Columbia River Project Water Use Plan

Kinbasket and Arrow Lakes Reservoirs Revegetation Management Plan

Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir

Implementation Year 11

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Study Period: 2020

Okanagan Nation Alliance, Westbank, BC

and

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KINBASKET AND ARROW LAKES RESERVOIRS

Monitoring Program No. CLBMON-11B1

Wildlife Effectiveness Monitoring and Enhancement Area Identification for Lower and Mid-Arrow Lakes Reservoir




Wildlife Physical Works Baseline Data Collection: Burton Creek Flats
Final Report 2021

Prepared for

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From left to right: Pond B1 during construction, Long-billed Curlew (*Numenius americanus)*, Western Toad (*Anaxyrus boreas*), and Pond A2 following construction. Photos credits: Mike Miller, Gary Davidson, Doug Adama, Gary Davidson.

EXECUTIVE SUMMARY

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project to assess the efficacy of revegetation and Wildlife Physical Works (WPW) projects (CLBWORKS-2 and CLBWORKS-30) at enhancing the suitability of habitats in the drawdown zone of Arrow Lakes Reservoir for wildlife. Wildlife effectiveness monitoring of revegetation occurred from 2009 until 2019. In 2020 effectiveness monitoring shifted from revegetation to focus entirely on the physical works construction at Burton Creek.

Baseline bird and arthropod sampling at the Burton project occurred in 2018 and 2019. Additional baseline monitoring included bat acoustic monitoring (2017-2019), wildlife camera trapping (2019), and odonate (i.e., dragonflies) surveys (2019). The first phase of the physical works was constructed at Burton Creek in September 2019, and the second phase of physical works construction is planned for the spring of 2021.

The 2020 sampling year was the first year of post-construction physical works monitoring at Burton Creek (phase 1). The advent of the COVID-19 pandemic during this study year had a significant impact on the planned monitoring activities. As such, some surveys (e.g., songbird monitoring and targeted amphibian and reptile surveys) were modified, and certain planned activities (such as odonate and aquatic macroinvertebrate sampling) were cancelled for that year.

As in previous years, the survey focus was on terrestrial arthropods and songbirds, which reflect both prey (e.g., arthropod) and predator (e.g., songbird) response to the physical works construction. We surveyed arthropod populations in both the constructed physical works and nearby pre-treatment (phase 2) areas in the WPW area with the use of pitfall traps and Malaise traps. We surveyed birds with the use of acoustic autonomous recording units (ARUs). Additionally, waterfowl and other water and shoreline-associated bird species were surveyed from April to October 2020.

We also surveyed bat activity as well as general wildlife use of the WPW area. We surveyed bats with the use of ultrasonic ARUs and analyzed their activity via automatic call classification software. We recorded wildlife activity with the use of wildlife cameras and incidental wildlife observations. We scanned acoustic ARU recordings with a Western Toad classifier to detect any Western Toads calls.

We identified 11 species of spiders (Araneae) and 8 families of beetles (Coleoptera) from pitfall traps, within which were 13 species of carabid beetles (Carabidae). The carabid beetle samples were dominated by exotic species, including *Pterostichus melanarius, Carabus granulatus,* and *Clivina fossor*. The species of spiders and beetles were largely consistent with those found in previous years. Spider and beetle diversity, richness, and catch-per-unit effort data suggest a response to the WPW construction, although this is most likely due to the disturbance of the recent construction activity rather than any direct effect of the habitat improvement. Comparisons with baseline data also suggested some yearly variation in arthropod activity that is unrelated to the WPW. This was also true for overall arthropod biomass. We identified 26 families of Hymenoptera and 36 families of Diptera from Malaise traps.

We recorded 30 species of birds on acoustic ARUs, 21 of which were songbirds. Though we do not know the exact location of birds detected by ARU, some of the

species are consistent with those using wetland or open/grassy habitats. This indicates that the WPW area is being by songbirds, although field surveys are required to determine exactly where and how birds are using the WPW area (as opposed to adjacent habitat).

Waterbird surveys recorded 44 species of waterbirds (including waterfowl, loons, grebes, shorebirds, and herons), as well as 59 non-waterbird species. Waterbirds were often detected along the reservoir shoreline, and thus moved up or down from the upland areas depending on reservoir elevation. Mallards (*Anas platyrhynchos*) and Canada Geese (*Branta canadensis*) were observed in or near the constructed ponds prior to inundation. Other waterbird usage of the area depended on water levels, with more waterbird detections when it was inundated by the reservoir. The months with the highest waterbird abundances were September, October, and November, which can be attributed to fall migration and added numbers due to the presence of juvenile birds.

For other wildlife, we recorded 11 species of bat in the CLBWORKS-30B Burton WPW area, which were predominantly species of *Myotis*. White-tailed deer (*Odocoileus virginianus*) were the most frequently recorded mammal on wildlife cameras, though the most recorded animals were Canada Goose (*Branta canadensis*) and Mallard (*Anas platyrhynchos*). One Western Toad (*Anaxyrus boreas*) call was recorded in May, and there are incidental records of several other amphibian species in the area. A Columbia Spotted Frog (*Rana luteventris*) egg mass was located in the A1 pond.

Key Words: Arrow Lakes Reservoir, physical works, songbirds, arthropods, bats, amphibians, wildlife, effectiveness monitoring, drawdown zone, Burton Creek, hydro

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ACRONYMS AND DEFINITIONS

To ensure that readers of this report interpret the terminology used throughout, the following definitions are provided.

Arthropods: One of the focal groups for monitoring, this refers to invertebrates within the phylum *Arthropoda*. Particular taxa of interest include the following orders:

Araneae: Spiders

Coleoptera: Beetles

Diptera: True flies

Hymenoptera: Wasps, sawflies, bees, and ants

CPUE: Catch per unit effort. Refers to the number of individuals caught per trap, standardized to a 24-hour trapping period.

Drawdown Zone: a general term referring to the area ≤ 440.1 m ASL in a study site which is influenced by reservoir inundation. The drawdown zone encompasses the Wildlife Physical Works (WPW) location.

Wildlife Physical Works (WPW): The first stage of the Burton Creek WPW project was implemented in the fall of 2019. Additional WPW construction is planned for early 2021. The physical works in progress for Burton Creek include the creation of a series of tiered wetlands, mounding of soil to increase topographic heterogeneity, and planting a diverse community of vegetation.

COVID-19

The advent of the COVID-19 pandemic in early 2020 impacted monitoring activities planned for the Burton Creek wildlife physical works area in that year. Travel restrictions and other precautionary measures imposed to control the virus outbreak impacted survey start time and the ability of personnel to conduct certain surveys. Planned monitoring activities such as in-person songbird surveys, amphibian and reptile surveys, odonate surveys, and aquatic macroinvertebrate surveys were not completed because of these restrictions.

1.0 INTRODUCTION

The Columbia River Water Use Plan was developed as a result of a multi-stakeholder consultative process to determine how to best operate BC Hydro's Mica, Revelstoke, and Keenleyside facilities to balance environmental values, recreation, power generation, culture/heritage, navigation, and flood control. The goal of the Water Use Plan is to accommodate these values through operational means (i.e., patterns of water storage and release) and non-operational physical works in lieu of changing reservoir operations to address specific interests.

During the Water Use Planning process, the Consultative Committee supported the following projects to enhance wildlife habitat in the Arrow Lakes Reservoir, in lieu of maintaining lower reservoir levels:

1) A revegetation program to increase vegetation growth in the drawdown zone (CLBWORKS-2).
2) A study to evaluate the feasibility of enhancing or creating wildlife habitat in the drawdown zone in Revelstoke Reach (CLBWORKS-29A).
3) A study to identify high-value wildlife habitat sites for enhancement or protection in the Mid and Lower Arrow Lakes Reservoir (CLBWORKS-29B).
4) CLBWORKS-30: The implementation of wildlife physical works identified in CLBWORKS-29A and CLBWORKS 29B.

Revegetation was implemented in the drawdown zone of Arrow Lakes Reservoir under CLBWORKS-2 between 2008 to 2011. Revegetation effectiveness as a wildlife habitat enhancement strategy was assessed from 2009 to 2019 under CLBMON-11B1. South of Revelstoke Reach, options for wildlife enhancement strategies were developed under CLBWORKS-29B (Hawkes and Howard 2012; Hawkes and Tuttle 2016). The first phase of the Wildlife Physical Works was implemented under CLBWORKS-30B in 2019. In 2020 the focus of CLBMON-11B1 effectiveness monitoring shifted to the post-construction Wildlife Physical Works area at Burton Creek (CLBWORKS-30B).

The 2020 field season was the first year of effectiveness monitoring of Phase 1 of the post-construction Burton Creek Wildlife Physical Works (WPW), after two years of baseline surveys in the area (Hentze et al. 2019; Waytes et al. 2020). The first phase of WPW construction was implemented in September and October of 2019. Monitoring at Burton Creek focuses on a post-construction comparison to pre-WPW baseline data.

Anticipated benefits of the wetland construction at Burton Flats will be for wildlife including birds (songbirds, waterfowl, and shorebirds), amphibians, reptiles, mammals (bats), and insects (dragonflies), among others (Hawkes and Tuttle 2016). Species with provincial or federal conservation designation that may benefit from this project include the SARA-listed Western Toad (*Anaxyrus boreas*; Special Concern) and Little Brown Myotis (*Myotis lucifugus*; Endangered), and the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*). While this project does impact a pre-existing wetland in the area, the habitat that is affected by the physical works is relatively homogenous. However, there is always a risk that the created habitat will not function as desired.

2.0 OBJECTIVES

The objective of this project component of CLBMON-11B is to assess the effectiveness of the Burton Creek wildlife physical works project at improving conditions for nesting and migratory birds and wildlife in the drawdown zone of Arrow Lakes Reservoir. Baseline studies in the WPW area were initiated in 2017 and project construction began in 2019. This study component will continue in 2021.

Key Water Use Decisions Affected

The Terms of Reference for CLBMON-11B1 indicate that the results of this study will aid in more informed decision-making with respect to the need to balance the requirements of wildlife that are dependent on wetland and riparian habitats with other values such as recreational opportunities, flood control and power generation.

The key water use planning decisions affected by the results of this monitoring program are whether revegetation and wildlife physical works are effective in enhancing wildlife habitat. Results from this study will also assist in refining the approaches and methods for enhancing wildlife habitat through adaptive management.

3.0 STUDY AREA

The Hugh Keenleyside Dam, completed in 1968, impounded two naturally occurring lakes to form the Arrow Lakes Reservoir, an approximately 230-km long section of the Columbia River drainage between Revelstoke and Castlegar, B.C. (Map 1; Carr et al. 1993, Jackson et al. 1995). Two biogeoclimatic zones occur within the study area: Interior Cedar Hemlock (ICH) and Interior Douglas-fir (IDF). The reservoir has a north-south orientation and is set in the valley between the Monashee Mountains in the west and Selkirk Mountains in the east. Arrow Lakes Reservoir has a licensed storage volume of 7.1 million-acre feet (BC Hydro 2007). The normal operating range of the reservoir is between 418.64 m and 440.1 m above sea level (m ASL).

3.1 Burton Creek Existing Habitat

The Burton Creek WPW area was considered relative to existing vegetation at the site (Figure 3-1). In this case a habitat map was created relative to conditions observed in the 2019 aerial photos obtained for Arrow Lakes Reservoir. The habitat mapping was done at a slightly larger scale than the previous habitat mapping (i.e., CLBMON-33) but Table 3-1 provides a description of each habitat type in Figure 3-1, with the corresponding vegetation community type analogues from CLBMON-33. The habitat map includes an overlay of the phase 1 ponds and mounds (features A1 through A4, B1 and C2 and C3). These features were constructed in habitats dominated by native and non-native grasses and sedges (Reed canarygrass–Columbia sedge–Kellogg's sedge–Cottonwood, Reed canarygrass–bluejoint, Reed canarygrass, Kellogg's sedge–Columbia sedge), Marsh, and to a lesser extent alluvial–sparse graminoid dominated areas. The change in habitat type can be assessed over time relative to the revegetation prescriptions applied for phases 1 and 2.

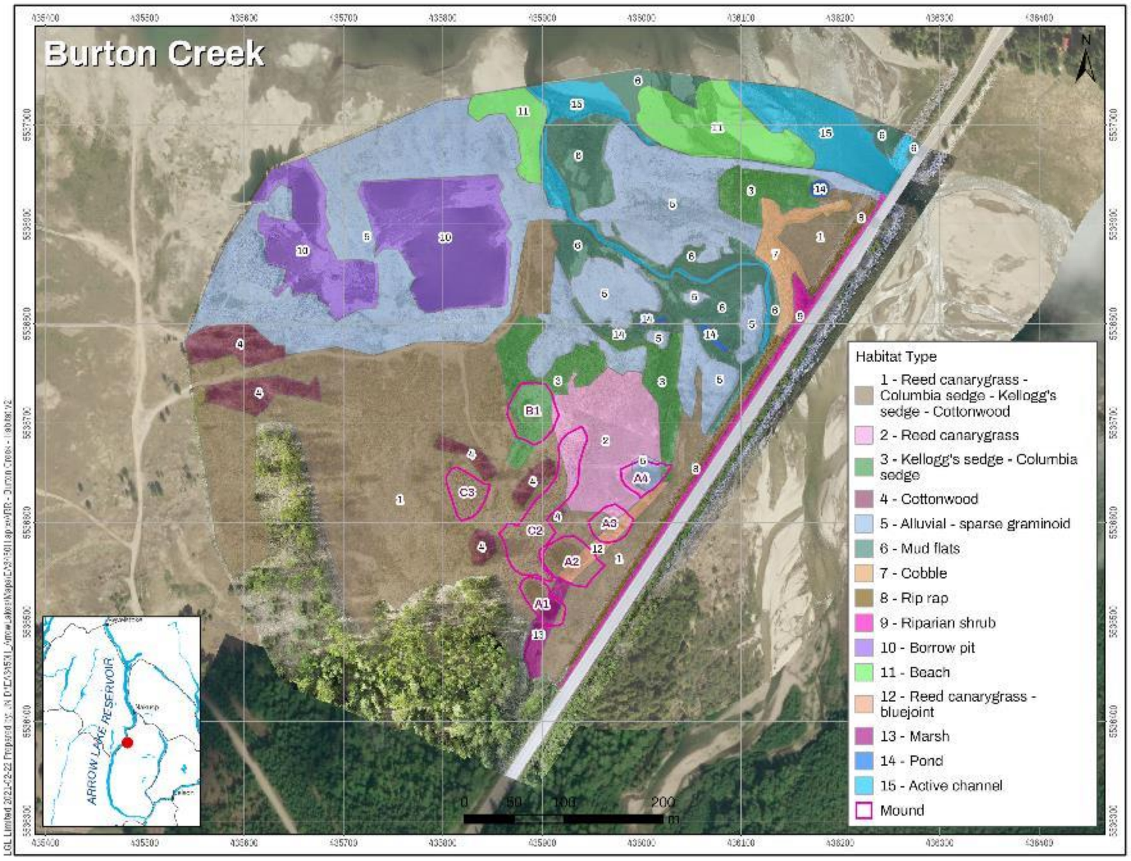


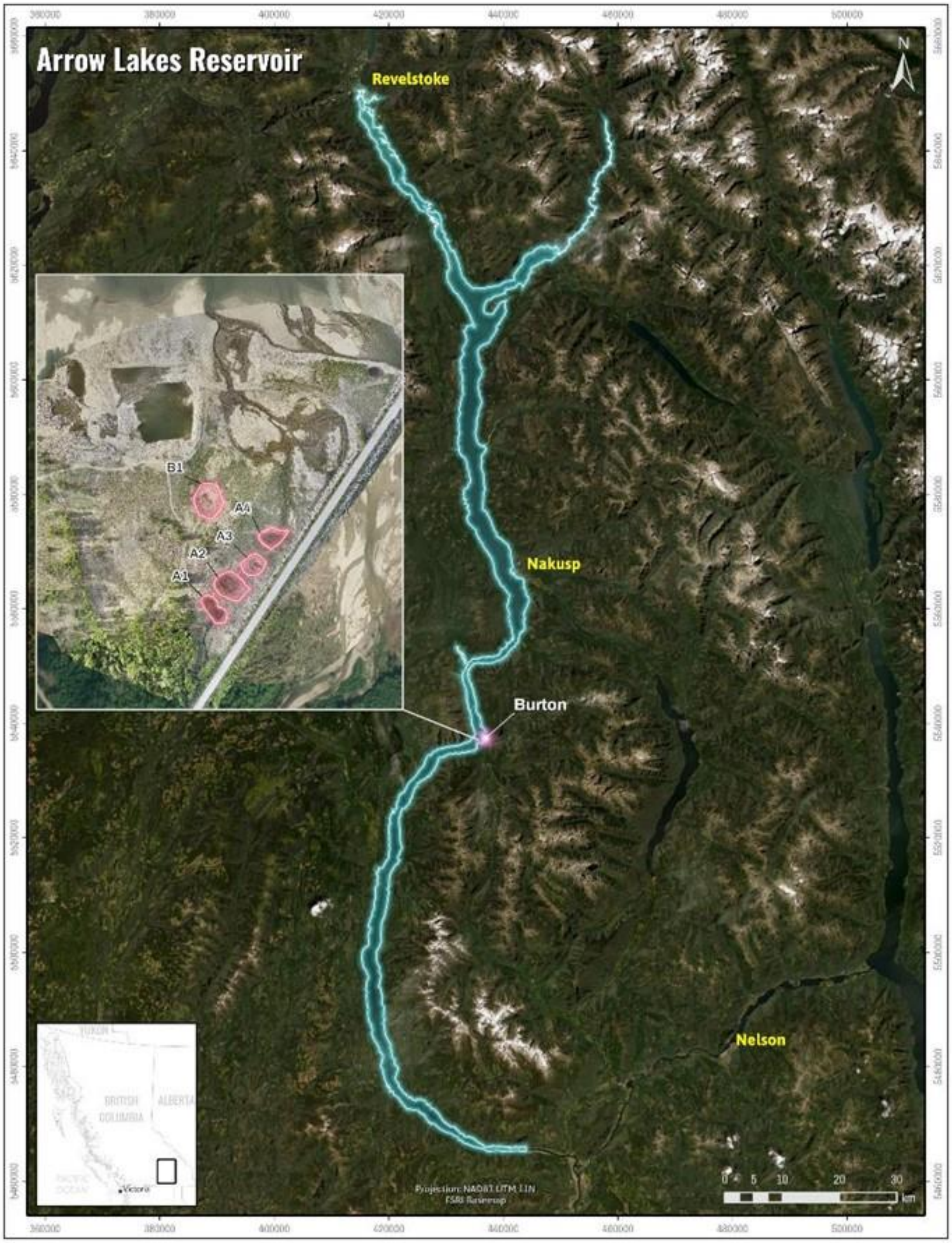
Figure 3-1. **Existing (2019) habitats mapped at the Burton Creek wildlife physical works location, Arrow Lakes Reservoir, Burton, BC.**

Table 3-1. Existing (2019) habitat type name, description, and relationship to existing vegetation community type (VCT) mapped for CLBMON-33.

