Peace Project Water Use Plan

WILLISTON WETLAND HABITAT MONITORING

Implementation Year 7

Reference: GMSMON-15

Study Period: 2017

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November 08, 2019

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File No. 104333-01

BC Hydro

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Attention: Teri Neighbour, Water License Requirements, Environment

Dear Ms. Neighbour**,**

Re: GMSMON-15 Year 7 Annual Report

Dear Ms. Neighbour,

Here we present a summary of data collected during the 2017 GMSMON-15 annual field monitoring. This report is written in memo format, in that findings are summarized and presented with minimal analysis or discussion. Basic comparisons among years were completed, but no rigorous multi-year trends were examined. Among year comparisons in this report serve to put into context the findings from 2017.

We also do not address management questions in this report as these questions require in-depth, multi-year analysis not normally conducted in annual reports. The management question table has been updated with results from 2017, building on data from previous years. In this regard, data from 2017 has not changed the conclusions of previous years.

Karl Bachmann and Andrew MacInnis contributed to an early draft of this report. Andrew MacInnis conducted the fisheries analysis and much of the write up of those sections.

If you have any questions with regards to the content of this report, please do not hesitate to contact me.

EXECUTIVE SUMMARY

The GMSMON-15 project is a 10-year program to monitor the effectiveness of the two demonstration wetland enhancement projects at improving wildlife habitat and maintaining the habitat over the life of the projects. Due to uncertainty in the final design of the projects it was not possible to make specific predictions about the responses of individual taxa or functional groups. The two projects were expected to provide benefits to wildlife and vegetation through an increase in shallow water habitat and a higher, more stable water level. Waterfowl, songbirds, amphibians, and vegetation were identified as the indicator groups for determining the effectiveness of the wetland projects. Fish populations are also being monitored, although improving fish habitat is not one of the goals of the wetland projects. This report presents the results from the seventh year of monitoring under GMSMON-15. The results provide the fourth year of post-construction data for the Airport Lagoon project and the third year of post-construction data results from the Beaver Pond project.

Environmental Conditions

Weather conditions in 2017 were within the normal range of values for previous years of the study. Early April started off warmer than average, cooling off in May, but by June temperatures were warmer than average. Reservoir operations were also similar to previous years. The minimum reservoir level was reached earlier and was higher than previous years, while the maximum level was reached late in July, but did not reach full pool (maximum level 671 m ASL).

Habitat Mapping

No vegetation surveys were conducted in 2017, and instead the focus was on comparing ortho-photos between pre and post-construction at Airport Lagoon to determine if discernable habitat change has occurred over that period. The habitat categories Basin Moss (BM), Basin Smartweed (BS) decreased in area (by 3.4 and 1.8 ha respectively), while Shoreline Grassland (SG) and Shoreline Driftwood (SD) increased (by 2.76 and 1.74 ha respectively). No other habitat classes changed in area by any discernable amount between 2014 and 2017.

Waterfowl Surveys

Surveys in 2017 returned the fewest birds of previous years (107 detections at Airport Lagoon), but species diversity and composition were similar to previous years. Waterfowl using Beaver Pond were detected in similar numbers as previous years for both abundance and diversity, albeit in very low numbers (four detections of two species).

Point Count Surveys

Results of point count surveys in 2017 were similar to previous years, with diversity and abundance close to what has been recorded since 2011. No new species were detected in 2017, and the most commonly detected species in previous years were again common in 2017. Habitat use by songbirds has changed over the course of the study, and trends differ between the two sites. Airport Lagoon has seen an increase in detections of birds using habitat in the drawdown zone, and in the forest habitat adjacent to the reservoir. Shrub use by birds has declined at Airport Lagoon. Habitat use at Beaver Pond runs somewhat counter to the trend at Airport Lagoon, with a decrease in drawdown zone habitat use and modest increases in shrub and forested habitat.

Amphibian Surveys

Results of amphibian surveys in 2017 returned the fewest detections of any previous year at Airport Lagoon. While low, these results were not an outlier to previous years. We specifically looked at adult life stages as those were the most likely to be identified and detected and allowed comparisons among years. Only one adult amphibian and one tadpole were observed at Airport Lagoon during two surveys. Beaver Pond surveys resulted in similar numbers as in previous years, with the second highest number of adult western toad detected since the initiation of this project. Amphibian abundance has been annually variable, but detections have been increasing since construction at both sites.

Fish Surveys

The number and relative abundance of fish collected in 2017 at Airport Lagoon was lower than recorded in 2014 and 2015, particularly for captures by fyke net. However, CPUE in 2017 remained higher than pre-construction monitoring with the observed abundance of the three most common fish species (Redside Shiner, Lake Chub, and Brassy Minnow) increasing in the post-construction period, likely due to the increase in habitat area. Less abundant species such as Prickly Sculpin and sucker species also appear to be increasing but additional sampling will be required to detect a response in these species. At Beaver Pond, consistent with previous years, low numbers of fish were captured. Fish were captured in the impoundment prior to inundation. These fish would have entered the impoundment when it was inundated during previous summers.

MANAGEMENT SUMMARY: STATUS OF GMSMON-15 MANAGEMENT QUESTIONS AND HYPOTHESES – YEAR 7

Management Question	Management Hypothesis (Null)	Year 7 (2017) Status
1) Are the enhanced (or newly created) wetlands used by fish?	H_{01}: Fish species composition and density in wetlands does not change following enhancement.	Preliminary results suggest there has been an increase in common fish species in **Airport Lagoon** post-construction. Results from the **Beaver Pond** site indicate little change in abundance or diversity has occurred. Additional data from both sites will help answer this management question.
2) Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?		The four years of post-construction data from the **Airport Lagoon** project shows continued use by waterfowl and other wildlife. The three years of post-construction data from the **Beaver Pond** project is consistent with the baseline data with limited use by waterfowl and other wildlife. **Beaver Pond** has seen increased detections of amphibians in the three years since construction.
	H_{03}: The species composition and density of waterfowl and songbirds does not change following enhancement.	The four years of post-construction data from the **Airport Lagoon** show continued use at similar density, with a slight increase in species diversity in 2017. The three years of post-construction data from the **Beaver Pond** project is consistent with the baseline data. Additional monitoring will be required for testing of this hypothesis.
	H_{04}: Amphibian abundance and diversity in the wetland does not change following wetland enhancement.	The four years of post-construction data from the **Airport Lagoon** showed variable amphibian abundance with a high number of detections in 2014, and consistently fewer detections in other years. Over the past three years there has been a slight decrease in amphibian detections at Airport Lagoon. The three years of post-construction data from the **Beaver Pond** site showed increases in amphibian abundance. Additional monitoring will be required for testing of this hypothesis.

Management Question	Management Hypothesis (Null)	Year 7 (2017) Status
3) Is there a change in the abundance, diversity and extent of vegetation in the enhancement area?	H_{02}: The density, diversity and spatial extent of riparian and aquatic vegetation does not change following enhancement.	Minor changes in riparian vegetation have been detected at the **Airport Lagoon** site. The fourth year of post-construction monitoring shows a decrease in some terrestrial vegetation categories and increases in others. The largest increase in area came from the category Shoreline Driftwood since 2014.
4) Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?		With four years of post-construction data from the **Airport Lagoon** site and three years of post-construction data from the **Beaver Pond** project it is not possible to comment on the long-term persistence and quality of habitat. The area of wetland habitat at both sites has remained stable to date.

INTRODUCTION

1.1 Background

During consultations under the Peace Water Use Plan (WUP), the Consultative Committee recognized that reservoir operations created large unproductive areas within the drawdown zone of Williston Reservoir (Anon. 2003). The resulting limited aquatic and riparian habitats were hypothesized to have two primary impacts: they limit the area's capacity to support fish and wildlife and they potentially increase the risk of predation for terrestrial wildlife utilizing the drawdown zone. The large area (~450 km^2) of the drawdown zone between the low and high water levels provides little wildlife habitat when exposed during low water levels and little habitat for fish when inundated (Anon. 2003). The fluctuating water levels were also identified as affecting riparian productivity around the reservoir.

It was noted that when water levels recede during drawdown, pools and isolated backwater areas formed in some locations around the reservoir. The contribution of these pools and backwaters to wildlife and fish productivity is variable, depending on the location. The Riparian and Wetland Habitat Management Plan was developed within the WUP to investigate the possibility of creating or enhancing additional perched wetland areas to increase riparian and wetland habitat (Anon. 2003). The components of the plan were an inventory of sites that were potentially suitable for enhancement, selection of sites for implementation of demonstration wetland enhancement projects, and a monitoring program to test their effectiveness in improving riparian and foreshore habitat for wetland species over the life of the project.

The inventory of potential enhancement sites was completed under GMSWORKS-16 *Williston Reservoir Wetlands Inventory*. A total of 42 sites in the Parsnip Arm were reviewed as potential wetland enhancement sites by Golder (2010). Of the 42 sites reviewed, five candidate sites were identified for demonstration projects on the basis of a combination of factors including (but not limited to) cost, feasibility, and potential benefit to wildlife (Golder 2010). The second phase was completed under GMSWORKS-17 *Williston Reservoir Trial Wetland*. Two of the five candidate sites were selected as demonstration sites and detailed designs developed (Golder 2011). Monitoring of the effectiveness of the wetland demonstration projects in improving wildlife habitat on the reservoir will be completed under GMSMON-15 *Reservoir Wetland Habitat*.

1.2 Monitoring Plan Overview

The GMSMON-15 project is a 10-year monitoring program to assess the effectiveness of the demonstration wetland enhancement projects at improving wildlife habitat and maintaining the habitat over the life of the two projects (BC Hydro 2010). This effectiveness monitoring program is designed to determine the response of selected indicator groups to the wetland enhancements and to increase knowledge of wildlife use of the drawdown zone for the selected groups, particularly birds and amphibians. Monitoring the responses of all species is not feasible; therefore, BC Hydro (2010) identified waterfowl, songbirds, amphibians, and vegetation as the wildlife indicator groups to be used for monitoring in GMSMON-15. Fish populations were also identified for monitoring as fish were observed at both of the selected demonstration sites (Golder 2010, 2011). While improving fish habitat is not one of the goals of the wetland enhancement projects, little is known about the fish species composition and distribution at the selected locations (BC Hydro 2010).

This report presents the results from the seventh year (2017) of the GMSMON-15 monitoring program which is the fourth year of post-construction data from the Airport Lagoon site and the third year of post-construction data from the Beaver Pond site. This report presents data only from 2017, no multi-year analyses were conducted, beyond presentation of summaries from previous years to compare to 2017.

1.0 MANAGEMENT QUESTIONS AND HYPOTHESES

The monitoring objectives and hypotheses for GMSMON-15 were stated in the Terms of Reference for the project (BC Hydro 2010). These are restated below along with a brief summary of how the testing of each hypothesis is approached in the study design.

Three key management questions regarding the effectiveness of the wetland enhancements were identified for the Reservoir Wetland Habitat monitoring program:

1. Are the enhanced (or newly created) wetlands used by fish?
2. Are the enhanced (or newly created) wetlands used by waterfowl and other wildlife?
3. Is there a change in the abundance, diversity and extent of vegetation in the enhancement area?
4. Is the area and quality of fish and wildlife habitat created by the wetland enhancement maintained over time?

Based on these management questions, the study was designed to test the following hypotheses stated in the Terms of Reference:

H_1: Fish species composition and density in wetlands changes following enhancement;

H_2: The density, diversity and spatial extent of riparian and aquatic vegetation does not change following enhancement;

H_3: The species composition and density of waterfowl and songbirds does not change following enhancement;

H_4: Amphibian abundance and diversity in the wetland does not change following wetland enhancement.

The monitoring program collects annual data on riparian and aquatic vegetation density, diversity, and spatial extent; waterfowl and songbird abundance and diversity; and amphibian abundance and diversity. The project tasks also include annual monitoring of fish diversity and abundance at the trial sites. There are no specific management questions or hypotheses for fish to be tested as the focus of the projects is on enhancing wildlife habitat rather than fish habitat.

The general approach is to sample each of the indicator groups at locations within the core area of the enhancement treatments and in peripheral riparian areas at both sites. Riparian vegetation is monitored using annual quadrat sampling and aerial photo analysis. Songbirds are surveyed using breeding bird point counts and nest searches. Waterfowl and shorebirds are surveyed by land-based observations. Amphibians are inventoried using systematic surveys to determine relative abundance. Fish population are sampled with minnow traps, fyke nets, and by electrofishing.

2.0 STUDY AREA

Williston Reservoir is located in northeastern British Columbia and was created by construction of the W.A.C. Bennett Dam at the head of the Peace River Canyon, about 20 km west of Hudson's Hope, B.C (BC Hydro 2007). The reservoir extends for about 260 km along the Rocky Mountain Trench from the Finlay River in the north to the Parsnip River in the south. The reservoir is generally divided into three geographic regions (from north to south): Finlay Reach, Peace Reach and Parsnip Reach (BC Hydro 2007).

The reservoir is located within the Sub-Boreal Spruce and Boreal White and Black Spruce biogeoclimatic zones (Meidinger and Pojar 1991). The Sub-Boreal Spruce zone is the dominant zone and occurs as two subzones and variants at lower elevations along most of the reservoir (Meidinger and Pojar 1991). The Boreal White and Black Spruce zone occurs only at the northern end of the reservoir in the Finlay Arm (Meidinger and Pojar 1991). The drawdown zone consists of large areas of mud, sand, and gravel flats with stranded large woody debris. Limited amounts of vegetation occur even following extended periods of drawdown. The water level varies annually with reservoir filling and drafting.

