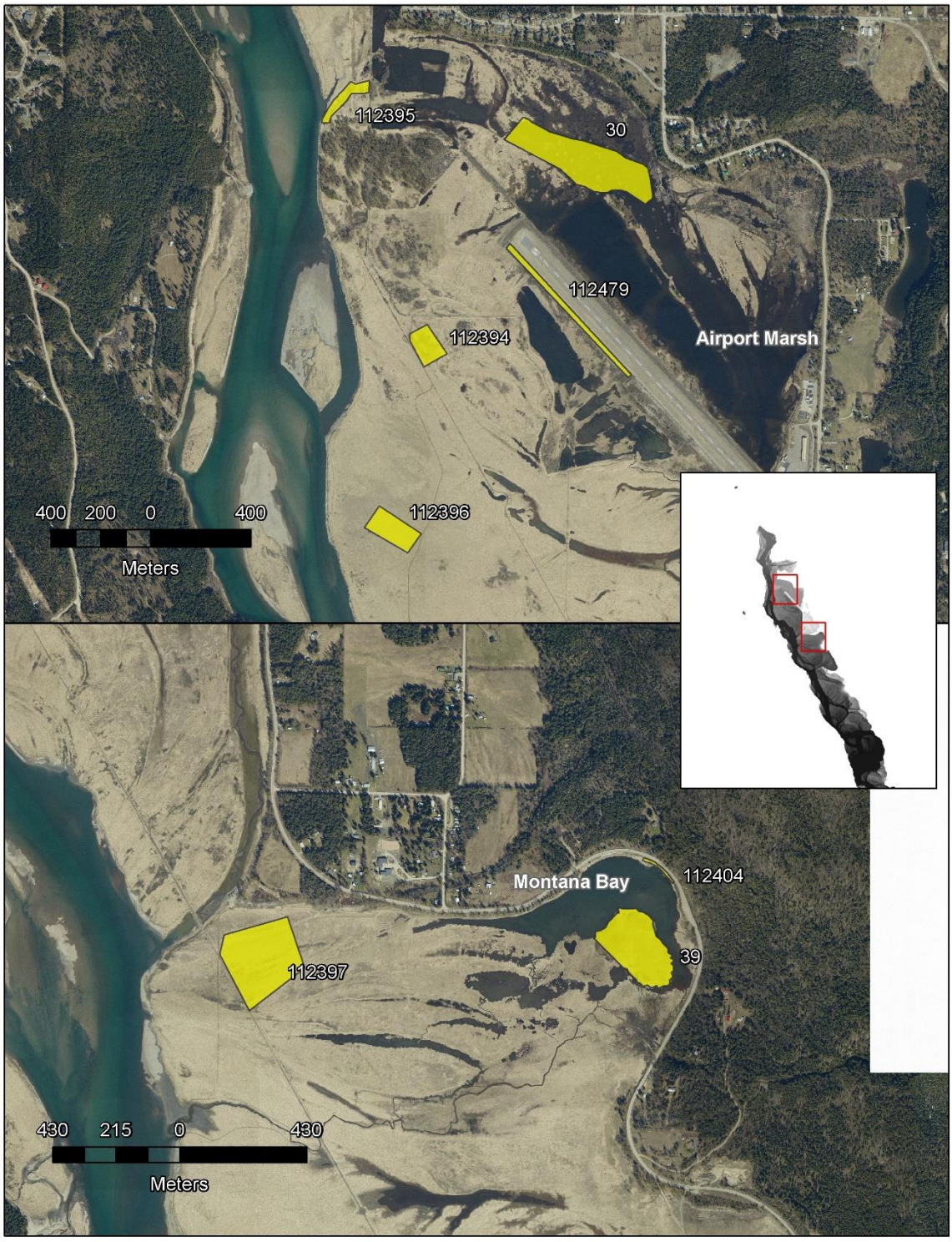


Bush Arm - km 85 (above) and km 69 (below) study sites

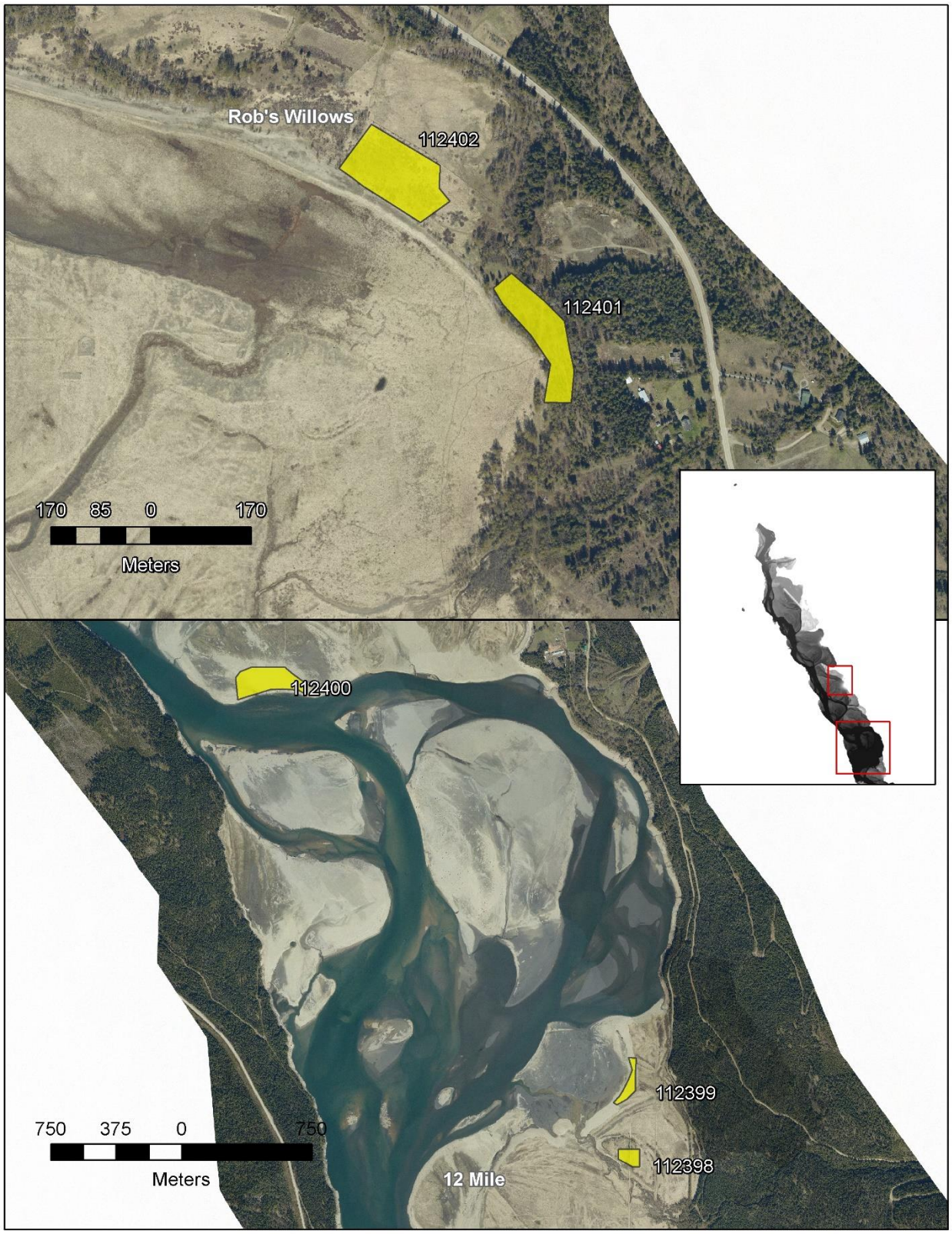


Bush Arm – Bush River causeway SAVS study sites

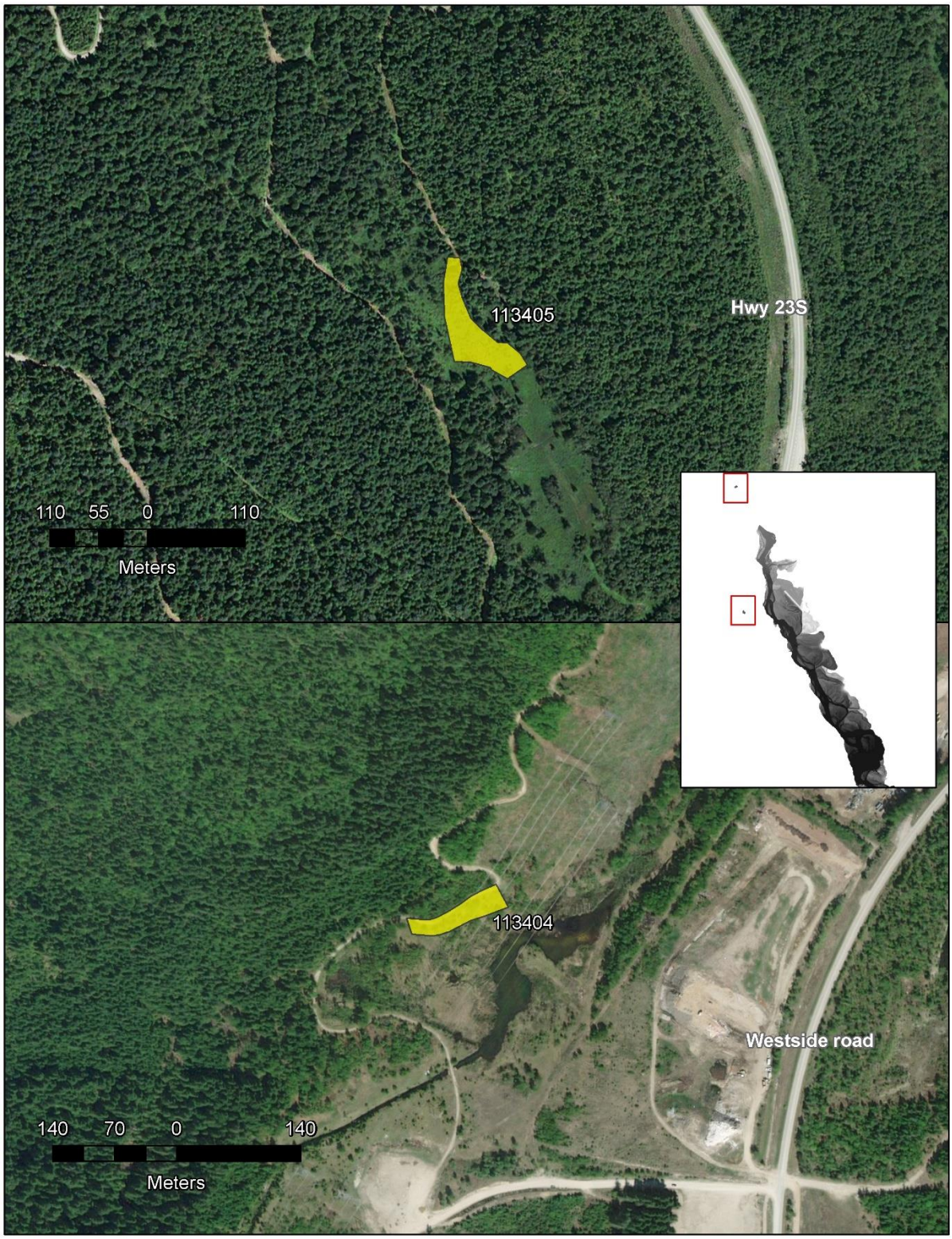
Appendix 6-4: Locations of nest mortality study sites at Revelstoke Reach, Arrow Lakes Reservoir



Revelstoke Reach – North



Revelstoke Reach – South



Revelstoke Reach – Cedar Waxwing (*Bombycilla cedrorum*) study sites outside of drawdown zone

Appendix 6-5: Nest mortalities due to reservoir operations (e.g., flooding) in 2017 in each reservoir (ALR = Arrow Lake Reservoir, KIN = Kinbasket Reservoir)

Area	Nest ID	Nest Position	Species	Elevation (m ASL)	Nest Height (m)