Code	Name	Description	VCT analogue
1	Reed canarygrass–Columbia sedge–Kellogg's sedge–Cottonwood	Association of non-native grasses (primarily reed canarygrass), native sedges (primarily Columbia sedge), and sporadic shrubs (mainly cottonwood); occurring at higher elevations on flat to convex topography, typically on well drained, coarse (gravely) substrates.	PA, BG, PC
2	Reed canarygrass	Dense reed canarygrass stands supporting minimal cover of other species; at mid elevations on flat to concave topography, typically on mesic, loamy substrates.	PC
3	Kellogg's sedge–Columbia sedge	Dense to moderately dense stands of Kellogg's and Columbia sedge, sometimes with a lesser component of reed canarygrass; occurring on some depressional terrain and along small water courses, on sandy to loamy substrates.	PC, RR, BG
4	Cottonwood	Small mature or semi-mature cottonwood stands occurring at high elevations and generally associated with (1).	CR, PA
5	Alluvial–sparse graminoid	Sparse ruderal cover of reed canary grass, Kellogg's sedge, horsetail, and annual forbs; occurring at mid to lower elevations on coarse gravel and gravelly sand (alluvial substrates).	PC, BG, BE
6	Mud flats	Low elevation, wet, generally unvegetated depressional flats and shallow basins adjacent to active channels.	BE, PE
7	Cobble	Cobble deposits, typically unvegetated.	BB
8	Rip rap	Rip rap used to reinforce highway bank; unvegetated	BB, IN
9	Riparian shrub	Shrub strip on steep slope of highway embankment (willows, red-osier dogwood, alder, cottonwood).	n/a
10	Borrow pit	Low elevation, remnant constructed borrow pits; ponded for a significant portion of the growing season; may support submergent macrophytes. Banks support ruderal annuals including the rare (S3/S4) moss grass.	n/a
11	Beach	Sparsely to unvegetated sandy beach.	BE, BG
12	Reed canarygrass–bluejoint	Transitional wetland graminoid association supported by subterranean creek flow; drier and less diverse than wetland immediately upstream (13).	RR
13	Marsh	Graminoid marsh fed by watercourse entering the drawdown zone from an upstream highway culvert; rich substrate supporting a dense cover of marsh plants including beaked sedge, bluejoint, small-flowered bulrush, marsh cinquefoil, and water smartweed.	RR
14	Pond	Low elevation, naturally formed shallow ponds adjacent to Burton Creek.	PO
15	Active channel	Active channels associated with Burton Creek; unvegetated.	n/a

3.2 Burton Creek Wildlife Physical Works

The Burton Creek WPW is located south of Nakusp, on the east side of the Arrow Lakes Reservoir. It is adjacent to Highway 6 from which it is highly visible, and accessible via Robazzo Road. The site is well-used by the public for recreation (e.g., picnics, camping, off-road vehicle use, dog walking, etc.). Prior to construction activities in 2019, this site was a depression with low vegetation species diversity, including non-native reed canarygrass (Figure 3-2; Figure 3-3). Most of the site was deemed unsuitable for aquatic invertebrates and aquatic macrophytes. While some wildlife use (e.g., songbirds and amphibians) had been documented from this area (Hawkes and Tuttle 2016), an influx of waterbirds and other species during periods of inundation indicate that the area is underutilized by wildlife when reservoir elevations are lower, including during key periods for migration or nesting for animals (Waytes et al. 2020).



Map 1. **Location of 2020 Wildlife Physical Works at Burton Creek (inset) within the drawdown zone of Arrow Lakes Reservoir, British Columbia.**

Figure 3-2. Pre-treatment (left) and post-treatment (right) photos of the Burton Creek Wildlife Physical Works location. Credit: M. Miller.

Figure 3-3. Photos of the pre-treatment (top) and post-treatment (bottom) Burton Creek Wildlife Physical Works location in 2019. Credit: R. Waytes and M. Miller.

The first phase of the physical works project was initiated at Burton Creek in September 2019 (Figure 3-4). Five ponds (A1-A4 and B1; Figure 3-5) and two mounds (C2 and C3) were constructed at Burton Creek in September and October of 2019 (Miller and Hawkes 2020). The constructed terrain was subsequently revegetated with a combination of native plants (sedges, shrubs, and trees) using locally salvaged material as well as nursery stock. The next planned phase of activity at Burton Creek includes the expansion of some ponds (A3 and A4), the construction of pond D1, and expansion of mounds C2 and C3. The environmental objectives for the physical works are found in Kerr Wood Leidel (2018). Pre-construction wildlife habitat suitability was considered to be low and is expected to increase substantially with the implementation of the physical works (Hawkes and Tuttle 2016).

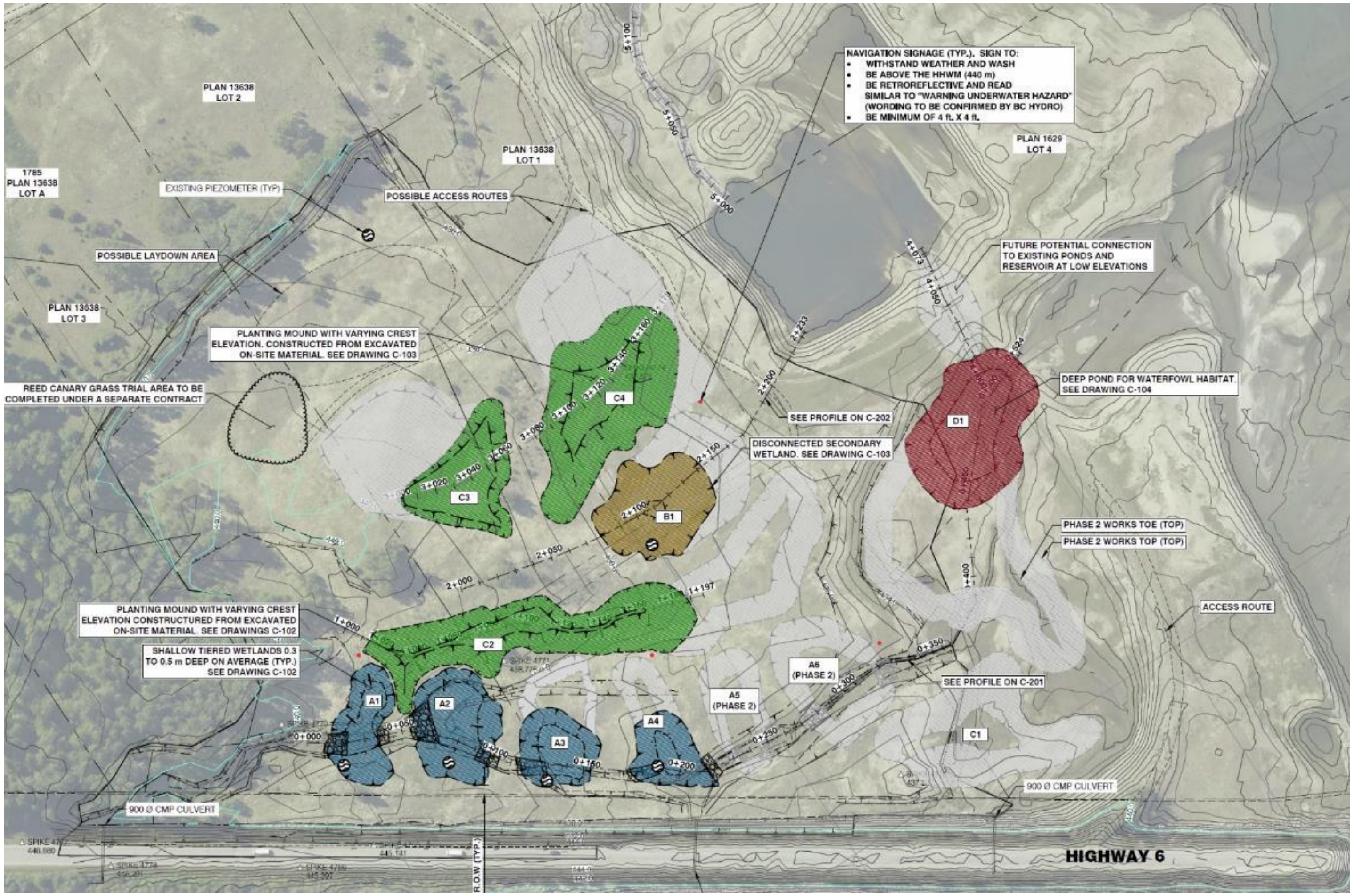


Figure 3-4. Schematic of the designed physical works at Burton Creek. The physical works incorporates elements of shallow tiered wetlands (blue polygons, secondary, stand-alone wetlands (brown), deep ponds (red), and planting mounds with varying crest elevations (green). Ponds A1-A4 and B1 and mounds C2 and C3 were constructed in September and October of 2019.

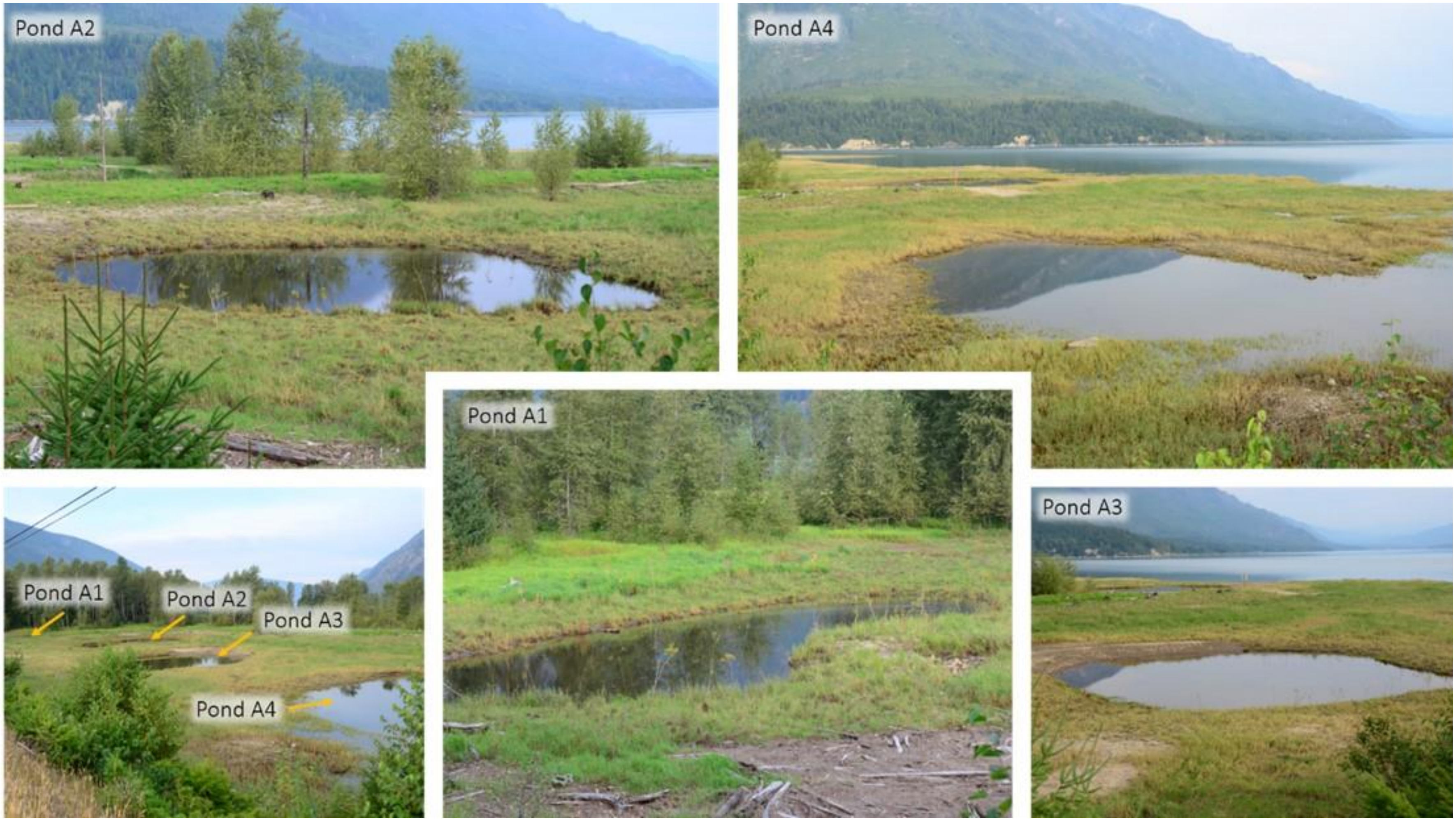


Figure 3-5. Photos of constructed ponds A1-A4 taken at Burton Creek in 2020. Credit: G. Davidson. See Appendix A for a photographic time series (August to November 2020 of the constructed ponds.

3.3 Arrow Lakes Hydrograph

Reservoir elevations in 2020 were lowest in February to April, hitting the lowest yearly point on March 3 (428.19 m ASL; Figure 3-6). Water levels increased after that, peaking on July 2 (439.69 m ASL). From a summertime peak, water levels typically drop until October/November when a secondary peak sometimes occurs. From that secondary peak, reservoir elevations then lower until the annual minima.

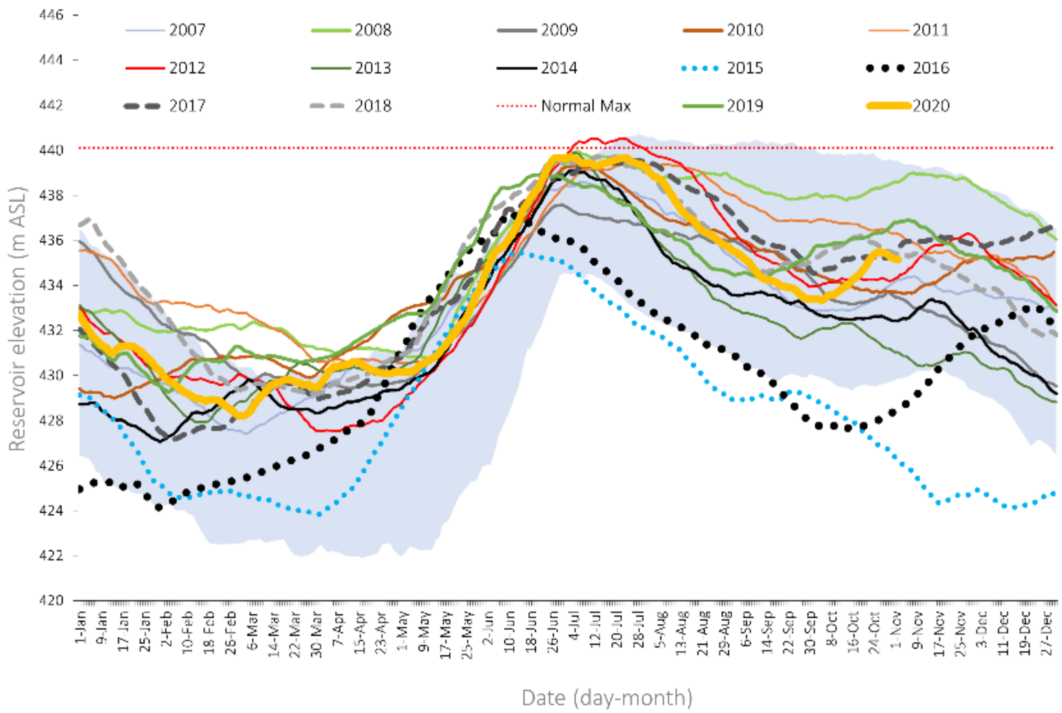


Figure 3-6. **Arrow Lakes Reservoir elevations for 2008 to Nov. 2, 2020.** The 10th and 90th percentiles are shown for 1969-2020 (shaded area); m ASL= metres above sea level.

4.0 INDICATOR TAXA

An effectiveness monitoring program should be designed to determine how well management activities, decisions, or practices meet the stated objectives of the program (Marcot 1998; Noon 2003). Key to designing an effectiveness monitoring program is the selection of sensitive and readily measurable response variables that are appropriate to the objectives of the management action (Machmer and Steeger 2002); however, the selection of indicators (e.g., focal species) can be challenging (Andersen 1999).