The two locations identified for the wetland demonstration projects are both located on the east side of the Parsnip Reach of the reservoir (Figure 1). The Airport Lagoon site (WDS 6-2) is located approximately six kilometres south of Mackenzie and is an approximately 75 ha site on the upstream side of a forest service road causeway. Except for two culverts at the base of the causeway the area was isolated from the main reservoir. Water supply to the lagoon is primarily from two unnamed streams located at the north end of the lagoon. At reservoir elevations >664.5 m, the reservoir was connected to the lagoon and water levels in the lagoon correspond to reservoir levels. The goal of the project was to create a larger area of permanently flooded habitat and reduce water level changes that would allow for colonization by submergent and emergent vegetation as well as enhance the riparian zone to benefit waterfowl, wading birds and amphibians (Golder 2011). In May 2013, the existing culverts were removed and two new culverts were installed at an elevation of two new culverts at an elevation of 666.99 m for the west culvert and 667.05 m for the east culvert (Golder 2013).

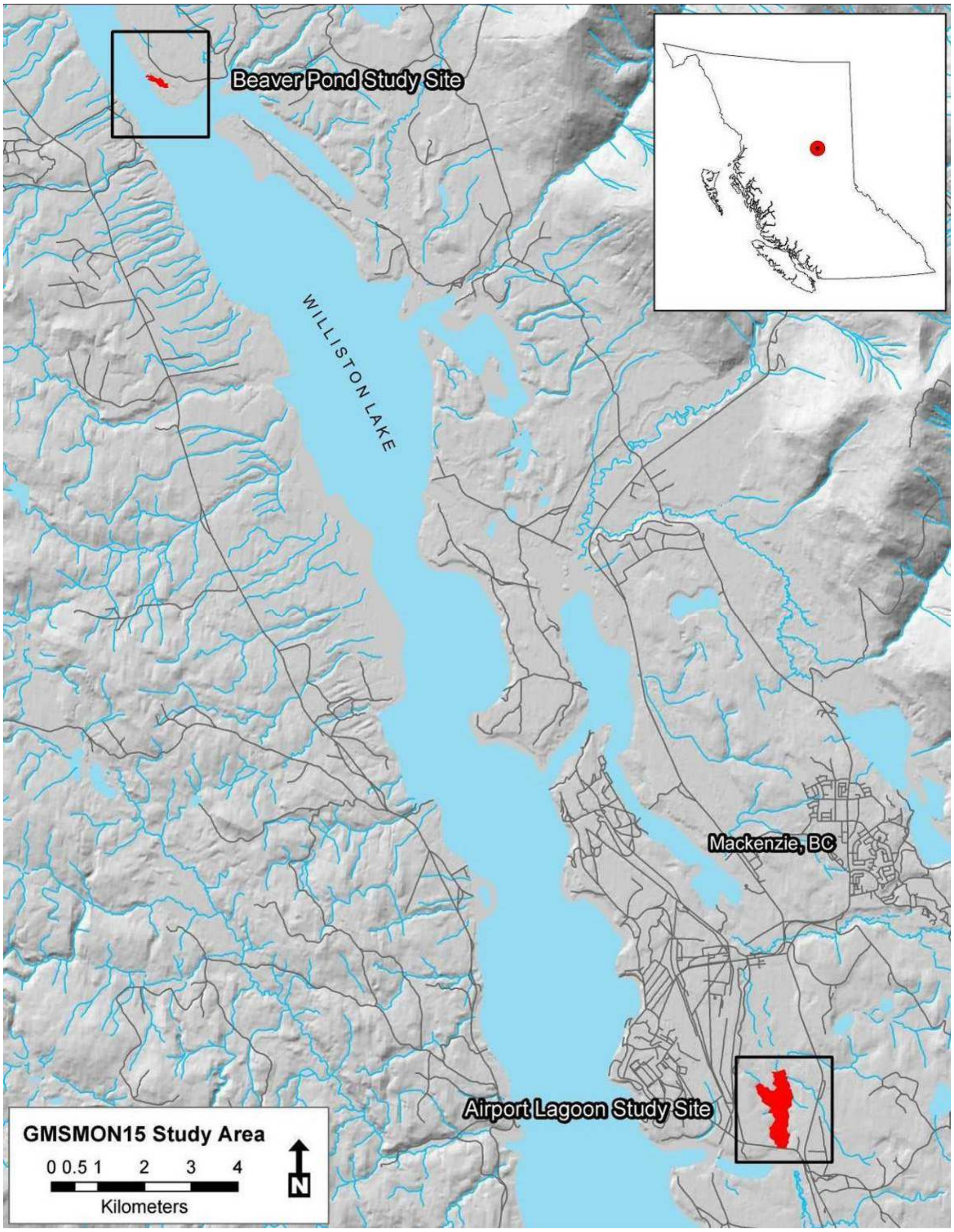

Figure 1. Location of the two wetland demonstration sites on the Parsnip Reach of Williston Reservoir.

Water levels observed in the lagoon in spring 2017 were at the design levels as a result of inundation by the reservoir and natural inflows to the site. The new permanent water level in the lagoon is shown in Figure 2 along with the pre-construction water level. The post-construction water level in the Airport Lagoon was mapped using aerial imagery acquired by UAV on June 21, 2014 when the reservoir level was 666.6 m and below the new culvert outlet elevation of 666.8 m. As in 2014 and 2015, some variation in the lagoon water level was observed in spring 2016 as a result of changes in flow from upland areas. An estimated 0.2-0.3

m drop in water level was observed at the Airport Lagoon following the spring freshet in this low elevation watershed.

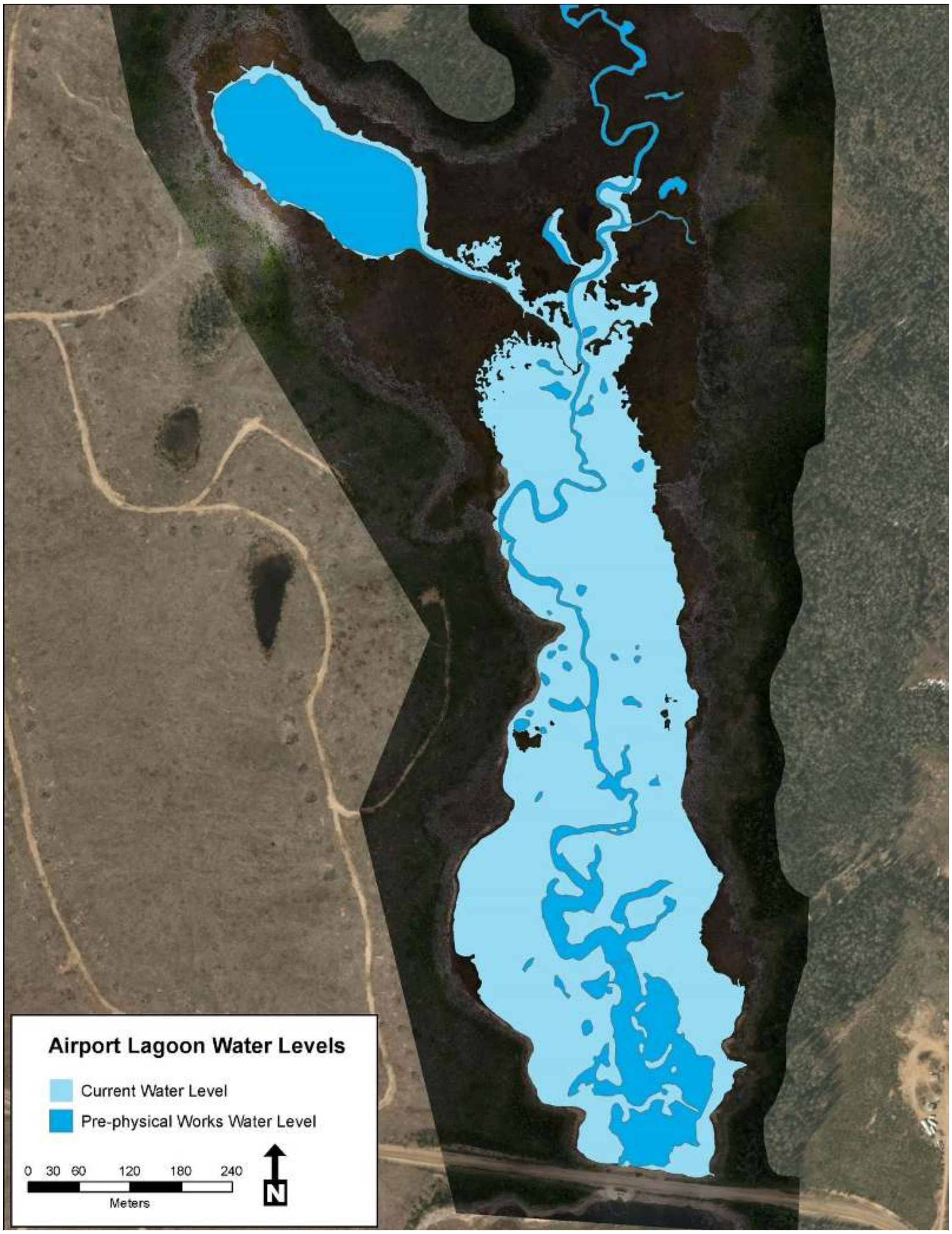

Figure 2. The pre- and post-enhancement permanent water levels at the Airport Lagoon.

The Beaver Pond site (WDS 34) is located approximately 22 km northwest of Mackenzie at the end of a short and narrow inlet on Heather Point (Figure 3). There are two beaver ponds located at the head of the inlet with a small stream draining the ponds. The stream also appeared to be partially supplied by an area of ground water seepage. The trial approach for this site was the installation of a berm to create a wetland of approximately 0.9 ha in area (Golder 2011). The proposed elevation for the berm was 669 m resulting in the wetland being directly connected to the reservoir during periods when it exceeds this elevation. Prior to construction, this area was dry (with the exception of the stream and an adjacent area of groundwater seepage) when water levels are below 666 m. The creation of an area with stable water levels is designed to allow for colonization by submergent and emergent vegetation, and enhance the riparian zone to benefit wading birds and amphibians (Golder 2011).

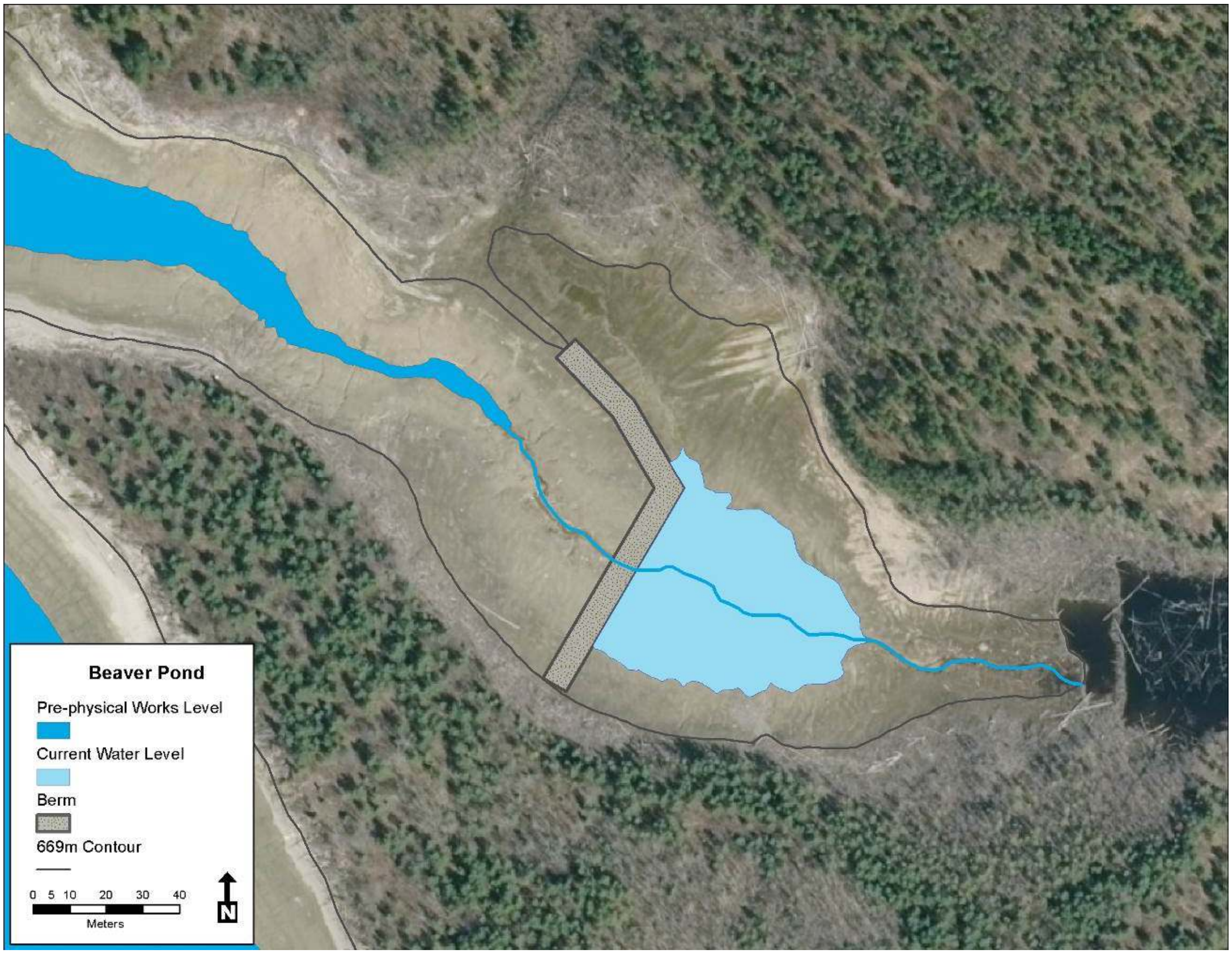

Figure 3. The pre- and post-enhancement permanent water levels at the Beaver Pond.

Construction of the Beaver Pond project was completed on May 24 – June 10, 2014. The berm was constructed in the planned location but did not reach the design elevation of 668.2 m due to challenges encountered during installation. The final elevation of the spillway was 667.25 m, reducing the area of the constructed wetland to approximately 0.3 ha. The new permanent water level in the lagoon is shown in Figure 3 along with the pre-construction water level. The extent of flooding is approximate and is based on the proposed berm, the as-built elevation, and observed post-construction water levels in the wetland. Elevation contours were generated from a digital elevation model (DEM) provided by BC Hydro. The shapefile of the proposed berm was provided by Golder Associates Ltd. (Golder 2011).