ALR	113611	Ground	American Wigeon	437.9	0
ALR	113741	Ground	Mallard	436.2	0
ALR	113598	Ground	Blue-winged Teal	436.7	0
ALR	114652	Low in Shrub	Virginia Rail	438.2	0
ALR	114236	Low in Shrub	Virginia Rail	438.2	0.1
ALR	114383	Ground	Spotted Sandpiper	438.4	0
ALR	113323	Ground	Spotted Sandpiper	435.3	0
ALR	113616	Ground	Spotted Sandpiper	438.6	0
ALR	114389	Ground	Spotted Sandpiper	439.2	0
ALR	114380	Ground	Spotted Sandpiper	438.5	0
ALR	114371	Ground	Spotted Sandpiper	438.8	0
ALR	114244	Ground	Spotted Sandpiper	438.2	0
ALR	113649	Ground	Wilson's Snipe	436.9	0
ALR	114798	Ground	Wilson's Snipe	438.8	0
ALR	114238	Low in Shrub	Common Yellowthroat	438.2	0.3
ALR	113491	Low in Shrub	Chipping Sparrow	437.1	0.3
ALR	113603	Low in Shrub	Clay-colored Sparrow	437.7	0.1
KIN	115576	Ground	Spotted Sandpiper	750.3	0
KIN	115452	Ground	Spotted Sandpiper	748.1	0
KIN	115454	Ground	Spotted Sandpiper	747.2	0
KIN	115391	Ground	Savannah Sparrow	748.7	0

Appendix 6-6: Nest records from the drawdown zones of Arrow Lakes Reservoir and Kinbasket Reservoir accumulated during ten years of the CLBMON-36 program. Nesting in the drawdown zones is defined by historical maximum water elevation and determined for each nest record using the digital elevation model cross-referenced against the nest coordinates. Nests elevated in vegetation above the high-water elevation are included