The selection of indicator taxa should be guided by their sensitivity to the management practice, the ease of collecting data, and the usefulness of the information to address the management activity (Chase and Guepel 2005). Potential indicators may include habitat attributes, keystone species, species at risk, species that are sensitive to specific habitat requirements, or species that can be readily monitored (Feinsinger 2001; Chase and Guepel 2005). The selection of indicators should also be appropriate to the spatial scale of the applied management activity and must take into consideration factors that are external to the monitoring program, such as inter- and intra-specific competition, predation, climatic change, disease, time of year, and in the case of CLBMON-11B1, normal reservoir operations.

The efficacy of the physical works constructed at Burton Creek was assessed using a Before-After assessment. Baseline data collection from 2017-2019 that occurred in the physical works area prior to its construction encompassed arthropods, birds (songbirds and waterfowl), bats, and amphibians and reptiles (obtained from CLBMON-37). Large mammal use (e.g., ungulates) of the physical works location was based on opportunistic observations of wildlife and associated signs, as well as the use of remotely triggered wildlife cameras in 2019. Starting in 2020, data reflects post-construction conditions of the physical works.

The indicator taxa selected for monitoring at the Burton Creek WPW site include terrestrial arthropods, birds (songbirds and waterbirds), bats, and wildlife usage patterns. The rationale for the inclusion of each of these groups is provided below.

5.0 TERRESTRIAL ARTHROPODS

Arthropods, including spiders and beetles, are the most diverse group of organisms found in terrestrial environments. Terrestrial arthropods are often abundant across many different ecosystems and habitats. A diversity of specialist species makes arthropods useful in monitoring studies because they respond rapidly to changes in the local and/or surrounding environment (McGeoch 1998; Schowalter 2006). Monitoring of ground beetles (Carabidae) and spiders (Araneae) has been particularly useful for monitoring effects in other large-scale monitoring studies across Canada (Buddle et al. 2000, 2006; Buddle and Shorthouse 2008; Pinzon et al. 2010; Work et al. 2008, 2013) and elsewhere. Even a small number of sampling units and few individuals can reliably reflect community structure, allowing for cost-effective, efficient sampling (Blanchet et al. 2015).

Arthropods are an important food source for many vertebrate taxa (e.g., birds, amphibians, and small mammals), and are integral to ecosystem processes such as decomposition, pollination, nutrient cycling, predation, and parasitism. Terrestrial arthropod abundance and diversity could be expected to increase with increasing vegetation structure and diversity (e.g., Humphrey et al. 1999; Söderström et al. 2001). Because of the trophic linkage between vegetation, arthropods, and songbirds, the inclusion of terrestrial arthropods as a focal species group to monitor makes intuitive sense.

5.1 Arthropod Sampling

Terrestrial arthropods were sampled at the Burton Creek Wildlife Physical Works site in 2020 (Appendix B). Sampling focused on the constructed and revegetated mounds (C2 and C3), as well as phase 2 pre-treatment areas of the WPW. Consistent with previous years (e.g., Hawkes et al. 2011, 2014, 2018b; Sharkey et al. 2018; Wood et al. 2018; Hentze et al. 2019; Waytes et al. 2020), arthropods were sampled via pitfall trap arrays and Malaise traps (Figure 5-1).

Three pitfall arrays were established on the constructed mounds and three arrays were established at pre-treatment areas of the phase 2 WPW, for a total of six arrays. We used polygons created for the constructed physical works features and for the phase 2 pre-treatment areas to determine the sampling areas of interest. Each set of three arrays were placed at randomly determined sampling locations within each polygon (physical works features or pre-treatment areas). We chose a 10 m minimum spacing for randomly selecting array unit locations. This inter-trap spacing distance for analyzing patterns of abundance, richness, and composition, aligns with that of Samu and Lövei (1995) and Bess et al. (2002).

Pitfall arrays comprised four traps (473 mL clear plastic Amcor® food cups) inserted into the ground, spaced ~1 m apart. Within each array, one pitfall trap was used to collect an arthropod diversity sample (used for arthropod identification, relative abundance, relative richness, and diversity). The remaining three pitfall traps were used to collect a biomass sample (to measure the dry weight of arthropod sample contents). Upon collection, biomass traps within each array were pooled. This resulted in one diversity sample and one biomass sample per pitfall trap array. Traps were filled with ~100 mL of preservation fluid (Propylene glycol, Univar Canada Ltd.) and checked daily to ensure functionality and record trap disturbance.

As with 2019 sampling (Waytes et al. 2020), three Malaise traps were set during each collection period in the WPW area as a descriptive measure of overall flying insect diversity in the area. Each Malaise trap generated one sample to be used for diversity information.

Figure 5-1. A pitfall trap array (left) and a Malaise trap (right) set in the Burton Creek WPW area in 2020. Credit: D. Adama.

To align with previous monitoring years and to capture temporal variation in arthropod abundance and composition, we collected samples in two collection periods. The two sampling periods were from 26-29 May and 6-9 June of 2020. The timing aligned with baseline sampling in 2019 (Waytes et al. 2020). Each trap was operational for approximately 72 hours. The arthropod sample was generated from two collection of six biomass pitfall samples, six diversity samples, and three Malaise trap samples.

5.2 Sample Processing and Identification

Arthropods from diversity pitfall trap samples were counted and classified to species for all spiders (Araneae) and ground beetles (Coleoptera: Carabidae), and to family for non-carabid beetles (Coleoptera). Malaise trap sample contents were sorted and identified to family for Hymenopterans and Dipterans.

Each biomass sample was weighed to the nearest centigram and placed in a drying oven. The samples were weighed each day during drying until the weight stabilized, indicating that drying was complete. Samples were dried for approximately 97.5 hours. The final dry weight of each sample was then used in biomass calculations.

5.3 Data Analyses

Samples are from 2020 (post-construction) and pre-construction baseline sampling years of 2018 and 2019. To eliminate temporal pseudoreplication, we limited the comparison of results to one sampling period per study year. Because the 2018 collection periods (8-11 June and 23-25 June) occurred later than those in 2019 (17-20 May and 3-6 June) and 2020 (26-29 May and 6-9 June) and to ensure the comparison was equivalent for time of year, we compared the results of the first collection in 2018 with that of the second collection in 2019 and 2020. This is reflected in data presented in box plots.

For results that did not involve multi-year comparisons (such as reporting arthropod families or species and associated abundances), all available data were used from both collection periods in 2020.

All data visualizations were conducted with the statistics program R version 4.0.3 (R Core Team 2020).

5.3.1 Arthropod Relative Abundance (CPUE)

Relative abundance was calculated as catch-per-unit-effort (CPUE), equal to the number of adult spiders (Araneae), beetles (Coleoptera), or ground beetles (Carabidae) caught per diversity pitfall trap sample, standardized to a 24-hour trapping period (i.e., individuals per trap-day). This metric was generated from diversity samples only (n=6). Boxplot graphs were provided for mean CPUE of pitfall trap samples.

5.3.2 Arthropod Richness

We standardized richness for trapping effort (per 24-hour trap day) for each pitfall trap array (n=6). This metric was generated from diversity samples only. Samples were rarefied to a sample size of two for comparison using the R package ‘vegan’ (Oksanen et al. 2020). Boxplot graphs were provided for rarefied richness of two groups (Araneae species and Carabidae species). For species richness comparisons, samples were limited to adult individuals identified to species (i.e., adult spiders and ground beetles).

5.3.3 Arthropod Diversity

We assessed arthropod diversity using the Shannon-Wiener index, standardized by trapping effort (per 24-hour trap day) for each pitfall trap array. This metric was generated from diversity samples only (n=6). Boxplot graphs were provided for diversity of two groups (Araneae species and Carabidae species). Samples were limited to adult individuals identified to species.

Families of Coleoptera and species of Araneae and Carabidae captured in pitfall trap arrays were presented as bar plots, with associated abundances. Families of Hymenoptera and Diptera captured in Malaise traps were also presented in bar plots with associated abundances.

5.3.4 Arthropod Biomass

Biomass was calculated as the dry weight of arthropods (mg) per trap-hour for each sample, restricted to pitfall trap biomass samples. Biomass pitfall trap results were presented via boxplot graphs.

5.4 Arthropod Results

5.4.1 Pitfall samples

Average insect biomass ± SE for pitfall arrays set in phase 1 constructed mounds was 2.56 ± 0.40 mg/hr during the first collection (n=3) and 4.42 ± 0.96 mg/hr during the second collection. Average insect biomass was comparatively higher for pitfall arrays set in phase 2 pre-treatment WPW areas, which had a biomass of 4.53 ± 0.63 during the first collection (n=3) and 7.05 ± 0.64 mg/hr for the second collection.

Median biomass was generally higher in 2020 compared to baseline data collected in 2018 and 2019 (Figure 5-2). This is especially true for biomass from pitfalls in the WPW pre-construction areas, compared to phase 1 mounds. The difference between the biomass from pitfall traps in phase 1 constructed areas and 2019 baseline data was less notable.

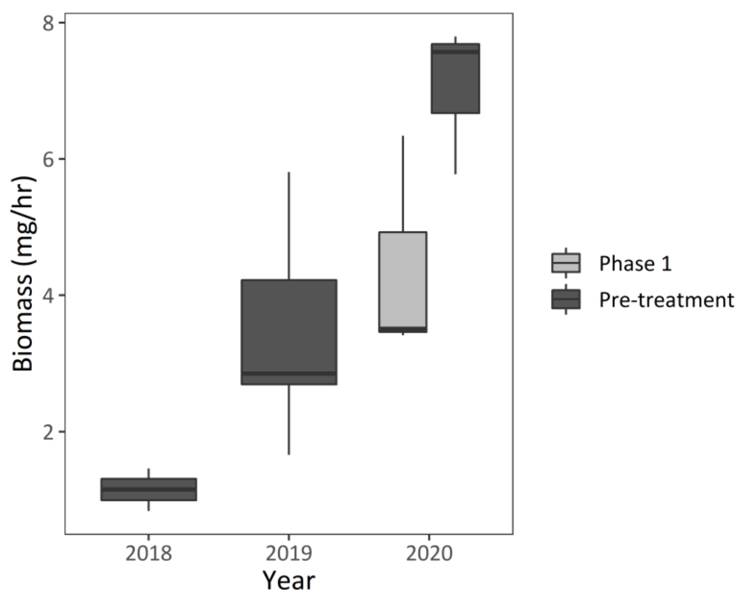


Figure 5-2. Arthropod biomass (mg) per trapping hour by sampling year for pitfall trapping in the Wildlife Physical Works area. Biomass collected in 2018 and 2019 (n=5 arrays per year) represents pre-treatment baseline conditions. Biomass from 2020 includes pitfall traps in phase 1 construction areas (n=3) and pre-treatment areas (n=3).

We collected a total of 118 adult beetles comprising 8 families (Figure 5-3). As in previous years, beetles in the family Carabidae were the most frequently collected. Beetles from families Chrysomelildae and Staphylinidae were also well represented in the samples, which is also consistent with 2019 sampling. Beetles from other families occurred infrequently.

We collected 50 adult carabid beetles comprising 13 species from 12 pitfall trap arrays (six set from 26-29 May and six set from 6-9 June 2020) (Figure 5-4). The samples were dominated by exotic species (including *Pterostichus melanarius, Carabus granulatus,* and *Clivina fossor*) (Figure 5-5). These species have been previously recorded in the WPW area.

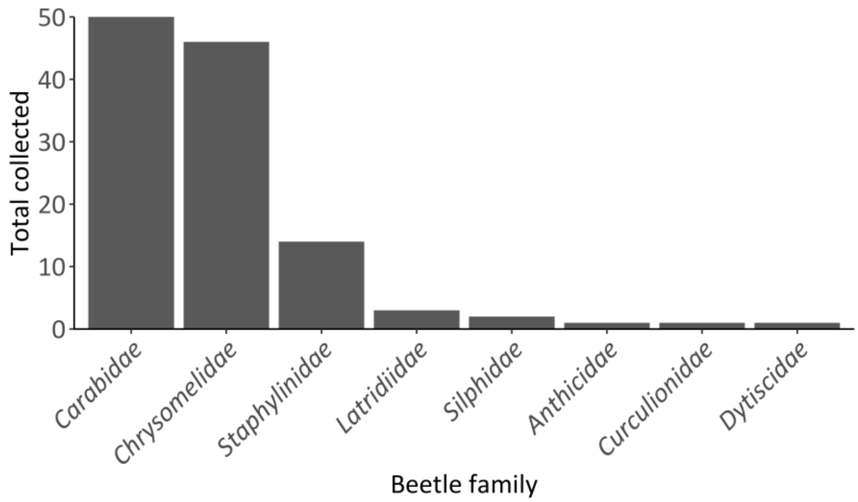


Figure 5-3. Families and abundances of adult beetles (not standardized to trapping effort) collected from pitfall traps in the Wildlife Physical Works site (n=12) in 2020.

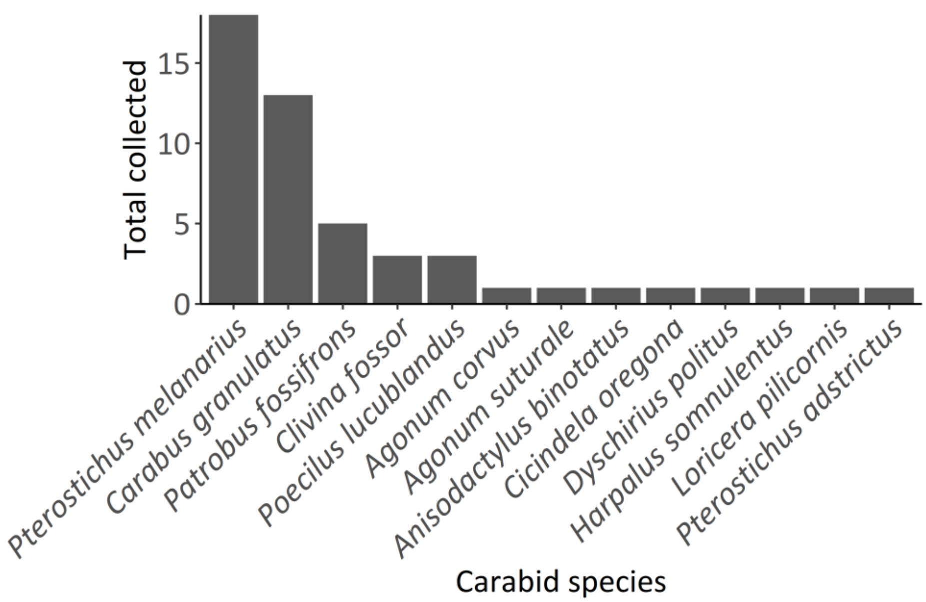


Figure 5-4. Species and abundances of adult carabid beetles (not standardized to trapping effort) collected from pitfall traps in the Wildlife Physical Works site (n=12) in 2020.

Figure 5-5. ***Clivina fossor*** **specimen collected from a pitfall trap during 2020 sampling.** Samples were collected at the Burton Creek Wildlife Physical Works site.

We collected 73 adult spiders comprising 4 families and 11 species from 12 pitfall arrays set in the WPW area (Figure 5-6). Many of the species have been found in previous years (Hentz et al. 2019; Waytes et al. 2020), including the two most common species, *Pardosa fuscula* and *Pardosa altamontis*.

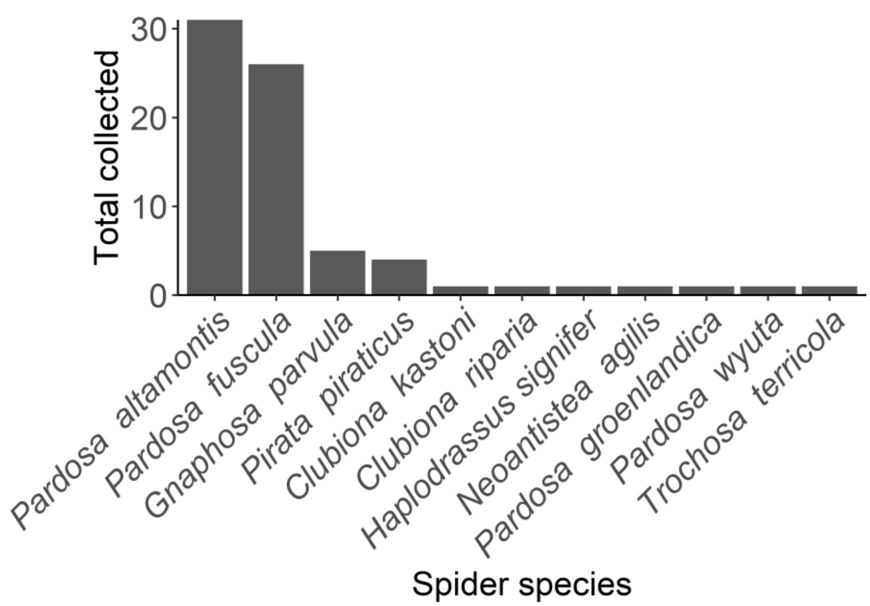


Figure 5-6. Species and abundances of adult spiders (not standardized to trapping effort) collected from pitfall traps in the Wildlife Physical Works site (n=12).

Median catch-per-unit effort (CPUE) for carabid beetles was similar between phase 1 physical works and planned pre-treatment areas in 2020 (n=3 for each), and higher than median catch-per-unit effort collected in previous years (Figure 5-7). The CPUE for spiders was similar between pre-treatment pitfall collections in 2018 (n=5) and those in 2020, and lower in 2020 compared to pre-treatment collections in 2019 (Figure 5-7). There was a lower median spider CPUE from pitfall traps on constructed mounds compared to those in pre-treatment areas.