The uniqueness of both sites, along with the specific physical works proposed for each, means there are no associated control or reference sites in this project. Pre-construction baseline data from both sites will used to assess the post-construction changes associated with each project.

3.0 METHODS

The sampling methods used in 2017 were consistent with those used in the previous years of the monitoring program. As in previous years, minor adjustments in the sampling program were required in 2017 to account for changes in reservoir elevation and weather conditions. The sampling methods for each of the indicator groups are described below, along with any adjustments that were required due to reservoir elevation or weather conditions at the time of sampling.

1.3 Environmental Conditions

Environmental conditions specific to each survey type were recorded at the start of each survey and periodically during the surveys. Daily reservoir elevations were provided by BC Hydro (BC Hydro Commercial Resource Optimization (CRO) database). Daily mean air temperature and precipitation data prior to and during the survey period were obtained from Environment Canada and observed at the Mackenzie Airport weather station (Station name: Mackenzie Airport Auto).

Accumulated degree days were also calculated using a base temperature of 5°C as an additional method to compare environmental conditions between years. The base temperature of 5°C was selected as an indicator of activity for breeding amphibians. A minimum night-time temperature of 5°C is used as an indicator for the timing of early season call surveys (e.g., USGS North American Amphibian Monitoring Program (Weir and Mossman 2005), Bird Studies Canada Marsh Monitoring Program (n.d.)).

1.4 Habitat Classification

All photo interpretation was completed in 2-D softcopy using ArcGIS (version 9.3, ESRI 2008). High resolution orthomosaic (5cm pixel resolution, 2017) of the Airport Lagoon provided by JR Canadian Mapping were used as the background layer for delineating polygons. Polygon delineation using air photos from 2017 was used to compare area and changes to distribution to mapped habitat from 2014. As the high resolution orthomosaic from 2014 was obtained one-year post-construction, it served as the baseline for monitoring the progression of vegetation changes. In 2017 no vegetation surveys were conducted, but efforts were focused on determining changes to habitat four years post construction.

A habitat classification scheme based on RISC (RISC 2010) was developed to capture all the habitat classes in the study area visible at the resolution available. Habitat classes were first determined from an overview of the study area to identify the larger vegetation features. As the study area was viewed at finer scales during photo interpretation more vegetation features were identified. As new vegetation features were encountered, additional habitat classes were created to accommodate them. Each habitat class was identified based on a common plant species assemblage and elevation within the drawdown zone. The spatial distribution of habitat classes often followed a similar pattern. For example, at the Airport Lagoon, a band of coarse woody debris and grass/shrub cover parallel to the edge of the reservoir at full pool usually transitioned downslope into a band of sparsely vegetated sand followed by an area of sparsely vegetated mud adjacent to the water's edge.

Due to the relatively small area of both of the study sites, a map scale of 1:1000 was used as the initial resolution for polygon typing. Where required, a larger scale was used to differentiate similar or small area polygons. Overall, the scale varied roughly between 1:2000 and 1:200 throughout the interpretation process depending on the size of the habitat polygon.

To quantify changes between 2014 and 2018, the habitat classes delineated in the first year were re-drawn with the new imagery. Area for each habitat class for the new layer were then calculated and comparisons were drawn between total area of the classes.

1.5 Waterfowl and Shorebird Surveys

Land-based surveys, following the protocols for absolute abundance inventories of waterfowl species (RIC 1999a), were used to record waterfowl and shorebird occurrence at the study sites. The survey methods were the same as those used in the previous years of the monitoring program. Shorebirds have been included in the surveys since 2012 to provide additional detail on bird use of the sites. Surveys began in early spring to capture migrating waterfowl and continued through to late spring. Waterfowl surveys were completed on May 2, 10, 21, and 30 at the Airport Lagoon site and on May 15th at the Beaver Pond site. Surveys are planned to account for the fact that typically the timing of surveys at Beaver Pond is limited by access issues (ice on Williston Reservoir and/or unfavourable weather conditions). Unseasonably warm spring temperatures facilitated early ice-off on Williston Reservoir, so the Beaver Pond site was accessible for the early spring survey effort. Surveys at both sites were completed at the previously established stations at each site (Figure 4 and Figure 5).

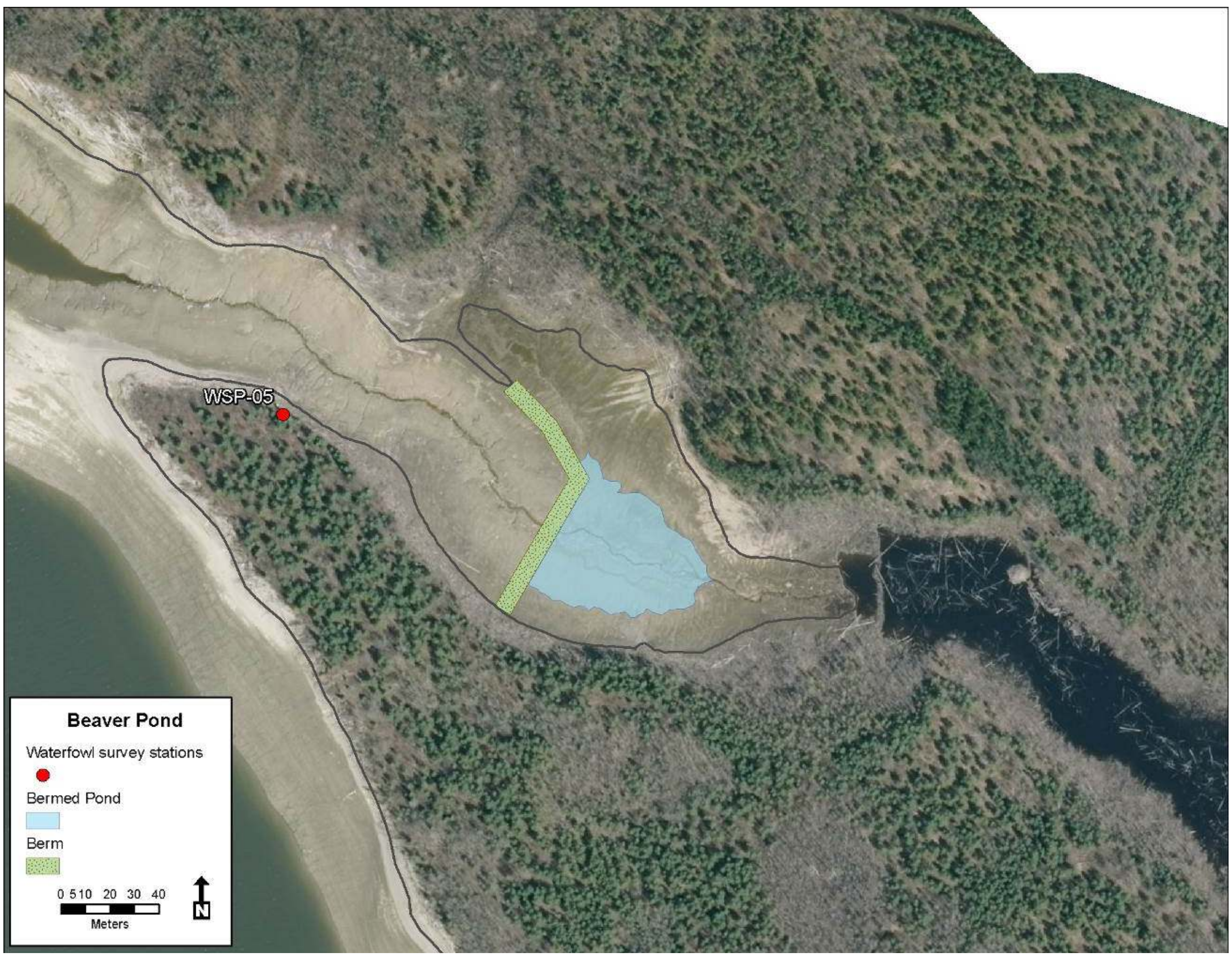

Figure 4. Waterfowl survey station location at the Beaver Pond site.

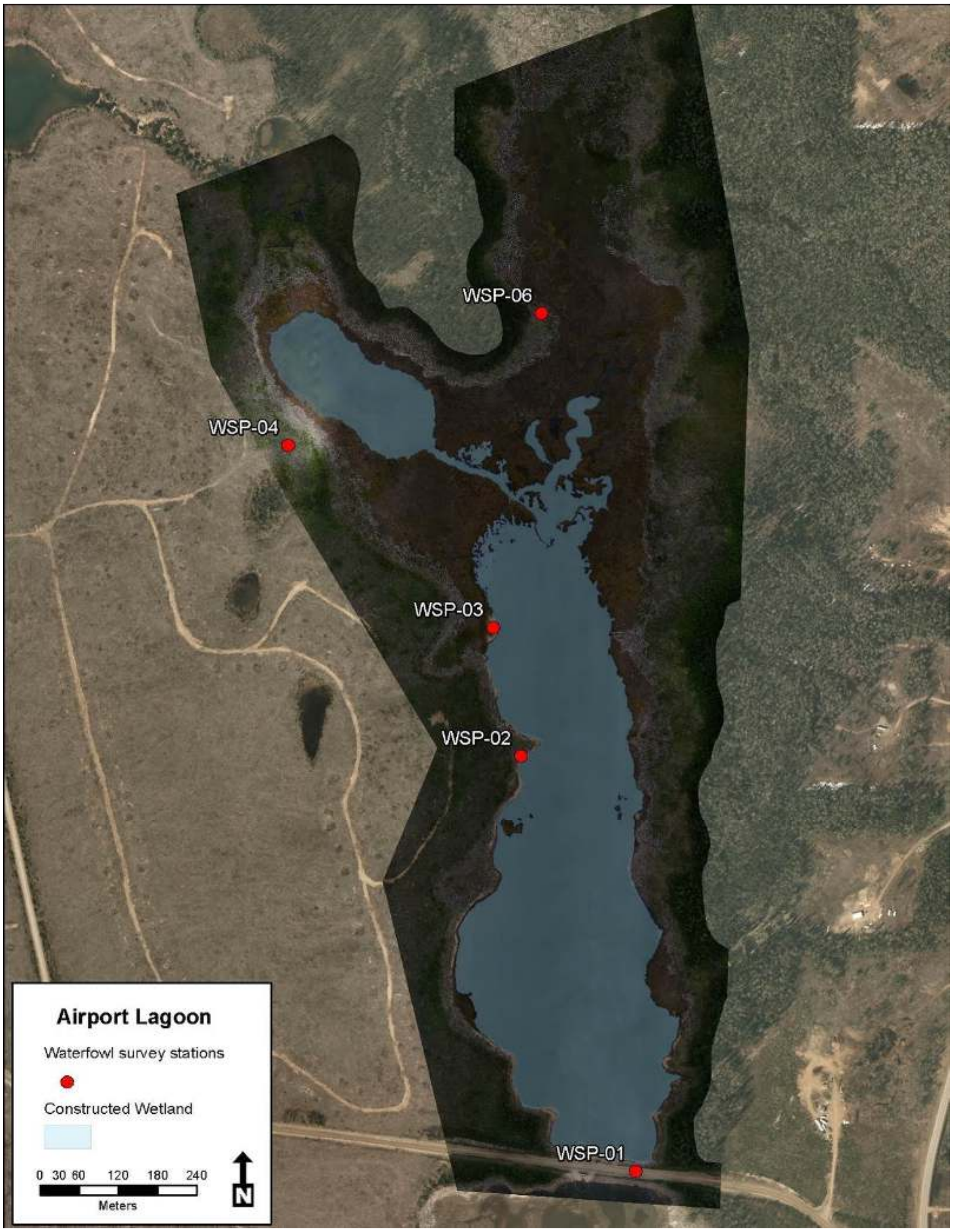

Figure 5. Waterfowl survey station locations at the Airport Lagoon site.

A combination of a modified RIC data form (1999a) and a map with an orthophoto background of each site was used to record waterfowl observations. Survey conditions (temperature, wind direction, wind speed, precipitation, cloud cover, and ceiling height) were noted at the beginning and end of each survey, and unusual circumstances (if any) in the wetland area that may have affected survey results. Upon arrival at a station, the observer scanned the area with binoculars to obtain an overview of birds present and note any bird or group of birds that may have taken flight upon arrival. Any birds that took flight on arrival at the station were recorded on the data form. Observers ensured that groups of birds were not double counted if they could be seen from more than one observation station. To avoid double counting birds, observers noted a suitable landmark to set the limit of the observations taken from that station. The location of such a boundary changed from survey to survey depending on water levels and the distribution of groups of waterfowl.

From a survey station, the respective survey area was slowly and systematically scanned at low magnification with binoculars. A spotting scope was used to identify birds or groups of birds that could not be identified with binoculars due to small size or distance from the observer. Observers drew a polygon with a unique ID number for every group of birds on field data maps created for this purpose. Care was taken to draw the polygon as accurately as possible by matching up landmarks with their corresponding location on the orthophoto background. On the observation form, a new data line was recorded for all groups that could be defined by species and number of individuals, with associated information such as number of broods present, sex, behaviour, and habitat descriptors within each polygon. Species codes followed RIC (2008).

1.6 Songbird Surveys

The point count survey methodology was consistent with all previous years of the project. Variable radius point counts and nest searches consistent with Bird Studies Canada and RIC methods (RIC 1999b, Bird Studies Canada 2009) were used to record breeding bird occurrences at the study sites. Point count surveys were conducted from May 31 to June 5, 2017. During this period three replicates were completed at the Airport Lagoon site (June 1, 3, and 5) and two replicates were completed at Beaver Pond (May 31 and June 4). Inclement weather on June 2 precluded point count surveys. All surveys were completed during the breeding season (May 28 - July 10) and within four hours of sunrise (Bird Studies Canada 2009). Based on previous experience conducting point count surveys in the cool, wet northern BC spring (Hentz and Cooper 2006, CBA 2008), surveys were conducted according to ‘modified’ RISC standards for environmental conditions (RIC 1999). These standards are as follows: wind speed ≤ Beaufort 3 (gentle breeze, leaves and twigs constantly move), precipitation = ‘very’ light rain, temperature > 3˚C. Species codes followed RIC (2008).