Common Name	Scientific Name	Arrow Lakes Reservoir	Kinbasket Reservoir
Common Loon	*Gavia immer*	6	0
Pied-billed Grebe	*Podilymbus podiceps*	31	0
Canada Goose	*Branta canadensis*	136	1
American Wigeon	*Mareca americana*	41	0
Mallard	*Anas platyrhynchos*	69	2
Blue-winged Teal	*Spatula discors*	3	1
Cinnamon Teal	*Spatula cyanoptera*	3	0
Unidentified Teal	*Spatula spp.*	4	0
Northern Shoveler	*Spatula clypeata*	1	0
Green-winged Teal	*Anas crecca*	9	2
Ring-necked Duck	*Aythya collaris*	1	0
Unidentified Duck	*Anatinae (gen, sp)*	5	0
Osprey	*Pandion haliaetus*	2	0
Northern Harrier	*Circus hudsonius*	3	0
Ruffed Grouse	*Bonasa umbellus*	1	0
Virginia Rail	*Rallus limicola*	47	0
Sora	*Porzana carolina*	45	0
Killdeer	*Charadrius vociferus*	33	29
American Avocet	*Recurvirostra americana*	1	0
Spotted Sandpiper	*Actitis macularius*	37	88
Wilson's Snipe	*Gallinago delicata*	61	17
Wilson's Phalarope	*Phalaropus tricolor*	2	0
Long-eared Owl	*Asio otus*	4	0
Short-eared Owl	*Asio flammeus*	6	0
Rufous Hummingbird	*Selasphorus rufus*	1	0
Downy Woodpecker	*Picoides pubescens*	1	0
Northern Flicker	*Colaptes auratus*	6	3
Western Wood-Pewee	*Contopus sordidulus*	8	0
Alder Flycatcher	*Empidonax alnorum*	2	2
Traill's Flycatcher	*Empidonax alnorum/traillii*	8	0
Willow Flycatcher	*Empidonax traillii*	155	14
Least Flycatcher	*Empidonax minimus*	15	1
Dusky Flycatcher	*Empidonax oberholseri*	5	4
Eastern Kingbird	*Tyrannus*	15	0
Unidentified Flycatcher	*Tyrannidae (gen, sp)*	9	2

Warbling Vireo	*Vireo gilvus*	8	0
Red-eyed Vireo	*Vireo olivaceus*	21	0
American Crow	*Corvus brachyrhynchos*	4	0
Tree Swallow	*Tachycineta bicolor*	1	2
Black-capped Chickadee	*Poecile atricapillus*	5	1
Marsh Wren	*Cistothorus palustris*	37	0
Mountain Bluebird	*Sialia currucoides*	1	14
Veery	*Catharus fuscescens*	31	0
Swainson's Thrush	*Catharus ustulatus*	4	3
Hermit Thrush	*Catharus guttatus*	1	0
American Robin	*Turdus migratorius*	45	10
Gray Catbird	*Dumetella carolinensis*	75	0
Cedar Waxwing	*Bombycilla cedrorum*	357	50
Tennessee Warbler	*Oreothlypis peregrina*	2	0
Yellow Warbler	*Setophaga petechia*	577	9
Yellow-rumped Warbler	*Setophaga coronata*	1	1
American Redstart	*Setophaga ruticilla*	70	1
Northern Waterthrush	*Parkesia noveboracensis*	1	0
MacGillivray's Warbler	*Geothlypis tolmiei*	8	1
Common Yellowthroat	*Geothlypis trichas*	80	5
Unidentified Warbler	*Parulidae (gen, sp)*	1	0
Chipping Sparrow	*Spizella passerina*	39	22
Clay-colored Sparrow	*Spizella pallida*	17	19
Vesper Sparrow	*Pooecetes gramineus*	0	5
Savannah Sparrow	*Passerculus sandwichensis*	38	343
Song Sparrow	*Melospiza melodia*	113	8
Lincoln's Sparrow	*Melospiza lincolnii*	14	37
Dark-eyed Junco	*Junco hyemalis*	1	2
Black-headed Grosbeak	*Pheucticus melanocephalus*	3	0
Lazuli Bunting	*Passerina amoena*	4	0
Red-winged Blackbird	*Agelaius phoeniceus*	62	0
Western Meadowlark	*Sturnella neglecta*	6	0
Yellow-headed Blackbird	*Xanthocephalus*	80	0
Bullock's Oriole	*Icterus bullockii*	2	0
American Goldfinch	*Spinus tristis*	1	0
Unidentified Bird	*Aves (gen, sp)*	4	0
Unidentified Songbird	*Aves (gen, sp)*	1	0
Total		**2491**	**699**