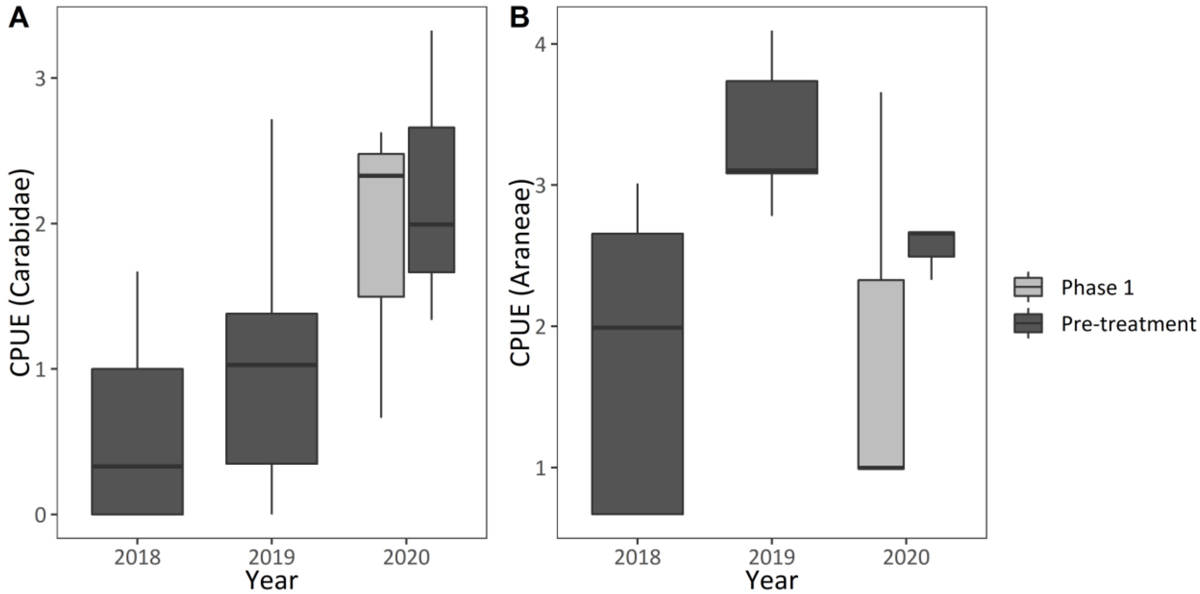


Figure 5-7. Catch-per-unit effort (CPUE) for carabid beetles (A) and spiders (B) from pitfall arrays per 24-hours by sampling year for the Wildlife Physical Works area. CPUE calculated for 2018 and 2019 (n=5 arrays per year) represents pre-treatment baseline conditions. CPUE calculated for 2020 includes pitfall traps in phase 1 construction areas (n=3) and pre-treatment areas (n=3).

Both carabid beetle and spider diversity and richness differed between sampling years (Figure 5-8). Median carabid diversity from the constructed physical works was similar to pre-treatment conditions in 2019, although less than the median diversity in pre-treatment areas in 2020. Carabid richness was similar between the constructed physical works and non-altered WPW area in 2020 and was potentially higher than in previous years. Median spider diversity and richness were slightly higher in the non-altered pre-treatment WPW areas compared to the phase 1 constructed mounds. Overall spider richness and diversity in 2020 seemed comparable to that in 2019.

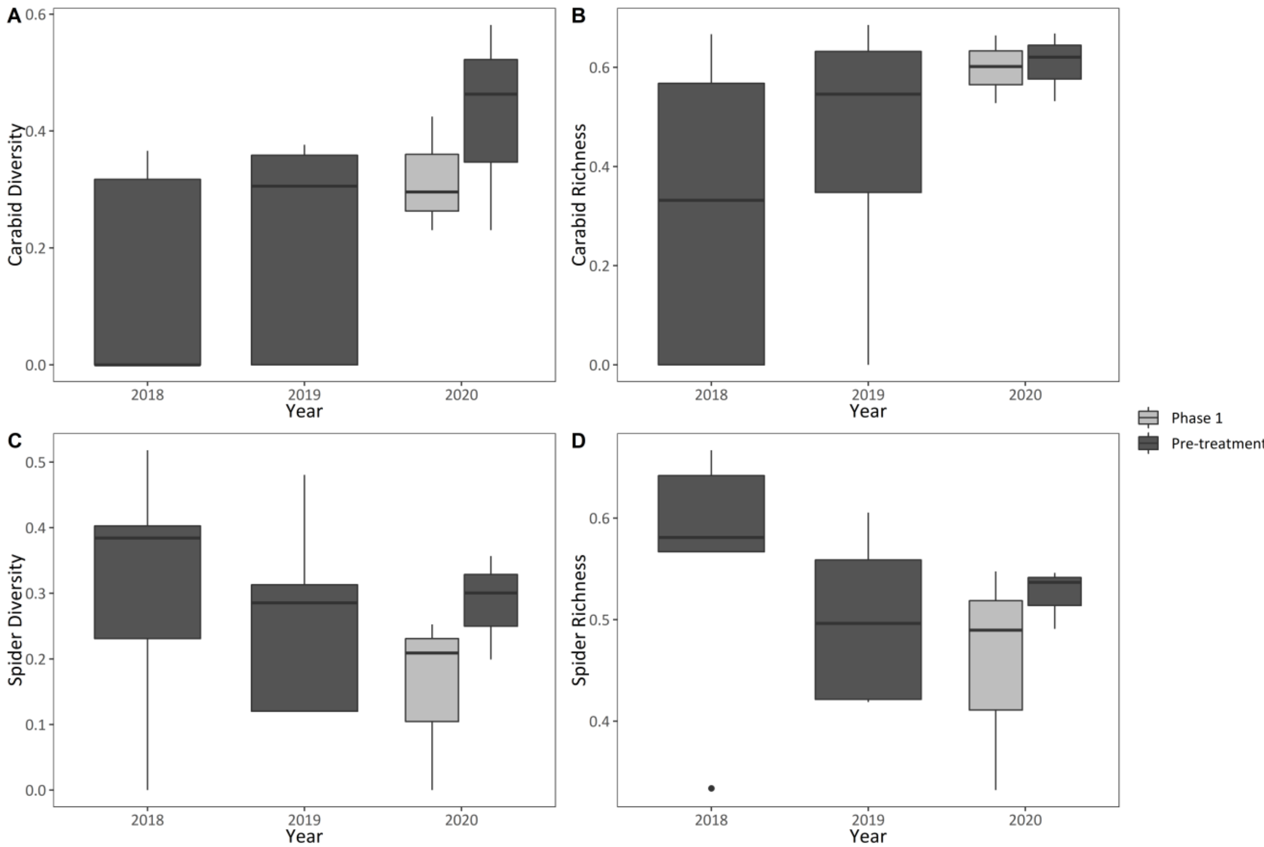


Figure 5-8. Standardized carabid diversity (A) and rarefied richness (B) and standardized spider diversity (C) and rarefied richness (D) per 24-hours by sampling year for the Wildlife Physical Works area. Data collected in 2018 and 2019 (n=5 arrays per year) represent pre-treatment baseline conditions. Diversity and richness from 2020 include pitfall traps in phase 1 construction areas (n=3) and pre-treatment areas (n=3).

5.4.2 Malaise samples

We collected 430 adult Hymenopterans consisting of 26 families (Figure 5-9) and 5941 adult Dipterans consisting of 36 families (Figure 5-10) from six Malaise traps. As in previous years, parasitic wasps dominated the Malaise trap samples. Wasps from the families Ichneumonidae and Diapriidae were the most abundant, followed by Braconidae. Wasps in the superfamily Chalcidoidea (including Eurytomidae, Mymaridae, and Pteromalidae, among others) were also well-represented in the samples. Flies in the families Chironomidae, Sciaridae, and Phoridae dominated Malaise trap samples.

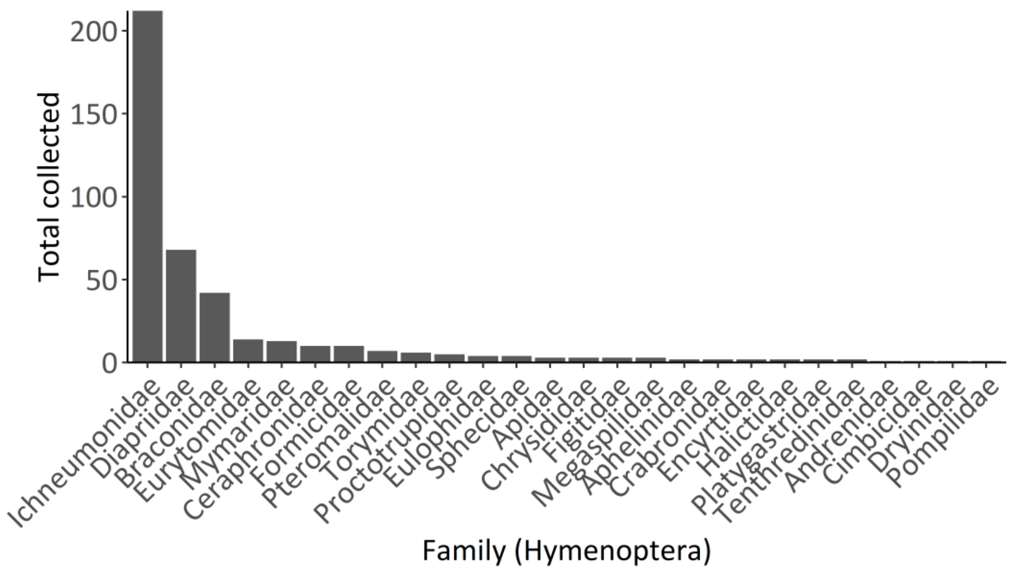


Figure 5-9. Hymenoptera families and associated abundances (not standardized to trapping effort) collected from all Malaise traps in the Wildlife Physical Works site (n=6) in 2020.

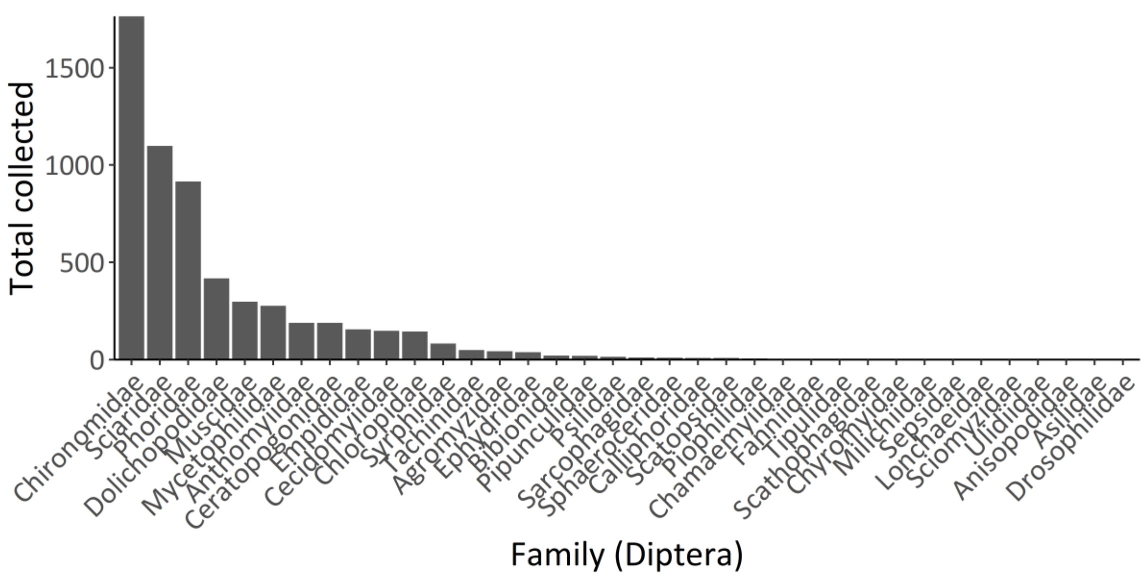


Figure 5-10. Diptera families and associated abundances (not standardized to trapping effort) collected from all Malaise traps in the Wildlife Physical Works site (n=6) in 2020.

5.5 Arthropod Discussion

We monitored spider and ground beetle populations in the Burton Creek WPW area as a measure of ecosystem response to the physical works. The short generation time and rapid population growth of arthropods allow them to respond earlier than other taxa to shifts in the environment, making them ideal indicators (Kremen et al. 1993). Both spiders and ground beetles are influenced by environmental features such as vegetation complexity and structure (Bucholz 2010; Blanchet et al. 2013). Increased vegetation diversity provides different niches for spiders that specialize in different modes of prey capture (Hatley and MacMahon 1980; Uetz 1991). As the vegetation complexity in the WPW area shifts from primarily reed canarygrass to a more diverse plant assemblage, we therefore expect to see shifts in the spider and ground beetle communities compared with baseline populations. Both spiders and ground beetles showed a relatively low diversity prior to WPW construction.

Results of arthropod surveys in 2020 suggest a response to the WPW construction, although this is more likely due to the disturbance of the recent construction activity rather than direct effects of habitat improvement. Arthropod biomass showed a potential increase in 2020 compared to previous years in the WPW area, although more so in pitfall traps located outside of the constructed areas. While this trend is promising, it may be at least partly due to yearly variation, or some other element not directly measured by our study (such as reservoir activity). This is reflected in differences between biomass measured in the baseline years of 2018 and 2019. Future sampling and the incorporation of controls outside of the immediate WPW area for reference could confirm this positive trend.

The species of spiders and carabid beetles found in the WPW area were consistent with those found in previous years. The most common spider species, *Pardosa altamontis* and *P. fuscula*, are known to prefer moist or wet habitats (Lowrie 1973; Dondale and Redner 1990). The prevalence of introduced carabid beetles is likely both a holdover from pre-construction conditions and a reflection of the recent disturbance to the habitat via the WPW construction. While arthropods can respond more quickly than other taxa to ecosystem shifts, more time is necessary for the establishment of the revegetation and for the area to recover from the disturbance of the construction to see potential positive effects on arthropod communities.

Carabid beetles and spiders showed opposite trends for CPUE, with carabid beetles increasing and spiders decreasing in 2020 compared to previous years. Though the trend in CPUE was positive for carabid beetles post-construction, the increase largely involved exotic and ‘weedy’ species. The decline in spider catch-per-unit effort between 2019 and 2020 could be due to the disturbance of the construction activities. Similarly to biomass, the change in CPUE could also be the result of yearly variation or reservoir activity, given the apparent differences between baseline CPUE data in 2018 and 2019. Establishing a control at the Burton Creek site outside of the WPW area could serve as a reference for variation outside of the effects of the WPW construction.

For a number of arthropod variables, including arthropod biomass, carabid and spider diversity, and spider CPUE, the values were lower in the constructed physical works compared to nearby areas that had not been subject to restoration activities. Given that the disturbance of the WPW construction occurred less than a year before arthropod monitoring took place, it was likely the impact of these activities that negatively affected arthropod presence and activity.

While ultimately the WPW should promote arthropod abundance and diversity in the area, and as such increase food availability for insectivorous wildlife, the current trends are not unexpected given the recent WPW construction. Continued monitoring will give a better indication of the success of the physical works. Additional controls could help control for yearly variation.

6.0 BIRDS

Monitoring the response of birds to management strategies has proven a pragmatic approach on several levels. For example, songbird monitoring can (1) measure the effectiveness of restoration and enhancement; (2) provide the necessary feedback for adaptive management; (3) guide restoration design by providing information on the health and habitat associations of the local bird populations; (4) be cost effective; and (5) provide education and outreach opportunities (Burnett et al. 2005). Because birds occupy an extremely diverse range of niches within an ecosystem and a relatively high position in the food chain, they are ideal indicators of environmental conditions (DeSante and Geupel 1987; Temple and Wiens 1989; Rich 2002). Along with the relative ease of study and the cost effectiveness of a songbird monitoring program, songbird monitoring provides researchers with feedback from a whole community of organisms, not just a single species. Thus, songbirds are model organisms for measuring the efficacy of restoration or enhancement projects. However, study designs need to account for the spatial characteristics of bird responses to restoration or enhancement projects, and they may not always be suitable for assessing fine-scale changes within broader landscape contexts.

6.1 Songbird Surveys

Travel restrictions due to the COVID-19 pandemic necessitated an alternative to in-person songbird point count surveys. Instead, six Wildlife Acoustics Song Meter autonomous recording units (ARUs; SM4 Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) were deployed to record bird songs in the WPW area (Figure 6-1; Appendix B). ARUs were deployed on 5 May 2020. Due to reservoir inundation, two detectors were removed on 29 May (ARU3A and ARU4A) and one detector was removed on 8 June (ARU1A). The remaining detectors (ARU2A, ARU5A, and ARU6A) were removed on 7 August 2020. Due to limited field presence, nest searches were not conducted in 2020.

We used acoustic ARU data to record bird species in the area. The protocols used for selecting the seasonal window, time of day, and appropriate weather for the surveys adhered to provincial standards for breeding bird surveys (RIC 1999). Two dates were randomly chosen within constrained time periods (5-10 June and 20-25 June). These chosen dates were 05 June and 23 June 2020. The timing of the dates chosen coincides with the height of the breeding season at which time locally breeding passerines are on territory and highly vocal and is consistent with survey dates in previous years. Prior to reviewing recordings, it was determined that a second date would be selected if sub-optimal weather conditions (i.e., rain, strong winds) occurred on the original chosen date. An ornithologist analyzed six-minute intervals of recordings from each ARU on the chosen dates, which corresponds to the standard point count window, and recorded all bird species detected. These intervals occurred approximately 15 minutes after sunrise. Because several acoustic ARU units were removed due to reservoir inundation, bird activity was monitored on four ARUs for the first time period and three ARUs for the second. Acoustic ARU recordings offer valuable information on bird species presence and can detect birds to a level similar to humans (Castro et al. 2019). While we cannot assess species abundance or habitat use from the recordings, they were used to indicate species presence.