Previous studies also suggested that peak breeding season for songbirds in the area occurs in mid-June (Hentz and Cooper 2006, CBA 2008). Survey dates fell within this window and were consistent with the timing of pre-enhancement monitoring efforts. Three replicates were completed at each site to give a ‘snapshot’ of the breeding bird community (RIC 1999b).

Consistent with survey effort in previous years, point counts were completed at the three established survey stations at the Beaver Pond site (Figure 6) and the 17 established survey stations at Airport Lagoon (Figure 7). Point count stations were distributed throughout the study sites to ensure maximum coverage. The centres of adjacent point count stations were located a minimum of 200 m apart to prevent overlap of the 100 m radius survey areas.

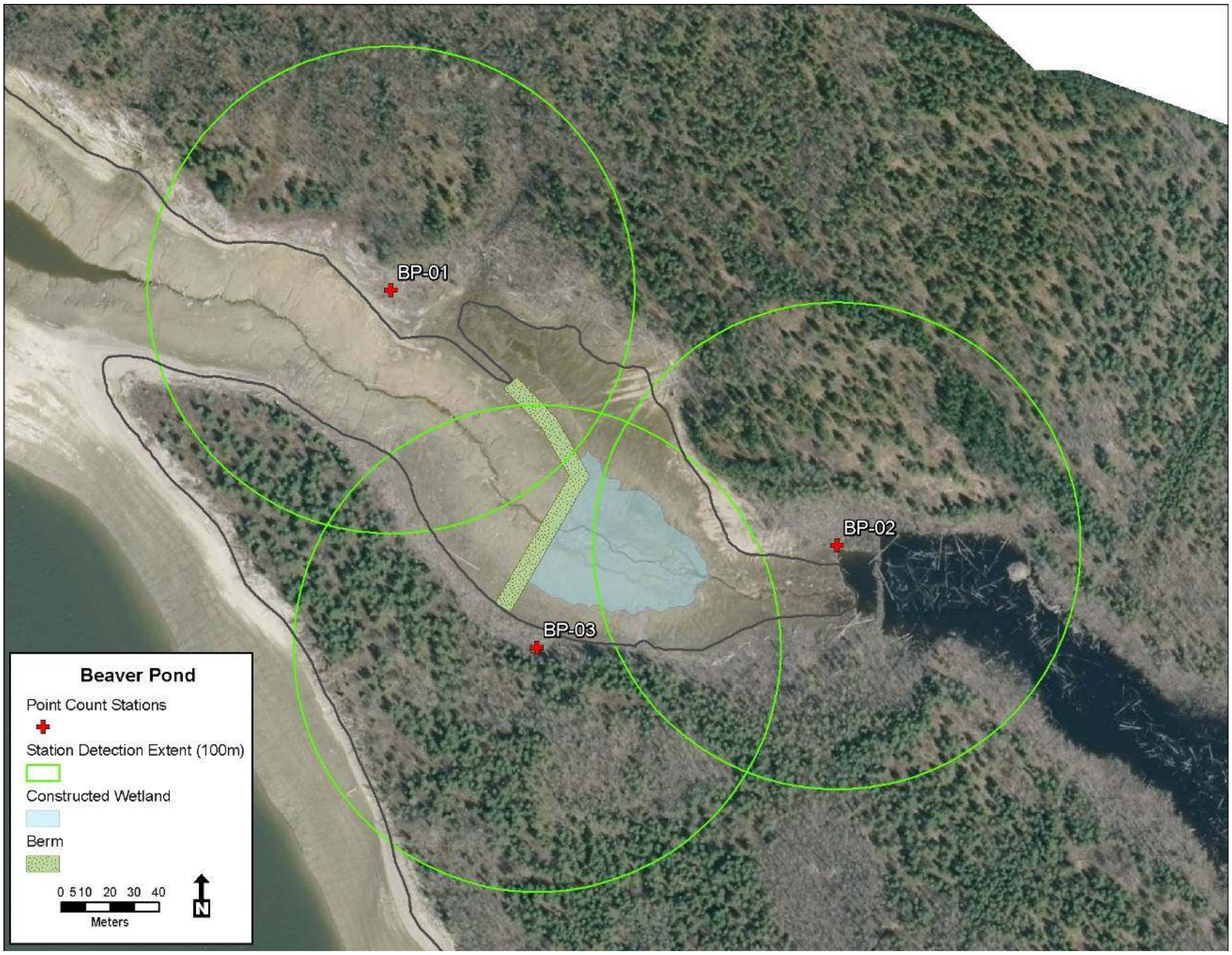

Figure 6. Point count station locations at the Beaver Pond site.

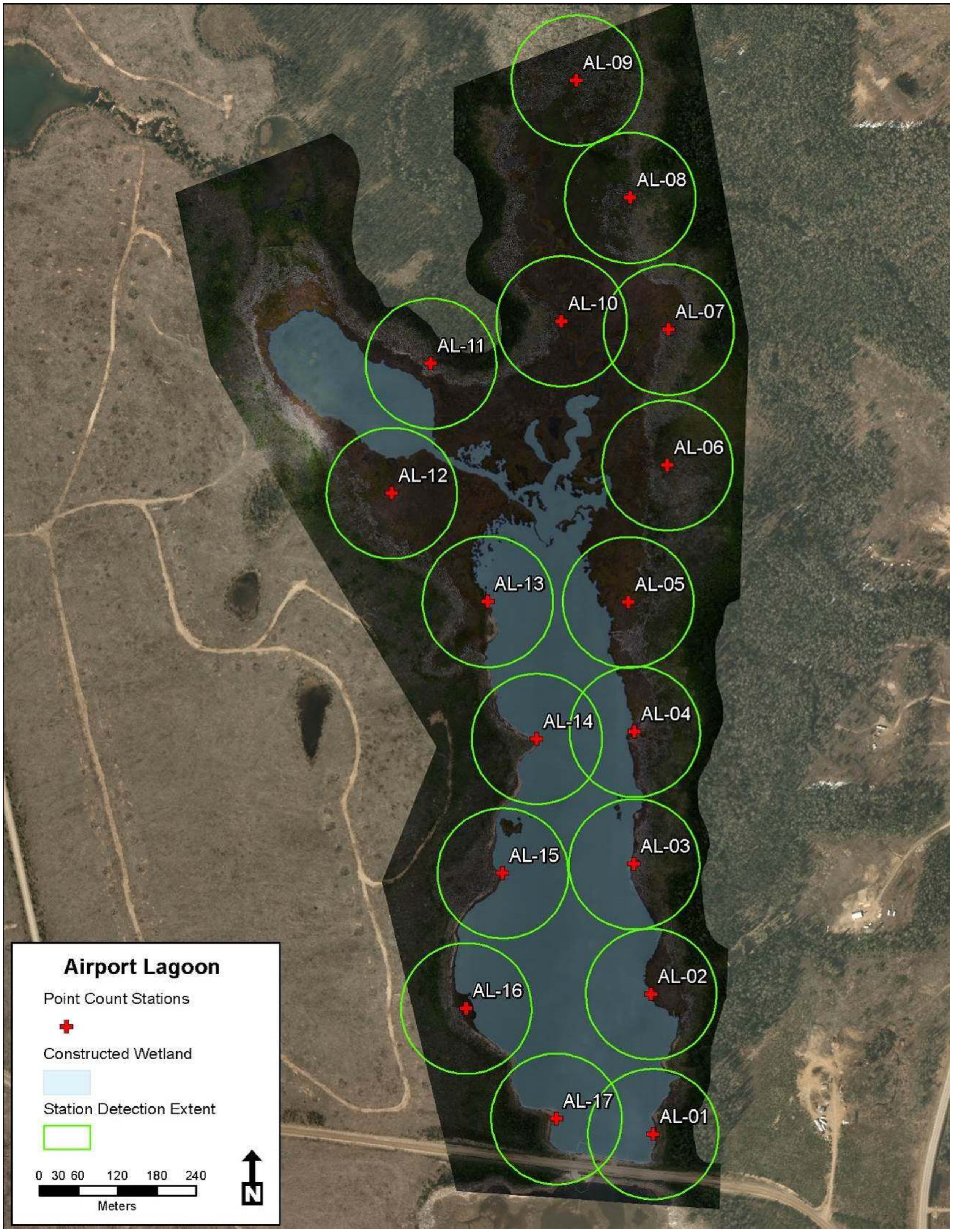

Figure 7. Point count station locations at the Airport Lagoon site.

Survey stations were approached quietly to minimize disturbance. Upon arrival, observers waited silently at the point count station for one minute to allow any effects of disturbance on resident birds to dissipate before commencing the survey. Point counts were conducted for five minutes.

At each point count station, environmental variables were recorded (ceiling, cloud cover, wind, precipitation) and time of day were noted. All birds seen or heard during the survey were recorded. Each detection (a detection can include more than one individual; e.g. a flock of 12 Pine Siskin could account for a single detection) within 100 m of the centre of the point count station was spatially mapped on a data sheet with concentric radii of 25, 50, 75 and 100 m. Birds beyond 100 m were noted on the data sheets but not spatially located, as distance estimation at greater distances is problematic (Alldredge et al. 2007).

Detections were assigned to one of two time intervals (0-3 and 3-5 minutes) based on the time that they were initially noted. They were categorised as in the drawdown zone; in the shrub fringe at the upper edge of the drawdown zone; in forested habitat bordering the shrub fringe; as 'flying-over' and not associated with any vegetation type; or unknown.

Opportunistic nest searches were conducted daily, following the completion of point count surveys. Searches were focused on areas where breeding behaviour (e.g., carrying food or nest-building material) had been observed within the drawdown zone and adjacent areas (within 50 m of the drawdown zone). Data including UTM coordinates, type of nest, species using it, height above ground and coarse resolution of vegetation composition in the surrounding area were recorded for each nest.

1.7 Amphibian Surveys

Systematic surveys consistent with inventory methods for pond-breeding amphibians were used to determine the diversity and relative abundance of amphibian species at Airport Lagoon and Beaver Pond (RIC 1998). Due to a lack of obvious strata, both sites were treated as a single stratum (RIC 1998). Survey efforts included 4 replicates of 11 randomly distributed transects along the peripheries of the inundated area of Airport Lagoon and 3 replicates at Beaver Pond, where the entire site was considered as a single transect. Two surveys were conducted at each site in 2017 (Table 1).

Table 1. 2017 amphibian survey dates by site.

Amphibian Survey dates - 2017		
Site	**Survey 1**	**Survey 2**
Airport Lagoon	May 2	May 21
Beaver Pond	May 19	May 31

Completion of the projects at both sites resulted in increased water levels that required the adjustment of eight of the original transects at Airport Lagoon and modifications to the Beaver Pond transect. The potential for modification of some transects after project construction was anticipated during development of the monitoring program. Changes to the transects at the Airport Lagoon and Beaver Pond sites are illustrated in Figure 8 and Figure 9, respectively.

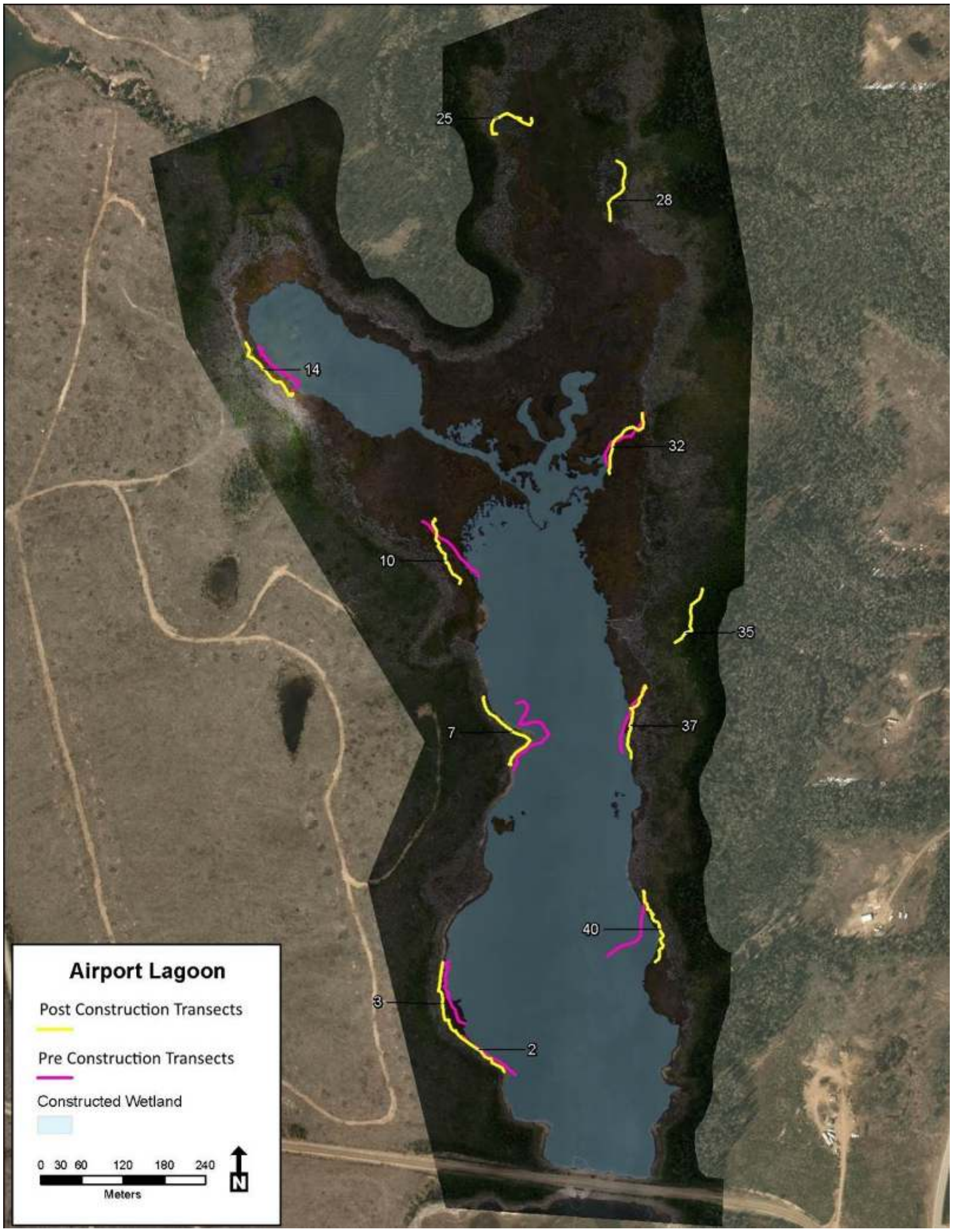

Figure 8. Amphibian survey transect locations at the Airport Lagoon site.

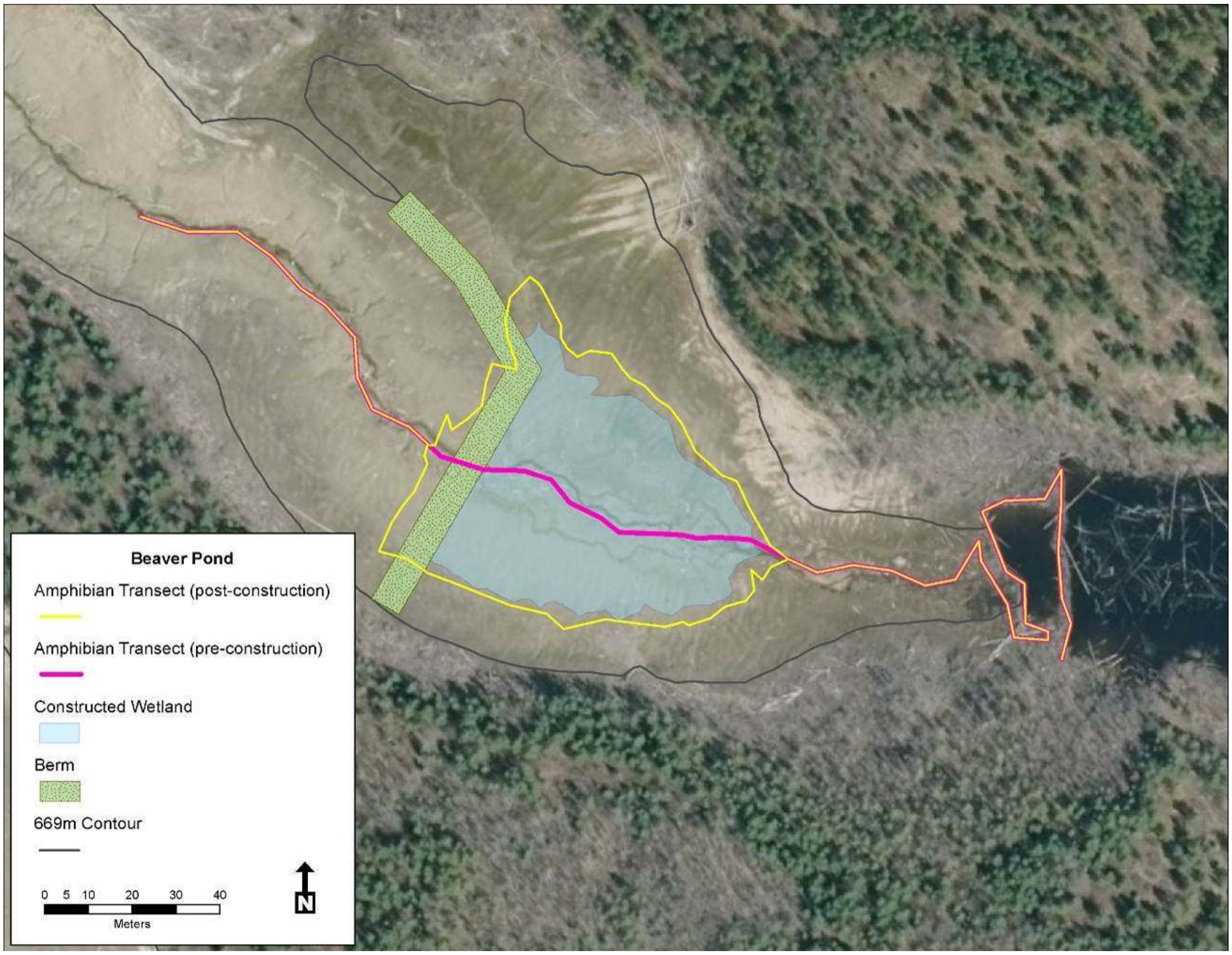

Figure 9. Amphibian survey tracks locations at the Beaver Pond site.

Prior to field surveys, a list of amphibian species likely to be encountered at each site was compiled based on the findings of Hengeveld (2000) along with the results from the first four years of this project (CBA 2012, 2013, 2014, 2015, 2016). A photograph was taken from the start point of each transect, oriented towards the end point. To allow for replication and calculation of detections per unit area, a hand-held GPS unit was used to record the start and end points along with the survey tracks for all transects.

The search area included shallow water (<1 m deep), the shorelines and areas within 3 m of the shoreline of the reservoir, ponds, streams, and riparian areas. A zig-zag search pattern applied above the waterline along with a linear search of shorelines ensured complete coverage of the area. On the shore, observers checked for the presence of amphibians underneath pieces of woody debris and other potential cover objects before returning all materials to their original position. Individuals were only captured on rare occasions when identification was not possible during the initial sighting and all amphibians were released immediately upon identification. Matsuda et al. (2006) and an unpublished tadpole key from the Ministry of Environment in Fort St John were used to confirm species identification. Species codes followed RIC (2008).

Data were recorded on RISC animal observation forms for amphibians. Survey conditions including precipitation, ambient temperature, wind speed, cloud cover, ceiling height, water temperature and condition (if applicable) were noted at the beginning and end of each transect. Species, developmental stage, behaviour, and habitat variables were recorded for each adult, larvae, and egg mass observed. Where it was not possible to exactly count large numbers of tadpoles (>100), they were simply recorded as 'tadpoles'.

1.8 Fish Surveys

Fish populations were sampled at both sites using a combination of methods following RIC (2001) guidelines. Fish sampling was conducted under Scientific Fish Collection Permit PG17-268444 issued by the Ministry of Forests, Lands and Natural Resource Operations. A combination of methods was used to ensure sampling of both large and small fish at each site and the different habitats available at low and high reservoir levels. In 2017, fish sampling at the Beaver Pond and Airport Lagoon sites was completed using minnow traps, backpack electrofishing, and fyke nets.

Fish sampling was completed at the Airport Lagoon site on May 17-18 and July 25-26, 2017 and at the Beaver Pond site on May 19-20 and July 27-28, 2017. The sampling locations are shown in Figure 10 and Figure 11 for the Airport Lagoon and Beaver Pond sites, respectively. The methods used on each date are summarized in Table 2. As the upper pond in the northwest arm of the lagoon is not accessible by boat at early season water levels, fish sampling was completed with minnow traps at this location. The May fish sampling at the Beaver Pond site was completed prior to this area being inundated.

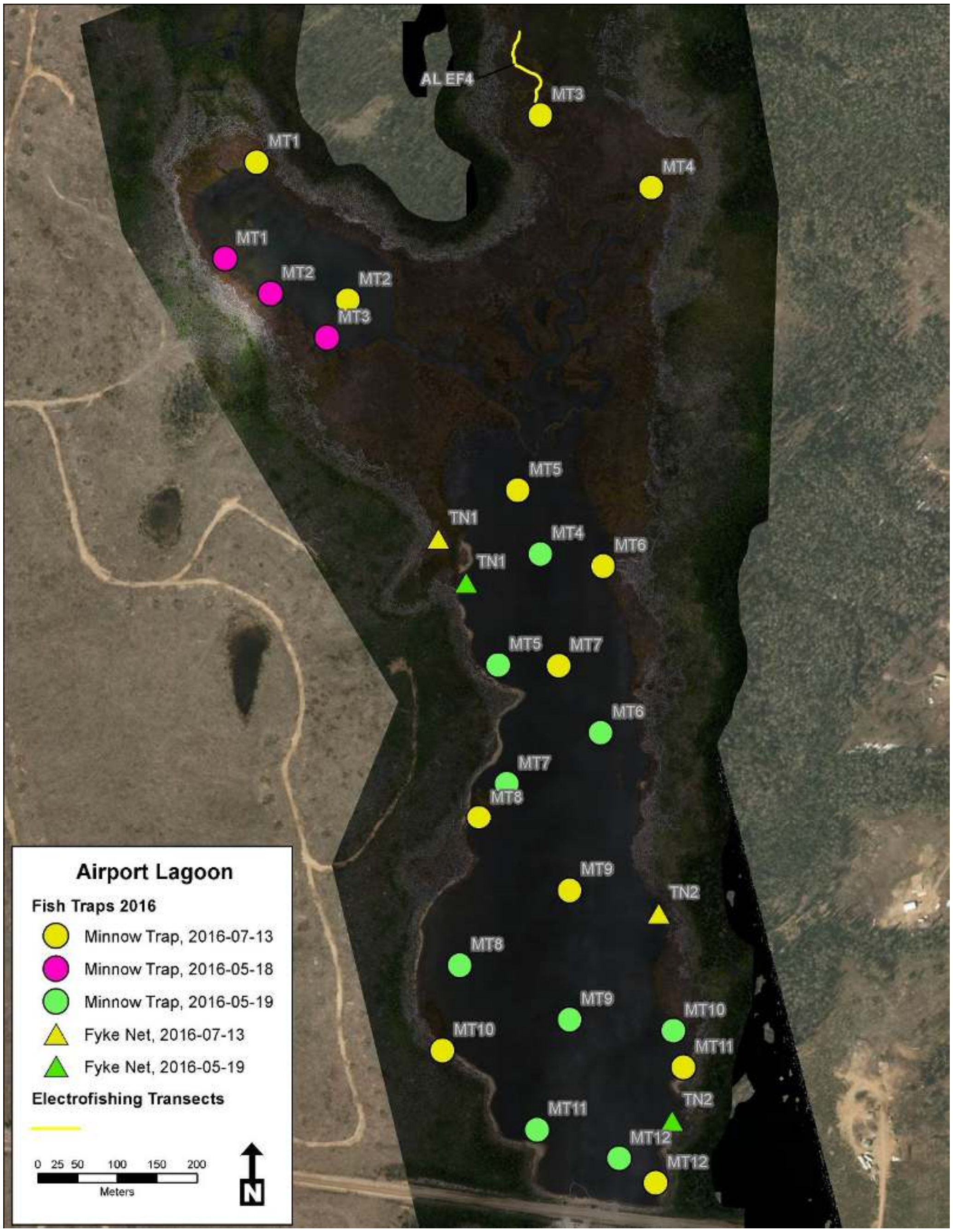

Figure 10. Fish sampling locations by date and method at the Airport Lagoon site.

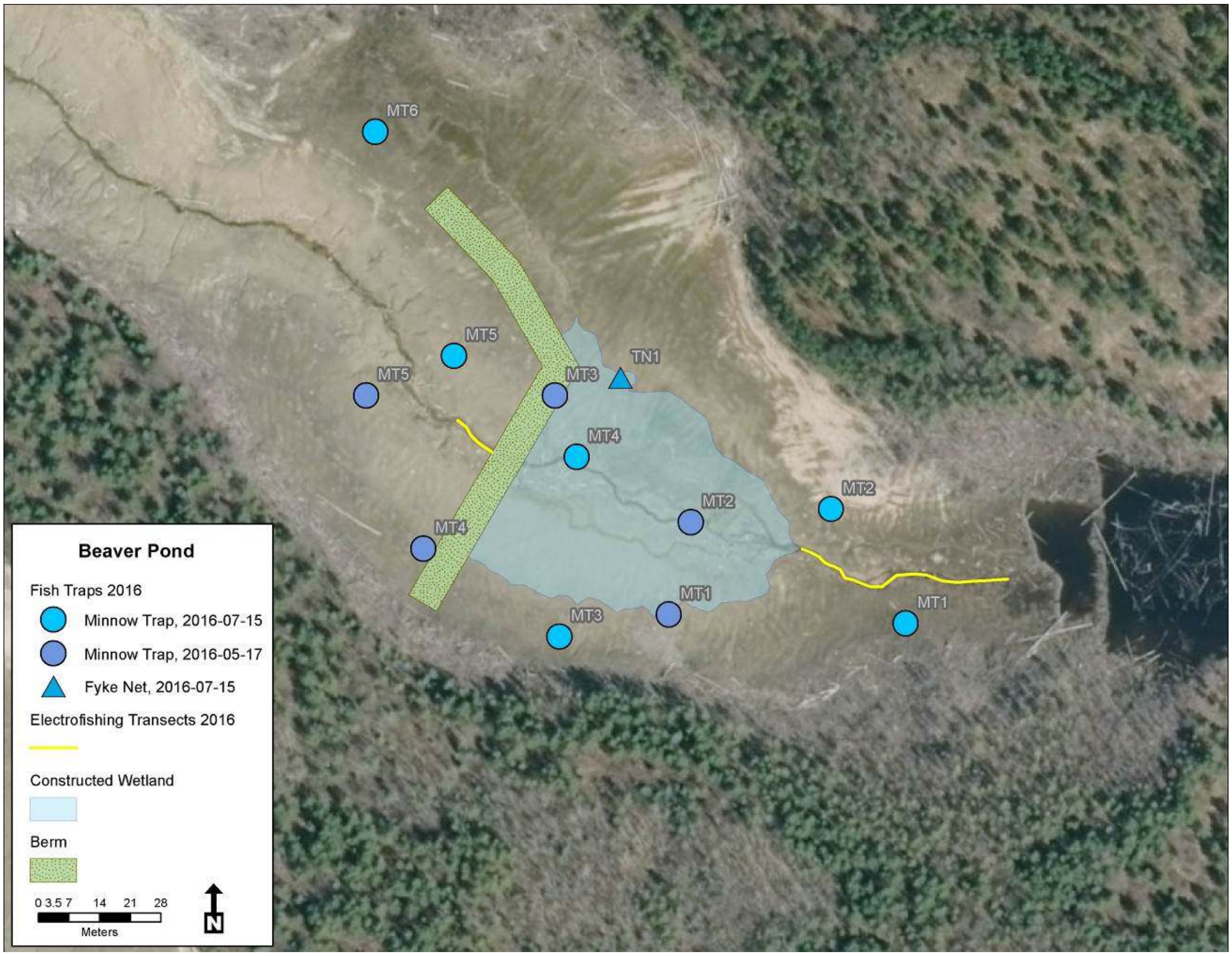

Figure 11. Fish sampling locations by date and method at the Beaver Pond site.