Figure 6-1. An acoustic (left) and ultrasonic (right) ARU attached to a tree near the WPW area in 2020. Credit: D. Adama.

6.2 Waterbird Surveys

Surveys focused on waterbirds were completed on 26 dates from 13 April through 29 October 2020 to monitor waterbird use in the WPW constructed ponds and nearby area. During each survey period a map showing the survey area and approximated water levels for that date was provided, and the number and species of birds (all birds, but with a focus on waterbirds) were recorded onto the map. Birds were recorded as waterbirds or land birds on two separate maps. The area surveyed included the WPW area plus additional and adjacent locations to ensure that bird usage of the WPW location was put into context of the surrounding area and relative to phase 1 of the WPW.

6.3 Bird Results

In total, 30 bird species (21 of which were songbirds) were detected from analysed ARU recordings on the two sampled dates (Table 6-1). This includes nineteen species during the first survey date (5 June) and eighteen species during the second survey date (23 June). One species of special concern, the Evening Grosbeak, was detected by an ARU (COSEWIC 2016).

Table 6-1. **Bird species detected from acoustic ARU recordings on 5 and 23 June 2020.** Check marks indicate dates bird species were detected**.**

	Date	
Species	05-Jun	23-Jun
American Crow		✓
American Redstart	✓	✓
American Robin	✓	
Black-capped Chickadee	✓	✓
Canada Goose		✓
Cedar Waxwing	✓	✓
Chipping Sparrow	✓	
Common Yellowthroat	✓	✓
Eastern Kingbird		✓
Evening Grosbeak*	✓	
Green-winged Teal	✓	
Hammond's Flycatcher	✓	✓
Killdeer	✓	
Lazuli Bunting	.	✓
MacGillivray's Warbler	✓	✓
Mallard	✓	
Northern Flicker		✓
Pine Siskin		✓
Red-breasted Nuthatch		✓
Red-eyed Vireo	✓	✓
Solitary Sandpiper	✓	
Spotted Sandpiper	✓	✓
Tree Swallow	✓	
Warbling Vireo	✓	✓
Western Meadowlark		✓
Willow Flycatcher	✓	
Wood Duck		✓
Yellow Warbler	✓	

*Evening Grosbeak appears on Schedule 1 of the *Species at Risk Act* as a species of Special Concern

In total, 44 species of waterfowl, loons, grebes, shorebirds, and herons (hereafter collectively referred to as "waterbirds") were recorded during spring through autumn waterbird surveys in 2020 at Burton Creek (

Appendix C). A total of 6,157 birds were counted over all visits. Corrected for effort, the months with the greatest bird abundances were September, October, November, and August (in that order). May had the lowest number of abundances per visit.

Waterbird sightings typically followed the reservoir edge. However, there were sightings of waterbirds using the constructed ponds. Prior to inundation, Mallards (*Anas platyrhynchos*) were recorded in ponds A1 and A3 in May and June. Additionally in June, Canada Geese (*Branta canadensis*) adults and their young were spotted in pond A2, and a Spotted Sandpiper (*Actitis macularius*) was recorded by pond A3. As the WPW area was inundated in June and July due to the rising reservoir levels, other species sighted in the proximity of the WPW were Common Mergansers (*Mergus merganser*), Common Loons (*Gavia immer*), and Spotted Sandpipers. Canada Geese still frequented the area after water levels receded in the later months, including an observation of 35 Canada Geese in pond A2 on October 21, and Spotted Sandpipers were recorded near ponds A2 and A3 at the end of August. Species sightings of note in the Burton Creek area included a Horned Grebe (*Podiceps auratus*), a species of special concern (COSEWIC 2009), in the October-November period as well as Black-necked Stilts (*Himantopus mexicanus*), a Long-billed Curlew (*Numenius americanus*), and a Double-crested Cormorant (*Phalacrocorax auratus*; Figure 6-2).

Figure 6-2. Waterbirds photographed in the Burton Creek area in 2020. From top left clockwise, Black-necked Stilts, a Long-billed Curlew, a Double-crested Cormorant, and a Whimbrel. Credit: G. Davidson.

59 species of birds other than waterbirds were also detected at Burton Creek. Over the course of the season, the most frequently sighted non-waterbird species during

physical site surveys were Bald Eagles (*Haliaeetus leucocephalus*), followed by American Pipits (*Anthus rubescens*) and Pine Siskins (*Spinus pinus*; Appendix D). Barn Swallows and Bank Swallows, both listed as threatened species by COSEWIC, frequented the area (COSEWIC 2011; COSEWIC 2013b). In July, a Western Meadowlark's (*Sturnella neglecta*) nest was found in Burton Creek, although not in the WPW area.

6.4 Bird Discussion

We recorded 21 species of songbirds on acoustic ARUs, which were either in the WPW area or adjacent to it. This suggests that the habitat is being used to some extent by songbirds, although not necessarily all the species detected. It is important to note that the bird surveys by acoustic ARUs are not directly comparable to in-person point counts. Acoustic ARUs do not have the same distance restraints that traditional point counts do (i.e., distance to detection can't reliably be determined from the recording), and so recordings may include species not immediately in the WPW area. Using acoustic surveys also limits our ability to understand how birds are using the habitat. However, the ARU recordings are helpful for understanding what species are present on site, especially considering in-person sampling constraints due to COVID-19. Of the species detected, Common Yellowthroat (*Geothlypis trichas*) is a wetland-associated species that may breed in the WPW area. Some forest-associated species detected such as the American Redstart (*Setophaga ruticilla*), Hammond's Flycatcher (*Empidonax hammondii*), and Pine Siskin were likely recorded from the nearby woodland rather than the WPW area. Other species such as the American Robin (*Turdus migratorius*), Chipping Sparrow (*Spizella passerine*), and Willow Flycatcher (*Empidonax traillii*) may have been recorded singing from the WPW area, but likely were not breeding in the area. The Evening Grosbeak (*Coccothraustes vespertinus*) was only recorded once, which is consistent with a flyover. Songbird species are expected to respond to changes in the vegetation structure of the WPW, especially because the area will likely provide habitat to bird species that would otherwise be unavailable in the drawdown zone. As the planted live stakes and shrubs in the WPW area become established and continue to grow, they will provide more suitable nesting opportunities for certain species.

The waterbirds detected in 2020 were distributed similarly to those observed in the 2019 surveys, as they were found to largely follow the rising shoreline due to reservoir inundation. Similar species were also detected between years, with a few notable species such as Black-necked Stilts and a Long-billed Curlew in 2020. High waterbird abundances in September, October, and November can be attributed to fall migration, as well as added numbers due to the presence of juvenile birds. Mallards and Canada Geese were observed in or near the constructed ponds. Outside of the waterbird surveys, wildlife cameras deployed in the WPW area detected species such as Mallards, Canada Geese, Wood Ducks (*Aix sponsa*), and Common Mergansers as the area became inundated.

7.0 BATS

There are 11 bat species potentially occurring in the Burton Creek area (Table 7-1), most confirmed by live capture studies. Of these species, Townsend's Big-eared Bat (*Corynorhinus townsendii*), Western Small-footed Myotis, Northern Myotis (*M. septentrionalis*), and Fringed Myotis (*M. thysanodes*) are blue-listed by the Conservation Data Centre (CDC), which is a status assigned to species that are particularly sensitive to impacts from human activities or natural events (BC CDC 2019). Federally, Northern Myotis and Little Brown Myotis (*M. lucifugus*) were emergency listed under the Species at Risk Act as Endangered (17 December 2014) due to the potential threat of White Nose Syndrome, a fungus caused by *Pseudogymnoascus destructans* that has been spreading westward since it was first documented in North America (COSEWIC 2013a). Fringed Myotis is considered Data Deficient by COSEWIC, meaning there is not enough scientific information available to support status designation.

Monitoring of bat species in the WPW area has occurred since 2017. Bat monitoring in the WPW area is important for the documentation of species at risk utilizing the area. Bat monitoring after WPW construction can also be used to compare against baseline pre-construction data.

Table 7-1. Provincial and national status of bat species potentially occurring in the Mid-Arrow Lakes area. 1-E = Schedule 1 of the *Species at Risk Act*; Endangered Status.

Common Name	Scientific Name	Code	Present	CDC Status	COSEWIC Status	SARA
Townsend's Big-eared Bat	*Corynorhinus townsendii*	COTO	Yes	Blue		
Big Brown Bat	*Eptesicus fuscus*	EPFU	Yes	Yellow		
Hoary Bat	*Lasiurus cinereus*	LACI	Yes	Yellow		
Silver-haired Bat	*Lasionycteris noctivagans*	LANO	Yes	Yellow		
California Myotis	*Myotis californicus*	MYCA	Yes	Yellow		
Long-eared Myotis	*Myotis evotis*	MYEV	Yes	Yellow		
Little Brown Myotis	*Myotis lucifugus*	MYLU	Yes	Yellow	Endangered	1-E (2014)
Northern Myotis	*Myotis septentrionalis*	MYSE	Yes	Blue	Endangered	1-E (2014)
Fringed Myotis	*Myotis thysanodes*	MYTH	Yes	Blue	Data Deficient	3 (2005)
Long-legged Myotis	*Myotis volans*	MYVO	Yes	Yellow		
Yuman Myotis	*Myotis yumanensis*	MYYU	Yes	Yellow		

7.1 Bat Sampling

To study bat presence in the Burton Creek WPW area, Wildlife Acoustics Song Meter autonomous recording units (SM4BAT Wildlife Acoustics, Inc., Maynard, Massachusetts, USA) were deployed from 4 May to 3 September in 2020 (Figure 6-1; Appendix B). Each unit was programmed with a schedule to record bat calls during two periods: i) half an hour before sunset for 5.5 hours, and ii) an hour before sunrise for 1.5 hours, for a total of 7 hours per 24-hour period. Six detectors were initially deployed, with two detectors subsequently removed on 30 May due to rising water levels (BUWPW3 and BUWPW4). This was an increase in sampling effort from previous years, from two ARUs in 2019 and three ARUs in 2017 and 2018.

Under ideal conditions, Wildlife Acoustics Song Meter detectors will sample bats in an airspace of 30 to 100m from the microphone, with bats emitting higher frequencies (e.g., *Myotis septentrionalis*) detected more often in the 30 m zone and bats emitting lower frequencies (e.g., *Lasionycteris noctivagans* and *Lasiurus cinereus*) detected up to ~100m from the microphone. The microphone paired with a Song Meter unit is omnidirectional, meaning that it will sample from almost all directions projecting out from the microphone. The microphones were set approximately 2m above ground or higher, attached to either extendable aluminum poles or tree branches, and the pitch of the microphone was set at approximately 90° (horizontal).

7.2 Data Analyses

Bat presence and activity in 2020 was assessed by analyzing triggered recordings from Wildlife Acoustics Song Meter units using their automatic classification software (Kaleidoscope Pro v. 5.3.9). Kaleidoscope utilizes classifiers developed from libraries of species-verified recordings to generate complex algorithms used in the automated identification process. Species classifiers can be selected to match the expected bat fauna in an area. The classifiers for 11 species that have been confirmed in the West Kootenays were selected for use in analysis of 2020 Wildlife Physical Works data. Auto ID analysis is intended for use on recordings of single bats in a low clutter environment, but some environmental (e.g., rain, wind, surface echoes, temperature changes, etc.) and biological (e.g., number of bats present, distance of bats, etc.) factors cannot be controlled and thus recording quality may vary. In addition, the acoustic signatures of many bat species overlap in their frequency ranges, making it difficult to confidently differentiate some species (Table 7-2; also, Szewczak et al. 2011a,b). Thus, the assignment of species is based in part on a probability that the species is present, and we treat our classifications as indicative rather than definitive. Data collected by autonomous recording devices do not provide an indication of the number of individual bats present in a given area.

Table 7-2. Typical frequencies (kHz) of calls from bat species expected to occur in habitats associated with the drawdown zone of the Lower and Mid-Arrow Lakes Reservoir.

	Frequency (kHz)		
Species	***Characteristic*** (***ƒ*** $_c$)	**Highest Apparent (Hi *ƒ*)**	**Lowest Apparent (Lo *ƒ*)**
Corynorhinus townsendii	21-26	40-45	19-23
Eptesicus fuscus	27-30	50-63	26-29
Lasiurus cinereus	18-22	21-31	18-22
Lasionycteris noctivagans	26-27	33-50	24-27
Myotis californicus	47-51	89-111	43-47
Myotis evotis	33-36	64-93	26-31
Myotis lucifugus	39-42	63-86	36-40
Myotis septentrionalis	40-47	95-114	32-42
Myotis thysanodes	23-26	57-88	17-22
Myotis volans	39-44	78-101	34-40
Myotis yumanensis	47-52	77-103	44-47

We calculated bat species richness for the WPW area and the number of recordings per detector-hour for each species and ARU. The number of recordings per detector-hour for each species was compared between years, with baseline data sets from 2017 (n=3 ARUs), 2018 (n=3), and 2019 (n=2). One ARU from 2020, which recorded no bat calls over the duration of its deployment, was removed from analysis as this was likely due to a loss of function.

7.3 Bat Results

All 11 species of bat were detected by autonomous recording units from the wildlife physical works area. These were predominantly species of *Myotis*, especially Little Brown Myotis (*Myotis lucifugus*) (Table 7-3). Three detectors were removed early due to threat of inundation (BUWPW2 and BUWPW3) or loss of function (BUWPW1). Of the detectors that remained, the detector BUWPW2 recorded the fewest calls (7.66 calls per detector-hour) and the detector BUWPW6 the most calls (30.14 calls per detector-hour) (Figure 7-1). There was a large amount of within-site (between-detector) variation. General patterns of recordings per detector-hour were consistent for each species between years (Figure 7-2), except for a large jump in the detection rate of the Yuma Myotis (*Myotis yumanensis*) in 2020 compared to previous years. The higher number of Yuma Myotis detections was largely localized to detector BUWPW6 (Figure 7-2).

Table 7-3. Recordings per detector-hour for bat detectors deployed in the Burton Creek WPW area. Richness refers to the total number of species detected by the ARU. The most detected species at each detector is highlighted in light green. Species codes are provided in Table 7-1.

Species	ARUBUWPW1	ARUBUWPW2	ARUBUWPW3	ARUBUWPW4	ARUBUWPW5	ARUBUWPW6
CORTOW	-	0.006	-	-	0.016	0.005
EPTFUS	-	0.057	0.012	0.054	0.124	0.062
LASCIN	-	0.376	0.018	0.012	1.204	0.225
LASNOC	-	0.962	1.274	0.744	2.249	1.238
MYOCAL	-	1.031	0.798	0.827	2.29	4.055
MYOEVO	-	0.051	-	-	0.028	0.02
MYOLUC	-	4.462	1.25	2.464	7.586	10.388
MYOSEP	-	0.001	-	-	0.001	-
MYOTHY	-	0.001	-	-	0.001	-
MYOVOL	-	0.18	0.012	0.077	0.281	0.703
MYOYUM	-	0.529	0.321	0.929	1.004	13.444
Richness	-	11	7	7	11	9

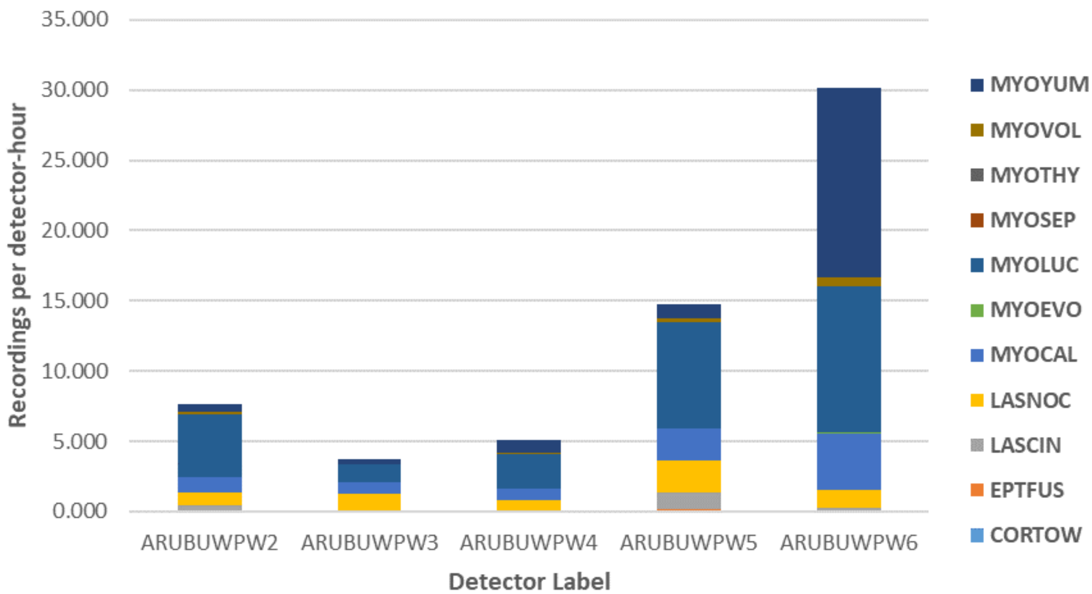


Figure 7-1. Relative abundance (recordings per detector-hour) of bat species by detector and site within Arrow Lake Reservoir, summer 2020.

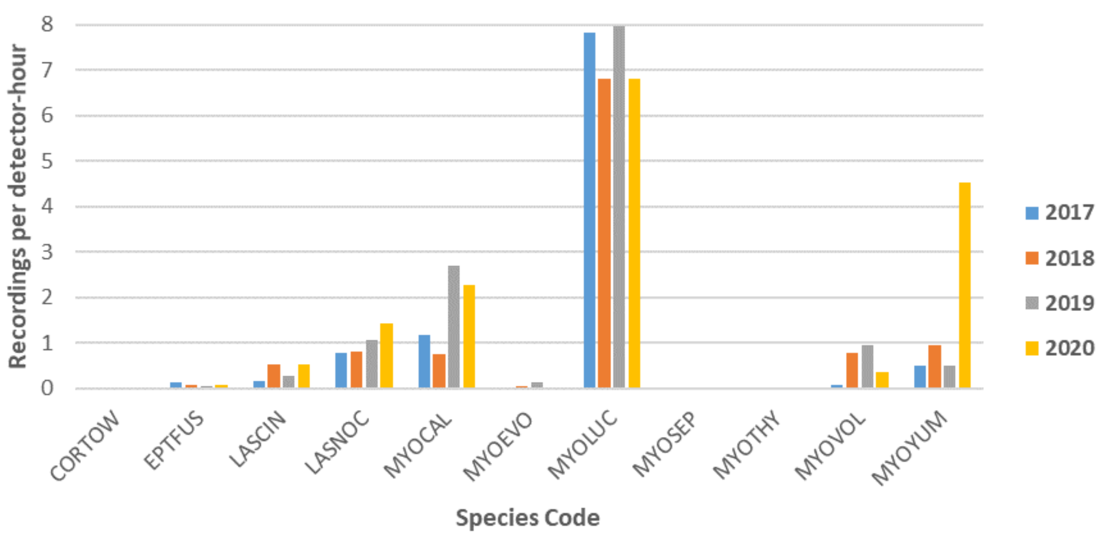


Figure 7-2. Proportion of recordings per detector-hour for all bat species documented by autonomous recording units deployed in the Burton Creek Wildlife Physical Works area. Bat species were monitored in 2017 (n=3 ARUs), 2018 (n=3), 2019 (n=2), and 2020 (n=5). Species codes are provided in Table 7-1.

7.4 Bat Discussion

All eleven bat species which were detected at Burton Creek in 2020 were consistent with those detected in previous years (Hentze et al. 2019; Waytes et al. 2020). This includes the Little Brown Myotis (*Myotis lucifugus*), a species of special concern that was one of the most abundant bats at the site. This species is designated as secure (yellow) in British Columbia, but has experienced severe declines in other parts of its range due in part to the impact of the White-nose

Syndrome (COSEWIC 2013a). Another federally designated bat, Northern Myotis (*M. septentrionalis*), was present at Burton Creek in low numbers, as well as the blue listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*M. thysanodes*). The higher detections of Yuma Myotis at one ARU in 2020 may have been due to the location of the detector, which had not been surveyed previously. It is possible that the ARU was located near a Yuma Myotis roost. Future sampling at this location would indicate whether this was the result of yearly variation.

8.0 AMPHIBIANS

Amphibians interact with both the terrestrial and aquatic components of an environment, and as such can be valuable indicators of changes to the ecosystem. Most amphibians breed in water (Duellman and Trueb 1986), making water availability essential for reproduction. Water quality and variability can affect amphibian development (Schmuck et al. 1994), and fluctuations in abiotic variables in the local environment (such as in ephemeral aquatic habitats) can influence the developmental rate of juveniles (Gerlanc and Kaufman 2005).

Amphibians are expected to benefit from the addition of the constructed ponds in the WPW area, especially during the breeding season (May-August). Amphibian species found previously in the area include the Western Toad, a species of special concern (COSEWIC 2012), Columbia Spotted Frog (*Rana luteiventris*), and Pacific Chorus Frog (*Pseudacris regilla*) (Hawkes et al. 2020). Given that amphibians were identified as one of the groups of wildlife that would benefit from the construction of wetlands at Burton it is important to understand how amphibians in the area interact with the WPW features.

8.1 Amphibian Sampling

The six Wildlife Acoustics Song Meter autonomous recording units (SM4) deployed for songbird sampling were also used to monitor for the calls of amphibians, including Western Toads (*Anaxyrus boreas*), a COSEWIC designated species of special concern (COSEWIC 2012). See Section 6.1 for more details on ARU deployment.

8.2 Data Analyses

We scanned the acoustic ARU recordings using a Western Toad recognizer to detect vocalizations with Song Scope™ software. The Western Toad recognizer was developed by the Bioacoustic Unit, a group within the Alberta Biodiversity Monitoring Unit (http://bioacoustic.abmi.ca/). We used the suggested Quality (30) and Score (50) threshold settings. This recognizer is species-specific and can detect the primary mating vocalizations of male Western Toads, allowing large amounts of data to be efficiently processed. Recognizer scans are then reviewed by human listening and/or spectrogram visualization to determine whether they correctly capture target calls or were false hits.

8.3 Amphibian Results

A single Western Toad vocalization was detected on an acoustic ARU (ARU4A; pond A4) on 13 May. A Western Toad was also observed in pond B1 on June 10. Incidental amphibian observations included a Columbia Spotted Frog egg mass and tadpoles at Pond A1 (Figure 8-1), as well as Pacific Chorus Frog vocalizations, all of which were detected on 5 May.

Figure 8-1. Columbia Spotted Frog egg mass and tadpoles photographed on 5 May (left) and a Western Toad photographed at Burton Creek on June 10, 2020 (right). Photos by D. Adama.

8.4 Amphibian Discussion

Amphibian presence in the WPW area was recorded previously during work associated with CLBMON-37 (Hawkes et al. 2020). In 2020, all three previously recorded species were confirmed in the WPW area including a visual confirmation of a Western Toad using one of the constructed ponds and Columbia Spotted Frog eggs and tadpoles in another. The Committee on the Status of Endangered Wildlife in Canada assessed the Western Toad as Special Concern (COSEWIC 2012) and it was listed under Schedule 1 of the Canadian Species at Risk Act (SARA) in 2005. The management objective outlined by Environment and Climate Change Canada (2016) is “to maintain stable or increasing populations distributed throughout the species’ present range in Canada”. The construction of wetland/pond habitat at the Burton Creek location should provide suitable breeding habitat for Western Toad thereby contributing to the maintenance of Western Toad populations at this location. Dedicated in-person surveys are required to determine usage of the constructed ponds at Burton, particularly during the breeding season in May and later in August when tadpoles are emerging as toadlets. The use of the area by Long-toed Salamander (*Ambystoma macrodactylum*) is expected but surveys during late April (and at night) would determine whether the species is in the area and using the WPW ponds at Burton Creek.

9.0 GENERAL WILDLIFE

Remote wildlife cameras are a cost effective, non-invasive tool for assessing and monitoring many terrestrial wildlife species, especially large- and medium-sized animals, as well as more inconspicuous species. With sufficient maintenance, wildlife cameras can provide long-term monitoring of an area. When deployed appropriately they can be used to study the use and distribution of wildlife species across areas and habitats (Burton et al. 2015). As such, wildlife cameras provide a tool for continuously monitoring the return and usage of wildlife to anthropogenically altered habitats as these habitats develop over time.

9.1 Wildlife Sampling

Wildlife use of the WPW area was recorded with wildlife camera photos as well as incidental observations. Incidental wildlife observations were recorded opportunistically during other site surveys. Six RECONYX® HyperFire 2™ cameras were set up in the Burton Creek WPW area to monitor wildlife use of the WPW and surrounding areas (Appendix E). Cameras were deployed on 5 May 2020. One camera was removed on 29 May and two cameras were removed on 8 June due to water ingress from the reservoir. The remaining three cameras were removed on 3 September 2020. Cameras were programmed to take ten photos with each trigger using the 'RapidFire' setting, which takes about two frames per second. After the last photo, each camera was programmed with a quiet period of one minute. Trigger sensitivity was set to medium-high. Remote cameras have the potential to provide more complete information about the suite of species using an area since they record 24 hours a day. Wildlife camera photos taken in 2020 can be compared to those taken pre-WPW construction. It is expected that the wetland project will increase habitat suitability for a variety of wildlife, thus, we expect an increase in species richness using this site.

9.2 Data Analyses

Wildlife photographs were processed using Reconyx MapView Professional™. Each photograph was visually assessed for wildlife. If wildlife were present, they were sorted by species and number of individuals. We presented wildlife photographs by species and the associated number of photographs. It should be noted that wildlife photographs are not directly related to animal abundance, as one animal can trigger multiple photographs and multiple cameras may record the same animal. These data should be used only as a general reference for which species of wildlife are found in the area.

9.3 Wildlife Results

There were 3,390 wildlife photographs taken at the Burton Creek WPW from 5 May to 3 September 2020, excluding photographs triggered by moving vegetation. Excluding photos of humans using the area, 2,728 of the photos were of wildlife. The most common species photographed was the Canada Goose (1,163 photographs), followed by Mallards (903 photographs) and white-tailed deer (418 photographs) (Figure 9-1; Figure 9-2; Figure 9-3). The highest number of photos taken of waterbirds was in July, likely corresponding with increased reservoir levels (Appendix F). Other animals photographed were an American beaver *(Castor canadensis*), Great Blue Heron (*Aredea herodias Herodias)*, Common Merganser, Wood Duck, an unknown canid species, and birds such as the American Robin, Belted Kingfisher (*Megaceryle alcyon*), Mountain Bluebird (*Sialia currucoides*), and Northern Flicker (*Colaptes auratus*). In May, off-road vehicle use was captured by remotely triggered cameras, including the use of dirt bikes and ATVs.

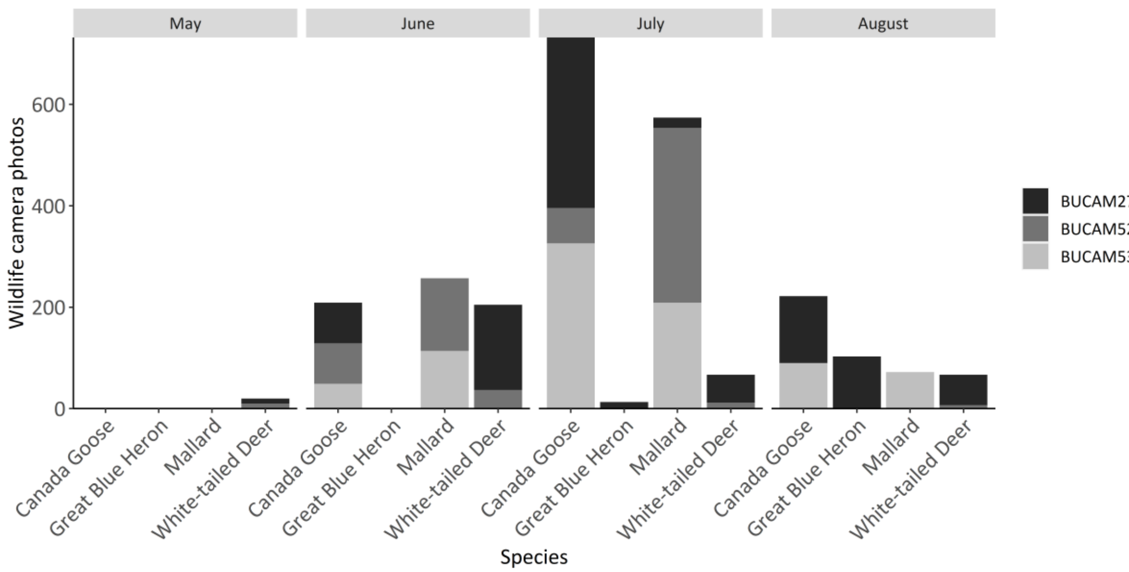


Figure 9-1. The number of wildlife camera photos taken per month by species and wildlife camera at the Burton Creek WPW area in 2020. Species were limited to those with over 100 photographs over the course of the summer. The data were limited to the three wildlife cameras present the entire four months (BUCAM27, BUCAM52, and BUCAM53; Appendix F).

Figure 9-2. Photographs of White-tailed Deer taken in the Burton Creek WPW area in 2020.

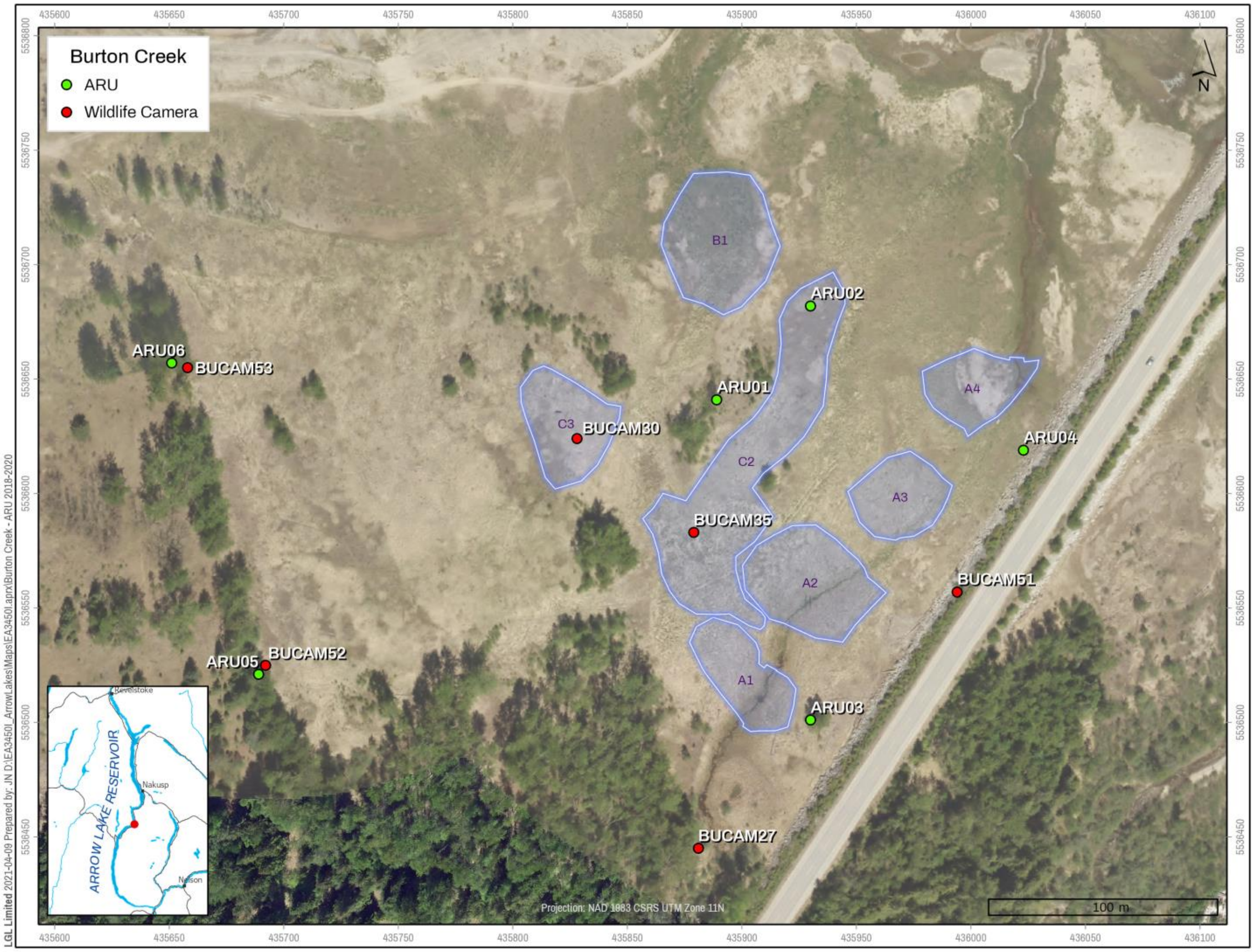
Figure 9-3. Photographs of Mallards and Canada Geese (top right) taken in the Burton Creek WPW area in 2020.

Incidental observations of wildlife use of the area during May and June sampling include sightings of Mountain Bluebirds *(Sialia currucoides*), a Northern Harrier (*Circus hudsonius*), and a flock of Mergansers. There were signs of ungulate browse on birch trees and *Lonicera*. A river otter was recorded in the proximity of the WPW area in July during waterbird surveys. A Western Terrestrial Garter Snake (*Thamnophis elegans*) observed during arthropod sampling.

9.4 Wildlife Discussion

Wildlife cameras and acoustic ARU recordings provided evidence of wildlife use of the area. White-tailed Deer were the most common mammal photographed by wildlife cameras, which was also the case in 2019. Several species of birds were detected, and the effects of reservoir inundation are evident (see Appendix F

Appendix E: Map of remote wildlife camera and ARU sampling locations for 2020.



Appendix F). While not a focus of the surveys, there was documented human use of the WPW area including off-road vehicle use.

10.0 CONCLUSIONS

CLBMON-11B1, initiated in 2009, is a long-term wildlife monitoring project that first aimed to assess the efficacy of revegetation prescriptions (2009 – 2019) and then to assess the efficacy of wildlife physical works for enhancing the suitability of habitats in the drawdown zone for wildlife (2019 – 2021). The final year of revegetation effectiveness monitoring was 2019 and the focus of this project has now shifted to monitoring the constructed physical works at Burton Creek. Wildlife physical works surveys focused on arthropod and songbird communities, as well as monitoring bats and other wildlife using the area. Prior to WPW construction, the suitability of the habitat in the area was considered to be low for most species (Hawkes and Tuttle 2016). This is consistent with the results of baseline studies in 2018 and 2019 (Hentze et al. 2019; Waytes et al. 2020).