Table 2. Fish sampling methods in 2017 at the Airport Lagoon and Beaver Pond sites.

Fish sampling summary - 2017			
Site	**Date**	**Method**	**Number of Samples**
Airport Lagoon	May 17	Electrofishing	1 reach
	May 17-18	Minnow trap	12 traps
		Fyke net	2 nets
	July 25-26	Minnow trap	12 traps
		Fyke net	2 nets
Beaver Pond	May 19-20	Electrofishing	2 reaches
		Minnow trap	5 traps
	July 27-28	Minnow trap	6 traps
		Fyke net	1 net

In 2017, two minnow trap sampling sessions were completed at both the Airport Lagoon and Beaver Pond sites. At both sites, the first sampling session was completed prior to inundation and the second session was completed after inundation. This is the first year after construction of the wetland that minnow trapping was completed at the Beaver Pond site prior to inundation. Minnow traps were baited with cat food and set for a minimum of 12 hours at random locations at each site.

Twelve minnow traps were used for each sampling session at the Airport Lagoon. During the first sampling session, three minnow traps set in random locations around the pond in the northwest arm of the lagoon and the other nine minnow traps were set at random locations in the new pond created by the higher elevation culverts. During the second session (after inundation) the 12 minnow traps were deployed at random locations throughout the lagoon. At the Beaver Pond site, five minnow traps were set at random locations around the impoundment. Six minnow traps were used during the second sampling session and were deployed at random locations within the inlet.

Backpack electrofishing (Smith-Root LR-20B) was used to sample the stream habitat that is present at both sites prior to inundation by the reservoir. A single reach was sampled at the Airport Lagoon site (Figure 10). This is the only one of the four previously sampled stream reaches at this site not affected by the new water level. Electrofishing at the Beaver Pond site occurred in the portions of the two stream reaches sampled in previous years that were not flooded by the new wetland (Figure 11).

Fyke net construction was based on the design in Bonar et al. (2000). Two nets were used at the Airport Lagoon during the May and July sampling. A single fyke net was used at the Beaver Pond site during the July sampling. Fyke nets were randomly deployed at each site with the lead anchored to the shore and the net set perpendicular to the shoreline. All sets were overnight for a minimum of 12 hours. While fyke nets were randomly deployed, an alternate site often needed to be selected in the field to ensure an effective net set. The fyke nets are 1 m deep and setting them with the cod end in water deeper than 1.5 m reduces the effectiveness by providing more opportunity for fish to avoid the cod end of the net. At high reservoir elevations, potential setting locations are further reduced by steep slopes requiring the fyke nets to be set in water deeper than the net.

All collected fishes were held in live wells after capture and processed as soon as the electrofishing pass, or net/trap haul was complete. Captured fishes were anaesthetized using CO_2 to ease handling and reduce the potential for handling injury. Captured fishes were identified to species, enumerated, and the fork length (total length for Burbot and sculpins) recorded to the nearest millimetre. All anaesthetized fishes were allowed to fully recover prior to release.

Due to high catch rates at the Airport Lagoon, subsampling was employed for the most abundant species to minimize holding and processing time. Subsampling was limited to fishes less than 100 mm fork length (FL) and to the most common species. For all electrofishing, minnow trap, and fyke net catches, a sample of approximately 50 individuals of the most common species (e.g., Lake Chub, Brassy Minnow, and Redside Shiner) were measured and the remaining fishes of the subsampled species were only counted. Separate subsamples were obtained for each gear type (minnow trap and fyke net) due to differences in selectivity between the methods (CBA 2014).

Environmental data were also collected during field visits to record the sampling conditions during each site visit. Additional data included water temperature, water depth, water clarity (relative turbidity or Secchi depth), pH, dissolved oxygen (DO), and conductivity. Water temperature, pH, DO, and conductivity were recorded at the surface using a calibrated YSI Pro Plus multi-parameter meter (YSI Inc., Ohio). Relative turbidity was recorded for each electrofishing reach according to RIC (2001) standards. Secchi depth (20 cm diameter disk) was used as a measure of turbidity for the inundated areas. The fish data collected were standardized to catch-per-unit-effort (CPUE) for each gear type (electrofishing = fish/minute, minnow traps and fyke nets = fish/hour) to allow for interannual comparison of fish diversity and relative abundance to identify changes related to the wetland treatments.

1.9 Data Entry and Analysis

Immediately after a field survey was completed, data sheets were scanned into pdf documents and stored in a redundant file storage system. Similarly, photographs taken during field surveys were labelled and filed by survey type. All data were entered into a customized database designed to minimize data entry errors by restricting the permissible range of values for a field or by using selections from drop-down lists.

Data were exported from the database to MS Excel to provide data summaries for each component of the monitoring project. Data from each vegetation transect were summarized to provide an overview of the vegetation community at each site. The vegetation percent cover data from each of the ten quadrats in a belt-transect were pooled to provide an average percent cover for each species. Waterfowl and amphibian survey results were summarized by survey date and site. As the intent of the breeding bird survey was to provide a snapshot of the breeding bird community at a site, data from all three replicates were pooled to provide summaries on species richness and relative abundance.

The collection of baseline data for the two sites is now complete with the construction of the Airport Lagoon project in May 2013 and the Beaver Pond project in 2014. Data collected in 2017 was the fourth year of post-construction data from the Airport Lagoon and the third year of post-construction data from the Beaver Pond site. Initial comparisons of the post-construction results to the baseline are provided for both sites. More detailed analyses are planned once additional years of post-construction data are collected.

For the 2017 annual report we presented results from previous years for comparison. For the sake of consistency within this report, and to allow comparison to 2017, we filtered and subset the entire dataset using the same assumptions. For this reason, there may be small differences between numbers reported for years 1-6 as compared to this Year 7 report.

2 RESULTS

2.1 Environmental Conditions

The annual change in water level for 2017 and the previous six years of this study are shown in Figure 12 along with the mean reservoir level.

In 2017, the reservoir reached its lowest level of 660.03 on April 11. 662.9 m on April 7. This is earlier than in most previous years of the monitoring program (8 May 2011, 25 April 2012, 3 May 2013, 26 April 2014, 21 April 2015 and 7 April 2016). The minimum elevation is higher than average but is similar to most years of the sampling program compared the well above average minimum elevations observed in 2015 and 2016 (Figure 12). Water levels in 2017 increased rapidly until mid-June in a pattern similar to most previous years. The reservoir reached a maximum of 671.04 m on July 29 which is above average but below the full pool elevation of 672.08 m. The timing of the peak elevation in 2017 was similar to average conditions and previous years of the project although the duration of the peak was shorter than previous years (Figure 12). Reservoir levels in all seven years of the project were higher than in 2010 when the reservoir elevation only reached a maximum of 665.54 m on November 8, 2010 (BC Hydro CRO database).

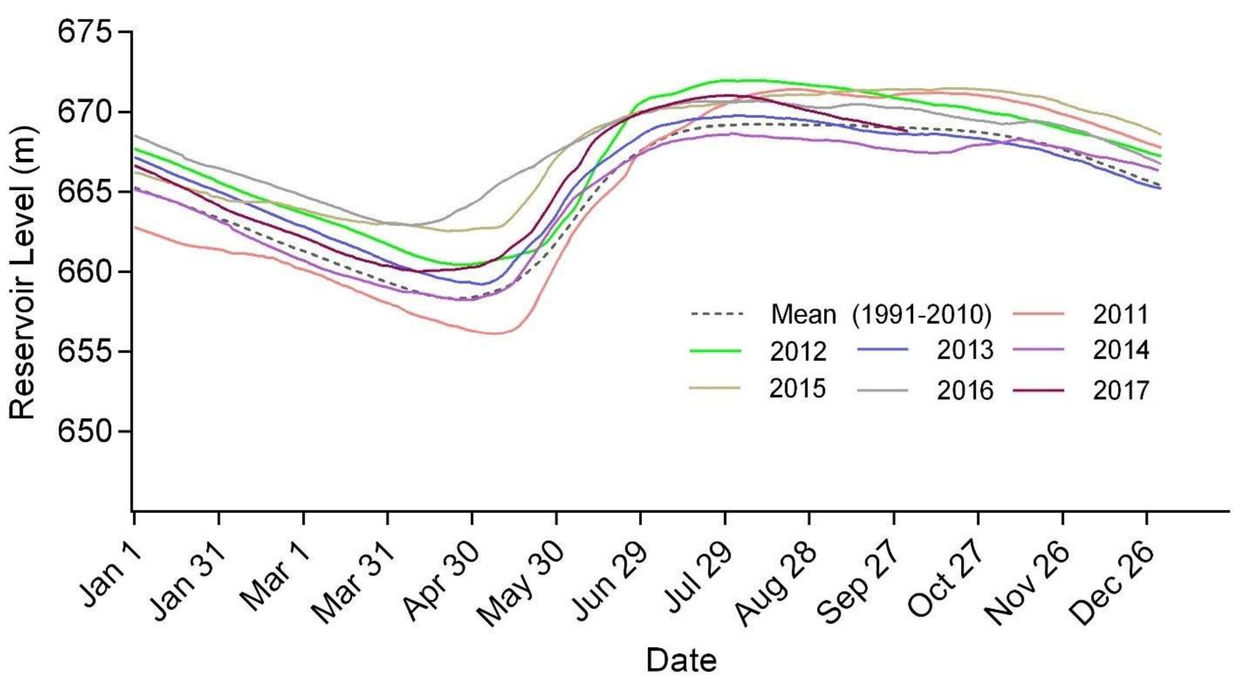

Figure 12. Annual Williston Reservoir elevations for 2011 to 2017 (BC Hydro CRO database).

In 2017, temperatures were above average in early April followed by a period of mostly average or below average temperatures until mid-May (Figure 13). Temperatures were then above average from mid-May into early June. Temperatures were close to average during the first half of the sampling period and generally above average during the second half of the sampling period (Figure 13). Cumulative precipitation in 2017 was below average for April and above average in May and June (Figure 14). As in previous years of the project with above average cumulative precipitation, this was primarily result of a single rainfall event (Figure 14). The cumulative precipitation in April of 2017 was the lowest recorded to date in this project while cumulative precipitation in May was the second highest recorded. The cumulative precipitation for

June was similar to other years with above average June precipitation. Conditions appeared to be drier than normal at the start of sampling in 2017 and this was assumed to be due to the low precipitation and warm temperatures in early April.

Based on accumulated degree days, 2017 was initially one of the coolest years of the project with limited accumulation of degree days until late May (Figure 15). Degree day accumulation was relatively rapid from late May to early June resulting in one of the highest years recorded with the exception of 2015 and 2016 (Figure 15). While temperatures in April were generally well above average, they were not consistently above 5°C until May 2 which is generally later than previous years of the project (2011: May 3, 2012: April 25, 2013: April 23, 2014: April 25, 2015: May 6, and 2016: April 27).

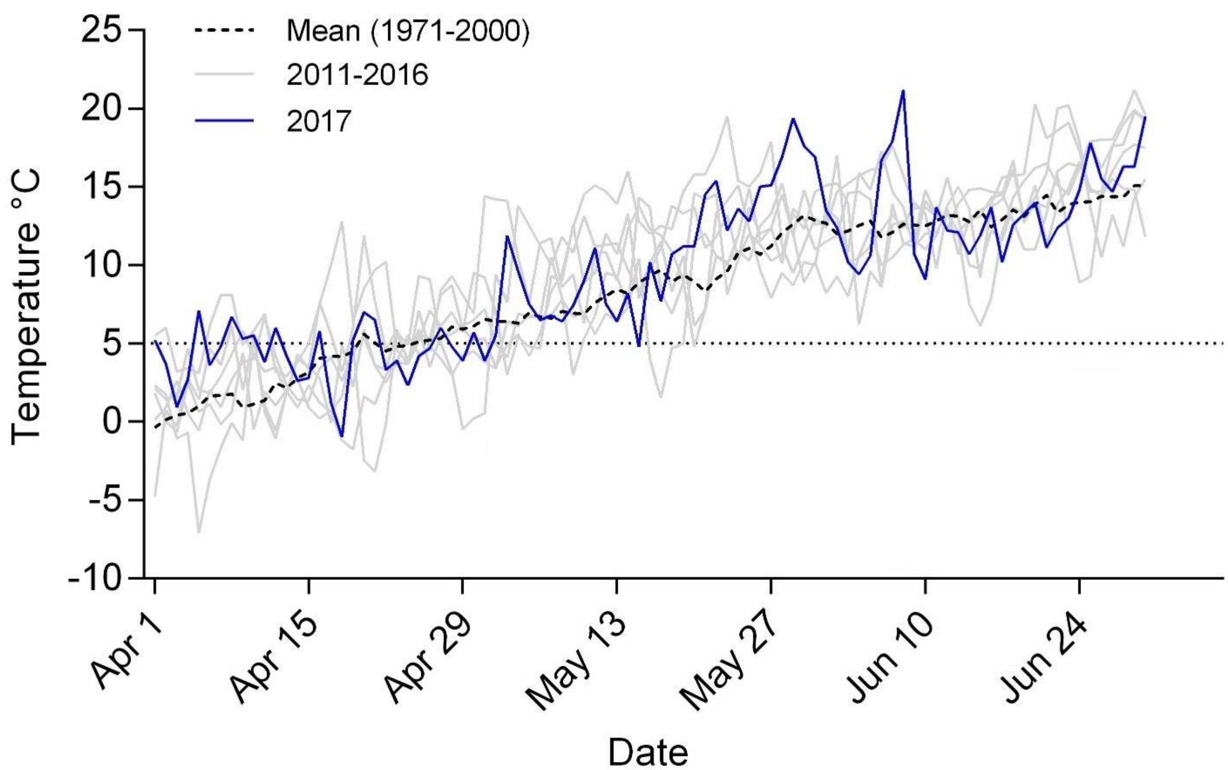

Figure 13. Daily mean air temperature and the long term mean (1971-2000) in the study region. Data from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).

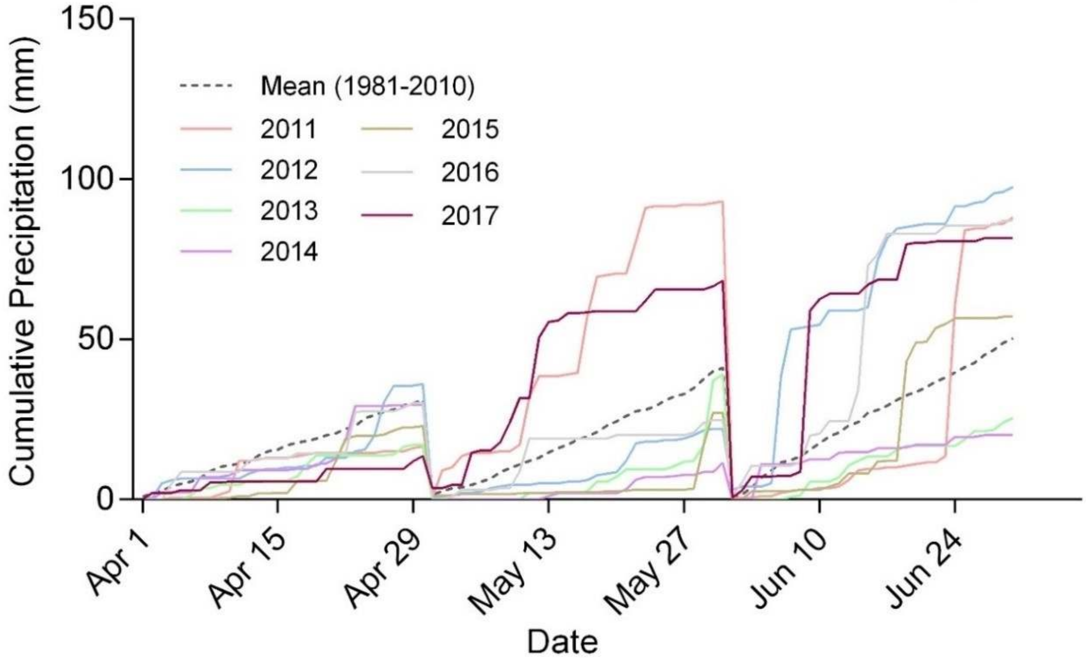

Figure 14. **Cumulative monthly total precipitation and the long term (1971-2000) means in the study region. Data from Environment Canada and observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

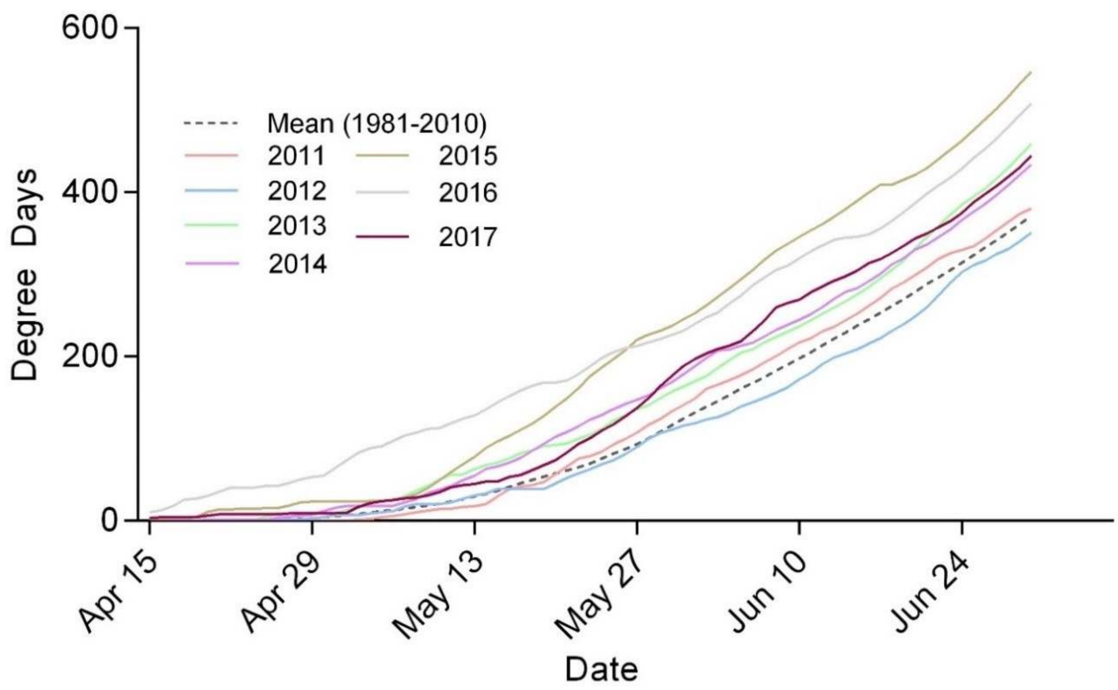

Figure 15. **Accumulated degree days (5°C base temperature) and the long-term mean (1971-2000) in the study region. Calculated from Environment Canada daily maximum and minimum temperatures observed at the Mackenzie Airport weather station (Station names: Mackenzie A and Mackenzie Airport Auto).**

2.2 Habitat Classification

Habitat classification in 2017 followed methods used to classify habitat in previous years. For Year 7, the focus was on determining if there were substantial changes to the distribution and abundance of each of the mapped habitat categories (**Error! Reference source not found.**).

In the four intervening years between construction of the wetland at Airport Lagoon and 2017 (when recent air photos were taken) there have been minor changes in area of certain habitat types. The habitat classes Basin Moss (BM) and Basin Smartweed (BS) were found to have decreased in area (Table 3). Shoreline Driftwood (SD), and Shoreline Grassland (SG) saw the greatest increase in area over the four years.

Table 3: Changes in area of each mapped habitat category between 2014 and 2017.

Changes to Habitat Classes 2014 – 2017		
Habitat Code	Habitat Description	Change in area between 2014 and 2017 (hectares)
BM	Basin Moss	-3.40
BS	Basin Smartweed	-1.76
FI	Floating Islands	-0.07
SD	Shoreline Driftwood	2.76
SG	Shoreline Grassland	1.74
SP	Streams and Ponds	0.92
SS	Shoreline Sand	-0.46
SW	Shoreline Willow	0.28
WD	Wetland Dead Trees	0
WH	Wetland Horsetail	0
WS	Wetland Sedge	0
WW	Wetland Willow	0

Habitat classes Wetland Horsetail (WH), Wetland Sedge (WS) and Wetland Willow (WW) saw no detectable change in area over the four years. The total mapped area remained the same (62.5 hectares) between the two years.

2.3 Waterfowl and Shorebird Surveys

In 2017 one survey of Beaver Pond and four surveys of Airport Lagoon were conducted. We detected a total of 136 birds, with 14 species of waterbird, and 6 species of shorebird on surveys from May 2nd to May 31st between the two sites (Table 4). Controlling for effort, these are still the lowest numbers recorded over the previous six years of data collection. Data from all years was summarized in 2017, applying the same assumptions to each of the previous years to allow comparison among years. In this report no distinction was made between waterbirds and waterfowl and thus Belted Kingfisher (*Megaceryle alcyon*), Osprey (*Pandion haliaetus*) and Bald Eagle (*Haliaeetus leucocephalus*) were included in these counts. Unknown species were filtered out leaving a dataset of 'waterbird' and 'shorebird' of known species. For comparisons among years, these same assumptions were applied to datasets from previous years.

Airport Lagoon

Counts in Year 7 were the lowest since this project was initiated, despite the same number of surveys as in most previous years (Table 4). Shorebird numbers were the second lowest they had been, with 2013 only having fewer detections. Waterbird species diversity was low, but similar to previous years (14 species) and was within one standard deviation of the multi-year average (17.4 ± 3.6), while shorebird species diversity (6 species) was within less than one standard deviation from the multi-year average (5.9 ± 2.6). However, results from the previous four years suggested an increasing diversity over time, which Year 7 contradicts. A summary of all waterbird and shorebird observations by species and survey date for 2011-2017 is included in Appendix 1.

Table 4. Summary of waterbird and shorebird observations between 2011 - 2017 at the Airport Lagoon site, Williston Reservoir, BC.

Survey summary among years – Airport Lagoon								
		2011[1]	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Number of surveys		5	5	4	4	8	6	5
Number of Detections	Waterbirds	224	303	394	345	300	207	109
	Shorebirds	1	118	25	63	59	102	27
Total		**225**	**421**	**419**	**408**	**359**	**309**	**136**
Number of species	Waterbirds	14	17	15	24	19	19	14
	Shorebirds	1	6	5	6	7	10	6
Total		**15**	**23**	**20**	**30**	**26**	**29**	**20**

In 2017 the first survey resulted in the most detections of all four surveys conducted at the Airport Lagoon site (57 detections, Table 5). The subsequent decrease in numbers suggests that migration of waterbirds peaked earlier than the surveys began. Common waterbird species included American Wigeon (*Anas americana*), Canada Goose (*Branta canadensis*), Mallard (*Anas platyrhynchos*), and Common Merganser (*Mergus merganser*). The fifth most common species was Spotted Sandpiper (*Actitis macularius*).

[1] Shorebird surveys were not a formal component of waterfowl surveys in 2011.

Table 5: Summary of bird detections for each survey occasion in 2017.

Survey occasion summary 2017		
Survey Date	**Site**	**Total Birds Detected**
2017-05-02	Airport lagoon	57
2017-05-10	Airport lagoon	42
2017-05-21	Airport lagoon	12
2017-05-30	Airport lagoon	25

Beaver Pond

Consistent with previous surveys at the Beaver Pond site, waterbird and shorebird abundance and species diversity in 2017 were low (Table 6). In 2017, we detected two waterbird species and two shorebird species during one survey (May 19, 2017). Detections were similar to previous years, however, controlling for survey intensity more detections were made on the one survey in 2017 compared to the number of detections per survey in all previous years. Species composition in 2017 was similar to previous years, with Canada Goose and Bufflehead (*Bucephala albeola*) comprising the waterbird, and Spotted Sandpiper and Killdeer (*Charadrius vociferus*) representing shorebirds.

Table 6. Summary of waterbird and shorebird observations between 2011 - 2017 at the Beaver Pond site, Williston Reservoir, BC.

Survey summary among years – Beaver Pond								
		2011[2]	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Number of Surveys		1	2	-	-	4	2	1
Number of Detections	Waterbirds	2	2	0	0	1	2	2
	Shorebirds	0	2	0	0	1	1	2
	Total	6	2	0	0	10	6	7
Number of species	Waterbirds	2	0	0	0	1	2	2
	Shorebirds	*	2	0	0	1	1	2
	Total	2	2	0	0	2	3	4

[2] Shorebirds were not a formal component of the 2011 surveys.

2.4 Songbird Surveys

Airport Lagoon

Airport Lagoon was surveyed three times in 2017 on June 1st, June 3rd, and June 5th. We made 341 detections of songbird species (excluding waterbirds) in 2017, representing 36 species. Diversity in 2017 was similar to previous years and within one standard deviation of the 7-year mean (36.3 ± 3.5). A summary of species detected each year is included in Appendix 2.

Table 7. Summary of the total number of detections, and diversity of species each year at the Airport Lagoon site.

Summary of detections made at Airport Lagoon							
	2011	2012	2013	2014	2015	2016	2017
Number of Surveys	3	3	3	3	3	3	3
Number of Detections	372	423	295	315	284	318	341
Number of Species	38	41	35	35	30	39	36

Detection location has been included in the data collected since the 2012 surveys. Prior to and during the construction year for the project, the majority of detections occurred in the forested habitat adjacent to the drawdown zone (**Error! Reference source not found.**). Detections of birds in the drawdown zone have been increasing steadily since 2013, but post construction the number of birds detected in this habitat has risen sharply (Figure 16). Whether this increase is a function of increased habitat as a result of the wetland creation, or other, regional influences was not examined for this annual report.