The WPW construction at Burton Creek is anticipated to improve habitat suitability for wildlife including birds, amphibians, reptiles (Burton Creek currently has high suitability for snakes, which is not expected to change), mammals (bats), and insects (dragonflies), among others. Species with provincial or federal conservation designation that will benefit from this project include the provincially blue-listed and COSEWIC species of Special Concern, Western Toad (*Anaxyrus boreas*); the provincially blue-listed Townsend's Big-eared Bat (*Corynorhinus townsendii*) and Fringed Myotis (*Myotis thysanodes*); and the COSEWIC endangered Little Brown Myotis (*Myotis lucifugus*) (listed February 27, 2012).

Monitoring at Burton Creek in 2020 was the first year of post-construction WPW monitoring. Results of the monitoring indicated wildlife were using the area, including species with provincial or federal designation. This included signs of wildlife browse on planted vegetation and waterfowl and amphibian use of the WPW ponds. Wildlife interactions have the potential to affect establishment success of both herbaceous and woody vegetation. For example, towards the end of the WPW planting operation, a flock of Canada geese was observed to be grazing on recently planted sedges at pond B1 (Miller and Hawkes 2020). Similar geese-sedge interactions in the context of revegetation attempts have been reported for Kinbasket Reservoir (Hawkes and Miller 2016). Miller and Hawkes (2020) also found evidence of ungulate [elk (*Cervus canadensis*)] browse on recently planted shrubs, especially on mound C2 and the banks of ponds A1 and A2. Signs of early morning/overnight activity ranged from track imprints, to grazed stems and stripped leaves, to the uprooting of entire plants. Of note, by far the most frequently targeted species was twinberry (*Lonicera involucrata*), with roughly 80% of planted stock browsed by mid-October. Basal stem girdling by voles, which has reportedly reduced the survivorship of planted live stakes elsewhere in Arrow Lakes Reservoir (Keefer Ecological Services 2010), has not been observed yet at Burton Flats but is a potential concern and should be monitored.

There was some indication that the construction may have negatively affected arthropods, but this was likely due to the disturbance of the construction activities, which was expected as a short-term effect. It is expected that the area will increase in suitability for wildlife use as the planted vegetation becomes established and the area recovers from the disturbance of the construction efforts.

11.0 WILDLIFE PHYSICAL WORKS PERFORMANCE MEASURES

Phase 2 construction for the Burton Creek WPW is planned for the spring of 2021. Following the completion of the design work associated with the physical works site, the performance measures suggested by Hawkes and Tuttle (2016) can be reviewed and revised as needed. The objectives and performance measures as outlined by Hawkes and Tuttle (2016) are as follows:

1. Creation of new wetland habitat in an area dominated by grasses (i.e., no current wetland habitat – see Section 3.0) and expansion of wetland habitats in the vicinity of ponds A1 and A2 (Map 1).
    a. Temporal availability of wetland overlaps with the migratory bird (particularly wetland-associated species) and amphibian breeding seasons (May-August). The permanence of the wetland should be assessed (i.e., is the wetland available each year and for how long?)

  b. Minimum depth of pond required to support amphibian breeding and larval development (Section 3.0).

2. Wetland productivity.

   a. Successful establishment of native macrophytes (planted or natural) into newly created wetlands within five years. "Successful establishment" is defined here as continuous species presence for at least two years. Currently there are no macrophytes at the site proposed for physical works.

   b. Successful natural establishment of native macroinvertebrates (e.g., odonates, cladocerans, gastropods) into newly created wetlands within 5 years. "Successful establishment" is defined here as continuous species presence for at least two years. The current biomass of macroinvertebrates at this site is nil.

   c. Evidence of breeding by amphibians (specifically Western Toad). The number of egg strings or masses should be counted on an annual basis following the implementation of the physical works. Egg development should be tracked to determine if eggs metamorphose into froglets or toadlets. Western Toads currently breed in the ponds situated at elevations <434 m ALS, but do not breed at the site proposed for physical works.

   d. Evidence of use of the wetland by waterfowl and shorebirds. Waterfowl have been observed using the area proposed for physical works, but only in small numbers, especially when inundated by Arrow Lakes Reservoir.

   e. Evidence of use of habitat enhancements (e.g., nest boxes, floating islands) by target waterfowl species (which will need to be determined) following completion of construction.

   f. Evidence of use of the constructed wetland by bats (as determine by autonomous recording units) and use of enhancements such as bat boxes, snags, or other enhancements).

Work in 2020 provided data with which to evaluate some of these performance measures. However, because of the COVID-19 pandemic, most of the work completed in 2020 focused solely on data collection and some of the more detailed work that was planned (e.g., macroinvertebrate surveys)

12.0 RECOMMENDATIONS

In 2017, the Terms of Reference for CLBMON-11B1 were revised (Revision 1, June 29, 2017, BC Hydro 2017). The work completed in 2020 represents the third year of implementation under these revised Terms of Reference. The surveys in 2020 represent the first year of the WPW monitoring after its establishment. The recommendations provided below are intended to assess the suitability of the Wildlife Physical Works at Burton Creek as construction continues.

1. **Extend monitoring period for assessing efficacy of Wildlife Physical Works treatments.** Currently, the Burton Creek WPW has been partially implemented, with additional treatment application to follow in 2021. Results of the 2020 monitoring indicate that certain taxa (such as arthropods) may be more strongly responding to the disturbance of construction and revegetation activities. Future sampling once the vegetation is established and after the construction activities have ceased would help indicate the efficacy of the WPW post-disturbance.

Follow-up monitoring is recommended to be extended for three years following the completion of Phase 2 of the WPW program.

2. **Conduct targeted surveys for amphibians and reptiles in the Burton Creek Wildlife Physical Works site.** Targeted surveys were planned for 2020 but were not completed due to the COVID-19 pandemic. Acoustic ARU recordings indicated that Western Toads were in the area, but targeted surveys would record amphibian and reptile presence and habitat use. Surveys could also determine whether Long-toed Salamanders (*Ambystoma macrodactylum*) were in the area and using the constructed ponds. Amphibians and reptiles are expected to benefit from the constructed wetland complex. These data would compliment those collected in previous years under CLBMON-37.
3. **Continue to document post-treatment wildlife use of Burton Creek Wildlife Physical Works site with remote cameras.** Wildlife were documented in the Burton Creek WPW in 2019 before construction and in 2020 after phase 1 of the WPW construction. It is expected that the proposed wetland project will increase habitat suitability for a variety of wildlife, thus we expect an increase in species richness using the site.
4. **Record incidental observations of wildlife browse on Wildlife Physical Works revegetation.** Wildlife activity in the Burton Creek WPW area can be a positive sign, as it indicates wildlife use of the area, but excessive browse may impact revegetation establishment and success. Incidental observations indicated some wildlife browse on revegetated plants in the WPW in 2020. Examining wildlife browse on planted vegetation will allow us to understand wildlife interactions with revegetation in the area and could inform future management.
5. **Conduct targeted surveys for odonates in the Burton Creek Wildlife Physical Works site.** CLBWORKS-29B specifically mentions odonates as taxa predicted to benefit from the creation of the wetland habitat at this site (Hawkes and Tuttle 2016). Baseline data on odonates that was gathered before the implementation of the WPW will serve as a comparison to future odonate surveys.
6. **Survey aquatic macroinvertebrate establishment in constructed Wildlife Physical Works ponds.** The establishment and continued presence of native macroinvertebrates in WPW ponds can serve as one indication of wetland productivity and WPW success (Hawkes and Tuttle 2016).
7. **Deploy data loggers at the Wildlife Physical Works to collect physicochemical data (temperature, dissolved oxygen, and conductivity).** Monitoring wetland physicochemistry is essential for assessing changes in wetland integrity and provides valuable information for interpreting biological data, verifying wetland classification, and diagnosing potential stressors. Temperature, dissolved oxygen, and conductivity data loggers could be deployed in the constructed wetlands at Burton Creek to assess wetland integrity and productivity.
8. **Coordinate vegetation sampling planned under CLBMON-12 with work underway for CLBMON-11B1.** Certain aspects of vegetation, particularly vegetation structure, are important attributes for wildlife. The vegetation data collected for CLBMON-12 can be adapted slightly to provide an indication of structural changes in the vegetation communities developing at the WPW site. These data can provide an indication of changes to the suitability of wildlife habitat

at the WPW site and serve as an indicator of the efficacy of the WPW to provide suitable habitat for wildlife.

9. **Review waterbird sampling to assess changes in density (as a proxy for usage) pre- and post-WPW.** This will require delineating a specific area that encompasses the total area treated under phases 1 and 2. This is better defined following phase 2 work after which data collected in each year can be assessed relative to the defined area.

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14.0 APPENDICES

Appendix A: **Photographic time series for constructed physical works ponds.** Photos taken at Burton Creek from 20 August to 20 November 2020. Photo credit: G. Davidson.

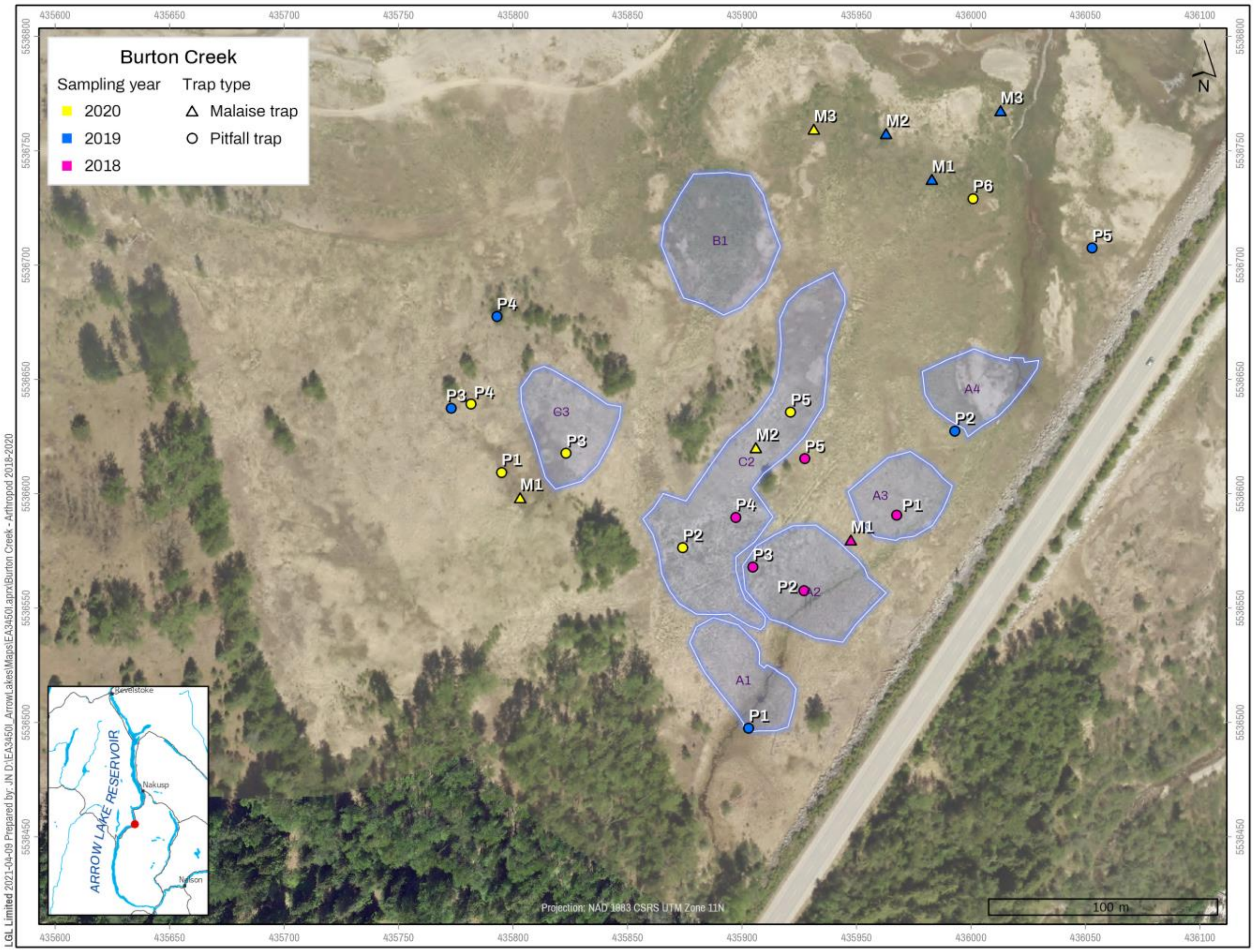
CLBWORKS-30B
Pond A1: Burton Flats Wetland Creation
August 20 through 20 November 2020
Photo credits: Gary Davidson, Nakusp, BC

CLBWORKS-30B
Pond A2: Burton Flats Wetland Creation
August 20 through 20 November 2020
Photo credits: Gary Davidson, Nakusp, BC

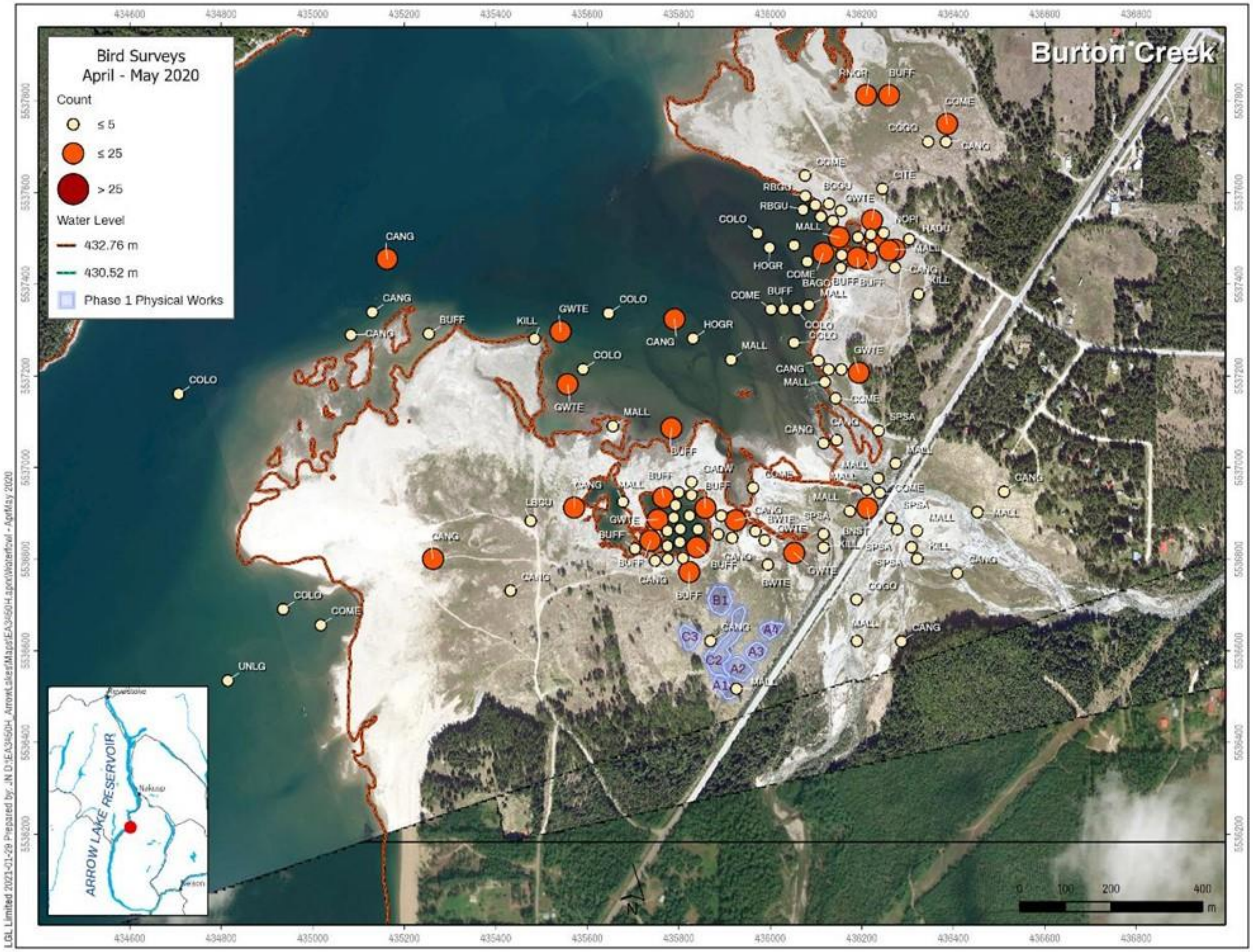
CLBWORKS-30B
Pond A3: Burton Flats Wetland Creation
August 20 through 20 November 2020
Photo credits: Gary Davidson, Nakusp, BC

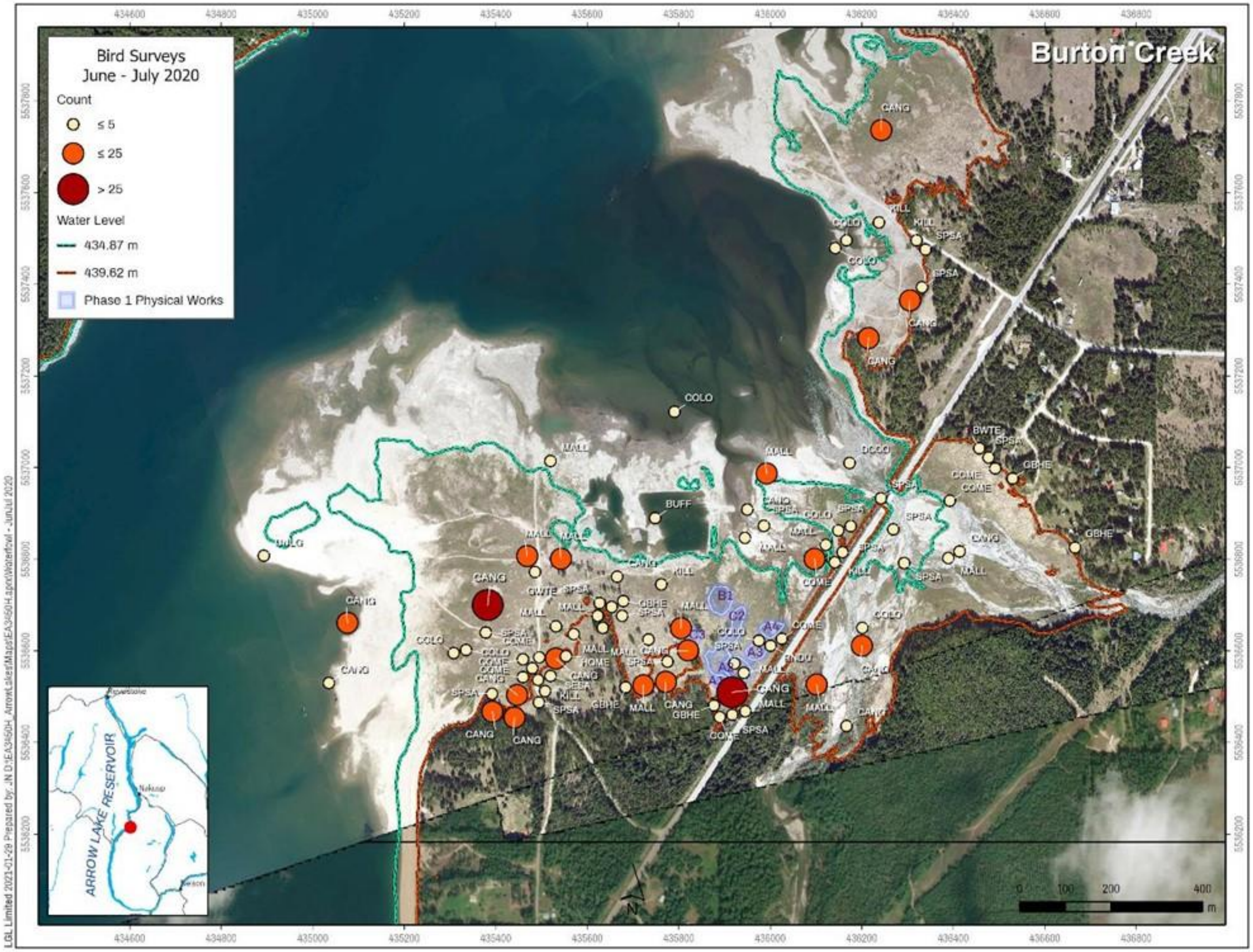
CLBWORKS-30B
Pond A4: Burton Flats Wetland Creation
August 20 through 20 November 2020
Photo credits: Gary Davidson, Nakusp, BC

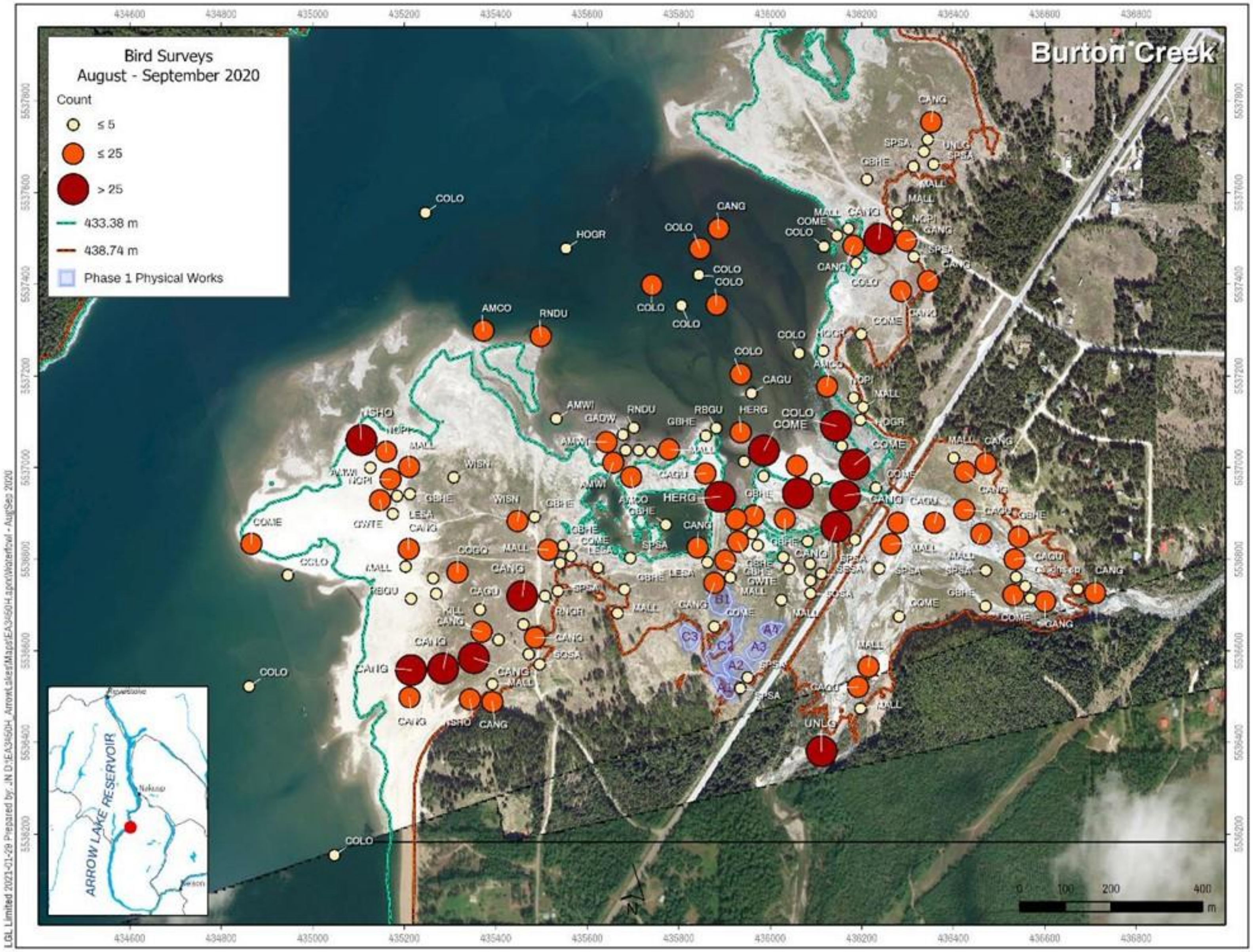
Appendix B: Map of arthropod sampling locations in 2020 (yellow points), with historic sampling locations (2018 and 2019) for reference.

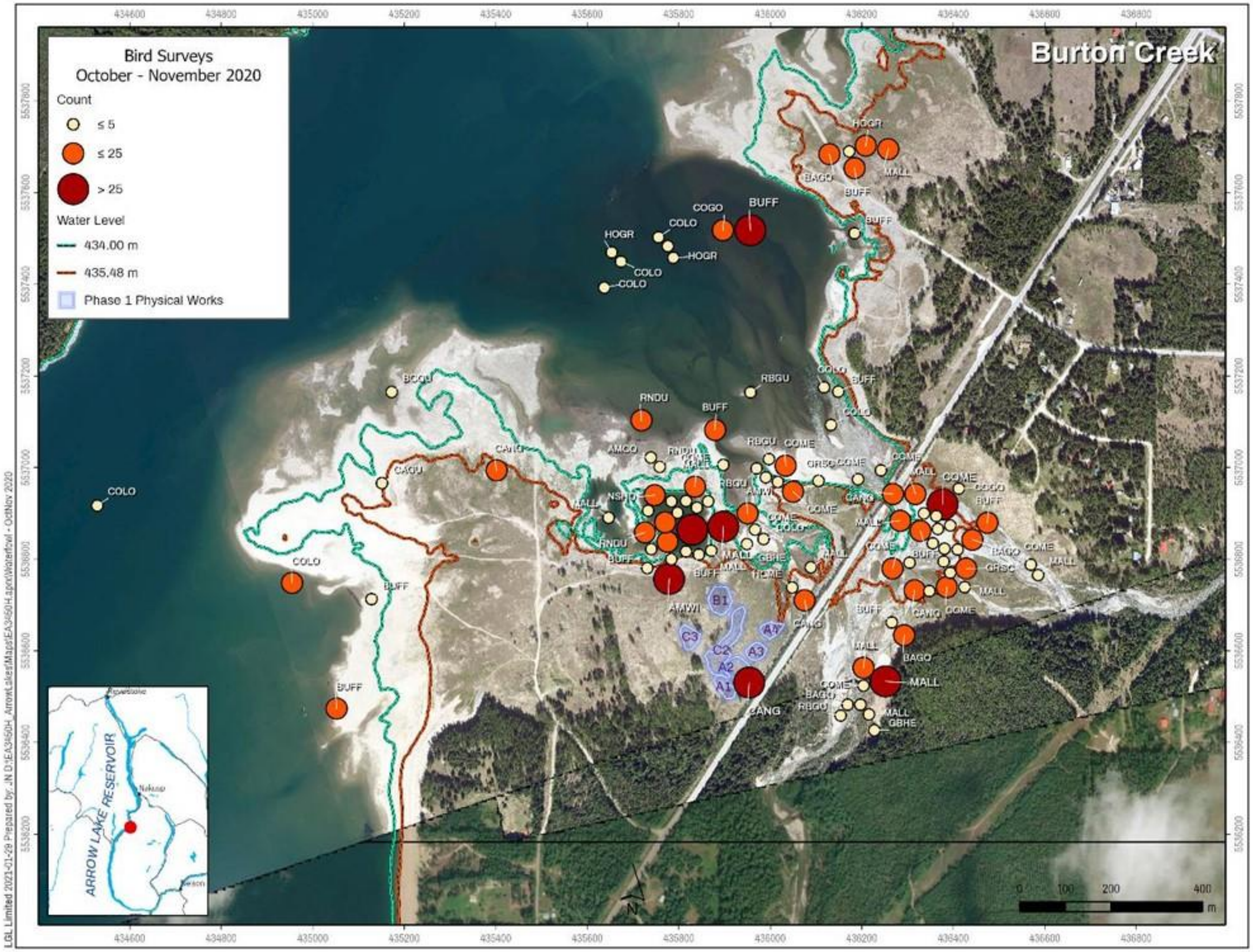


Appendix C: Distribution of waterbird species using the constructed Burton Creek wildlife physical works features (blue polygon) and surrounding areas in April/May 2020 (first figure), June/July 2020 (second figure), August/September 2020 (third figure), and October/November 2020 (fourth figure).


Burton Creek
Bird Surveys
April - May 2020
Count
≤ 5
≤ 25
> 25
Water Level
432.76 m
430.52 m
Phase 1 Physical Works
ARROW LAKE RESERVOIR


Burton Creek
Bird Surveys
June - July 2020
Count
≤ 5
≤ 25
> 25
Water Level
434.87 m
439.62 m
Phase 1 Physical Works
ARROW LAKE RESERVOIR


Burton Creek
Bird Surveys
August - September 2020
Count
≤ 5
≤ 25
> 25
433.38 m
438.74 m
Phase 1 Physical Works
ARROW LAKE RESERVOIR
LGL Limited 2021-01-29 Prepared by: JN

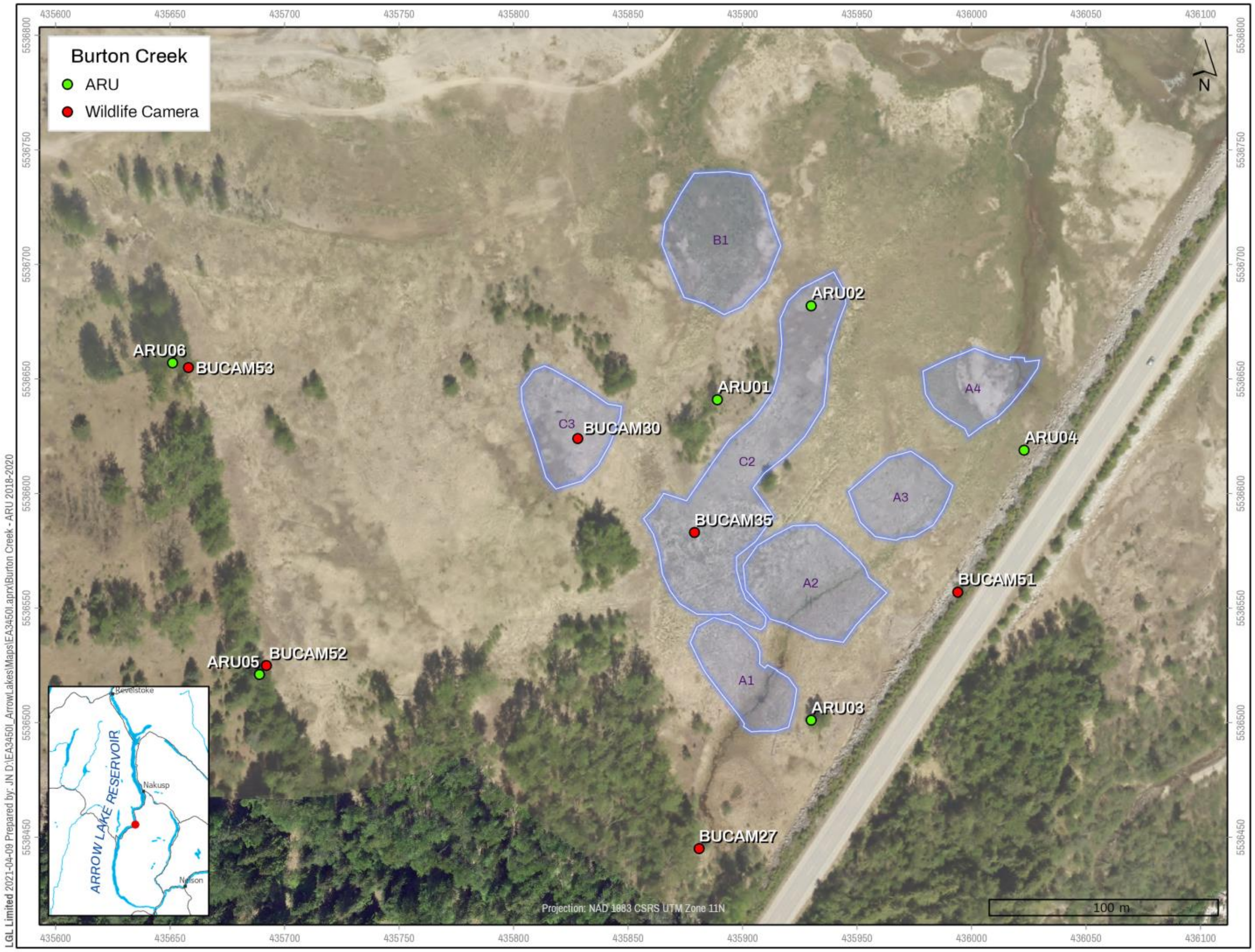

Burton Creek
Bird Surveys
October - November 2020
Count
≤ 5
≤ 25
> 25
Water Level
434.00 m
435.48 m
Phase 1 Physical Works
ARROW LAKE RESERVOIR
LGL Limited 2021-01-29 Prepared by: JN

Appendix D: Number of observations of all non-waterbird species detected during waterbird surveys in 2020. Table sorted alphabetically by species.

Species	Number of sightings
American Crow	56
American Dipper	2
American Goldfinch	1
American Kestrel	2
American Pipit	106
American Robin	48
Bald Eagle	151
Bank Swallow	19
Barn Swallow	86
Belted Kingfisher	20
Black-capped Chickadee	19
Brewer's Blackbird	23
Brown-headed Cowbird	1
Bullock's Oriole	1
Cedar Waxwing	25
Chipping Sparrow	10
Cliff Swallow	42
Common Raven	47
Common Yellowthroat	22
Dark-eyed Junco	7
Downy Woodpecker	1
Eastern Kingbird	3
European Starling	4
Gray Catbird	1
Hairy Woodpecker	2
Hammond's Flycatcher	4
Lapland Longspur	1
Lazuli Bunting	2
Least Flycatcher	1

Lincoln's Sparrow	1
MacGillivray's Warbler	6
Merlin	2
Mountain Bluebird	17
Nashville Warbler	2
Northern Flicker	16
Northern Goshawk	1
Northern Rough-winged Swallow	59
Osprey	16
Pileated Woodpecker	11
Pine Siskin	118
Red-breasted Nuthatch	1
Red-eyed Vireo	12
Red-tailed Hawk	1
Red-winged Blackbird	20
Savannah Sparrow	33
Song Sparrow	2
Townsend's Solitaire	2
Tree Swallow	45
Turkey Vulture	3
Varied Thrush	1
Vaux's Swift	4
Violet-green Swallow	11
Warbling Vireo	2
Western Meadowlark	22
Western Tanager	2
White-crowned Sparrow	2
Willow Flycatcher	3
Yellow Warbler	6
Yellow-rumped Warbler	14

Appendix E: Map of remote wildlife camera and ARU sampling locations for 2020.



Appendix F: Wildlife camera time lapse of Burton Wildlife Physical Works area. Top photos are 9 May to 6 June, middle photos are 25-29 June, and bottom photos are 23 July to 7 August.