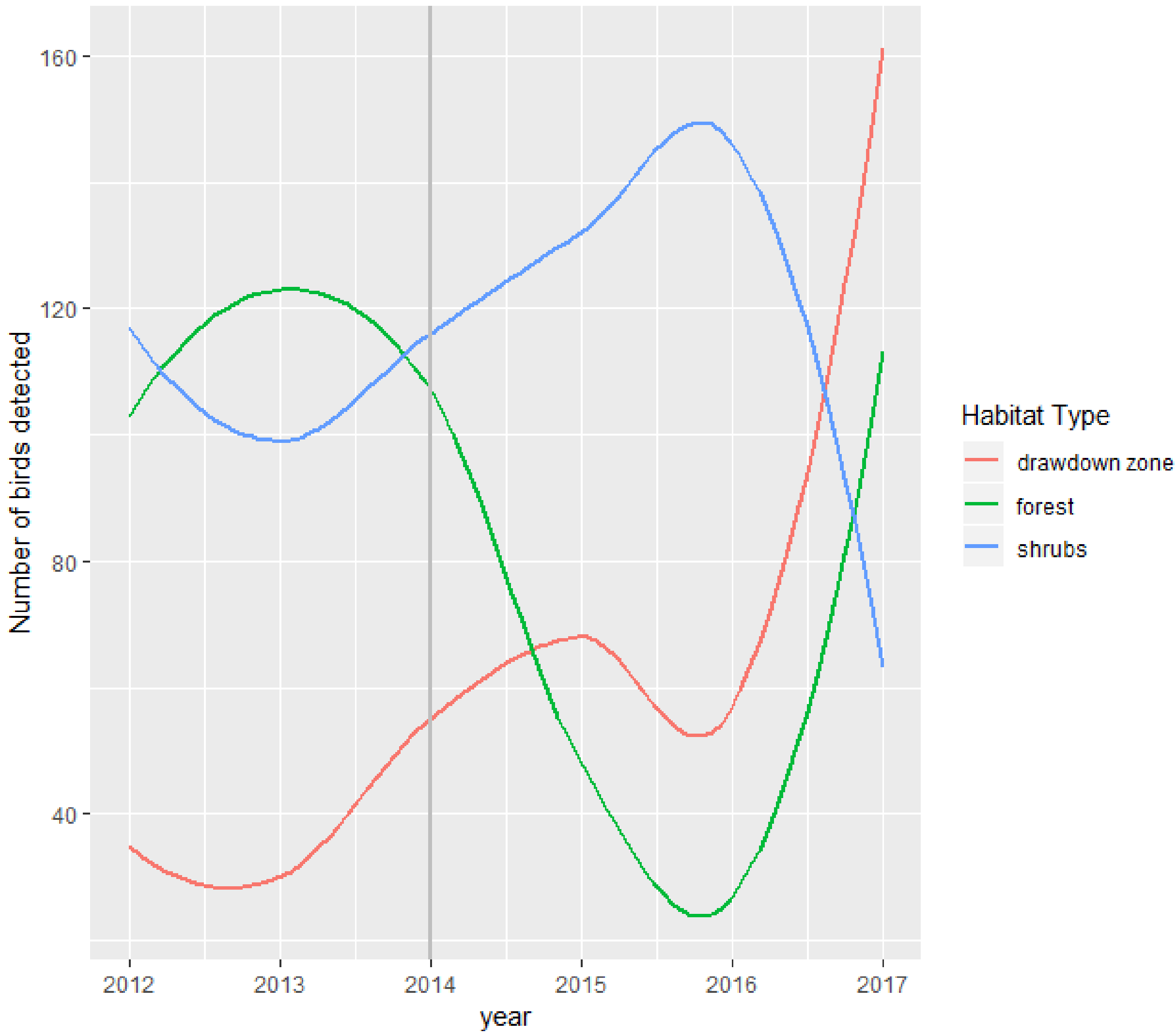

Figure 16: Habitat in which birds were detected over the 7-year study. The gray, vertical line represents one-year post construction of the Airport Lagoon wetland was created.

No new species were detected in 2017 which were not detected in previous years. The most common species among years were: American Redstart (*Setophaga ruticilla*), American Robin (*Turdus migratorius*), Chipping Sparrow (*Spizella passerina*), Orange-crowned Warbler (*Oreothlypis celata*), Warbling Vireo (*Vireo gilvus*), White-throated Sparrow (*Zonotrichia albicollis*) and Yellow-rumped Wabler (*Dendroica coronata*). These species were detected each year at both sites. The least common species detected in 2017 were detected in at least two other years – Barn Swallow (*Hirundo rustica*), MacGillivray's Warbler (*Oporornis tolmiei*), Varied Thrush (*Ixoreus naevius*) and White-crowned Sparrow (*Zonotrichia leucophrys*).

<u>Beaver Pond:</u>

Beaver Pond was surveyed twice in 2017 on May 31st, and June 4th. A total of 42 detections of 16 species were documented (Table 8). The diversity of species in 2017 was within one standard deviation of the 7-year average (17.6 ± 2), while the number of species detected in 2017 was also within one standard deviation of the mean (55 ± 16.5), despite fewer surveys in all but 2016 (this site was surveyed three times annually in all years except 2016 and 2017). As with Airport Lagoon, no new species were detected in 2017 but among the mostly commonly detected species diversity at Beaver Pond was higher than Airport Lagoon with the addition of Dusky Flycatcher (*Empidonax oberholseri*) to those species listed above.

Table 8. Summary of the number of detections and number of species detected between 2011 - 2017 at the Beaver Pond site.

Summary of detections made at Beaver Pond							
Year	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Number of Surveys	**3**	**3**	**3**	**3**	**3**	**2**	**2**
Number of Detections	61	71	80	52	45	34	42
Number of Species	18	21	19	16	17	16	16

Trends in habitat use over time at the Beaver Pond site contradicts trends at Airport Lagoon for shrub and drawdown zone habitat. Shrub habitat is experiencing a modest increase in the number of birds counted, while drawdown zone habitat has seen the counter trend, with a slight decrease. Similar to Airport Lagoon, the number of birds detected in forested habitat is increasing (Figure 17).

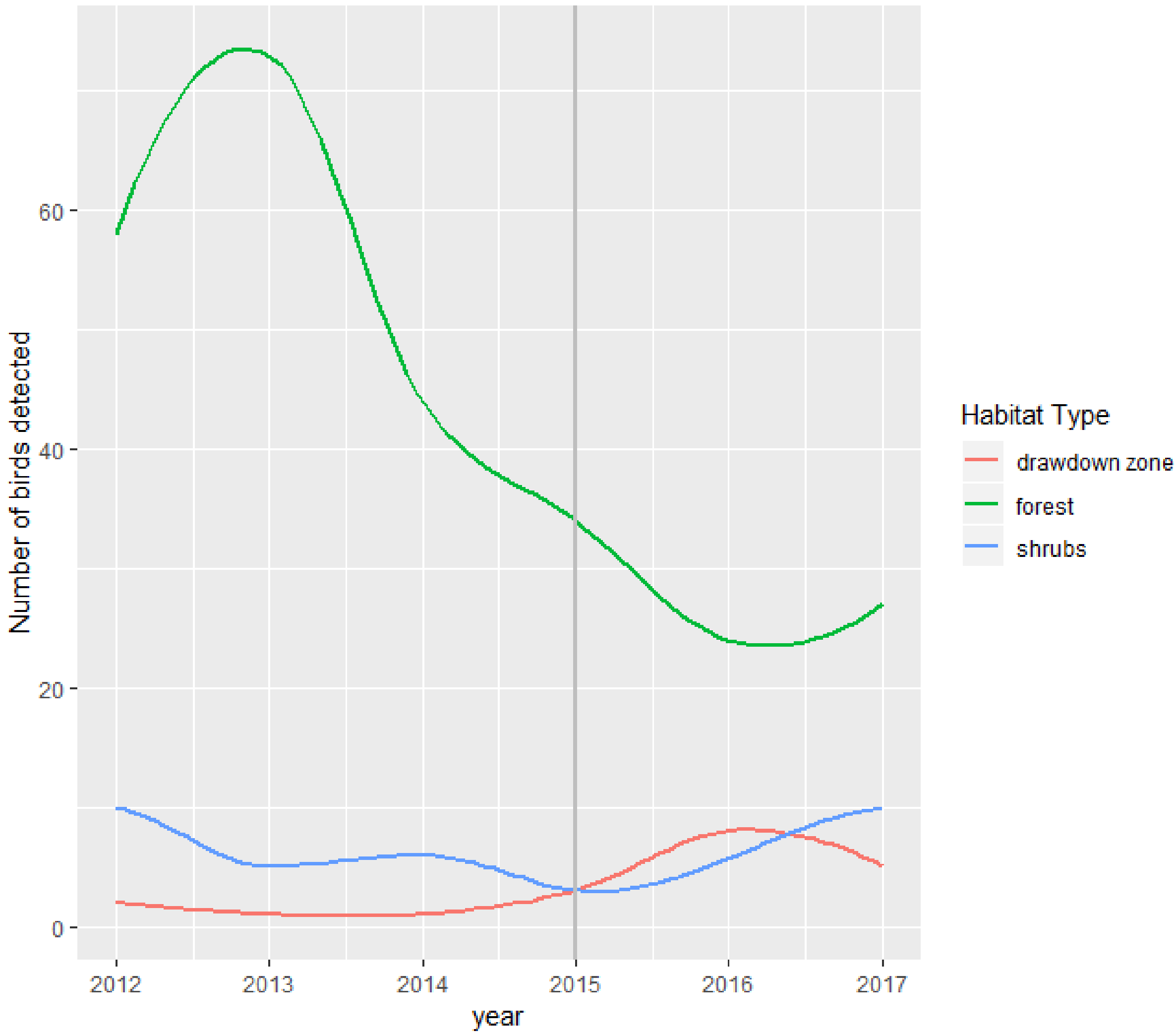

Figure 17: Trends in habitat use by detected birds at Beaver Pond.

2.5 Amphibian Surveys

<u>Airport Lagoon</u>

Airport Lagoon was surveyed twice in 2017, on May 2nd and May 21st. Amphibian survey results returned the fewest records of all previous years of the study (1 adult western toad and 1 tadpole of unknown species, Table 9).These two observations were made on transects 25 and 28, historically productive transects at Airport Lagoon (

Appendix 3). Comparing catch-per-unit-effort (CPUE) for adults 2017 (0.11 individuals / minute of searching) is below the mean (0.23 ± 0.19), but near the median CPUE (0.13) (Figure 18).

Table 9. Adult and juvenile amphibian detections by survey date in 2017 at Airport Lagoon.

Species summary – Airport Lagoon				
Site	Species	Age Class	2017-05-02	2017-05-21
Airport lagoon	western toad	adult	0	1
Airport lagoon	unknown	tadpoles	1	0

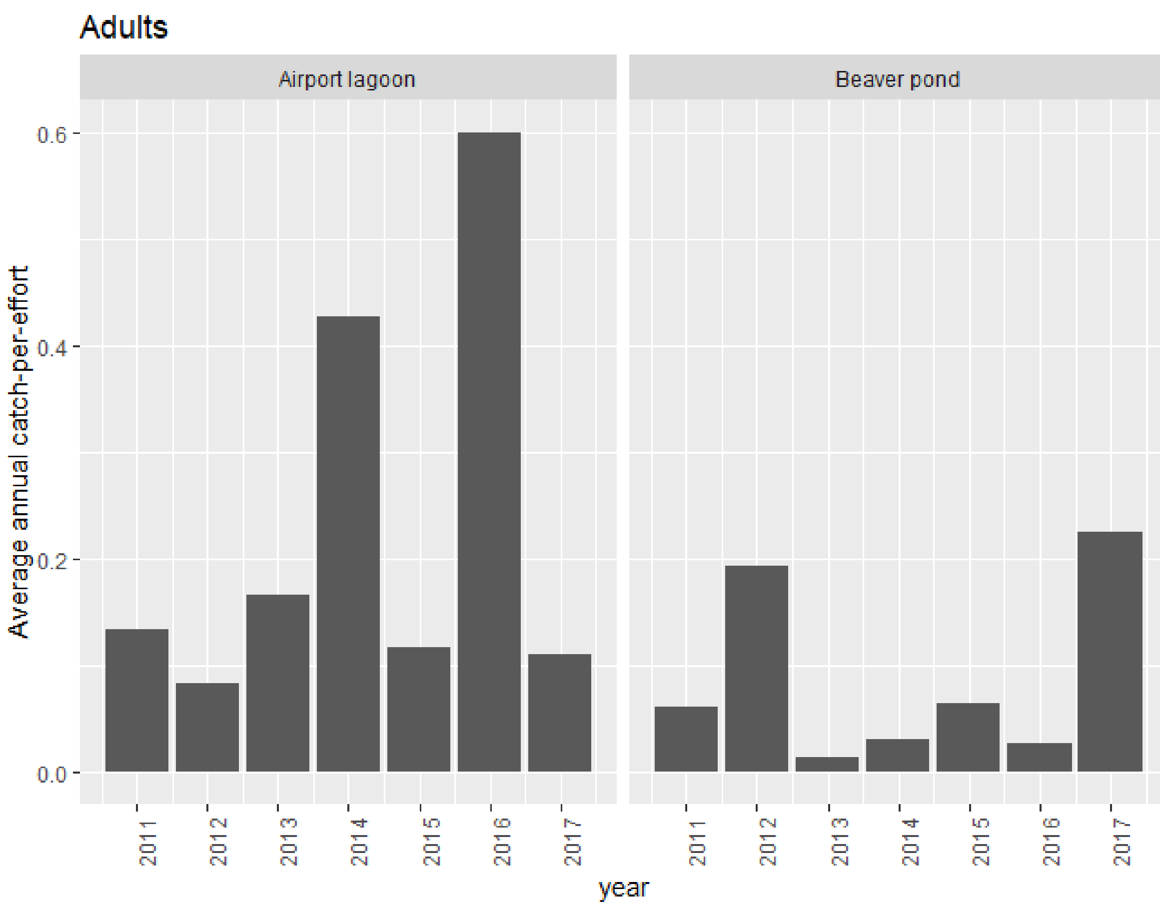

Figure 18: Catch per unit effort for adult amphibians at both sites for each year.

Total annual counts for Airport Lagoon in 2017 were well below previous years, with only 2012 having the same number of detections of tadpoles, and 2011 having only one more detection than the single detection of 2017 (Table 10, Figure 19).

Table 10: Annual counts of amphibians by site and age class.

Annual counts of amphibians detected at each site								
Site	Age Class	2011	2012	2013	2014	2015	2016	2017
Airport lagoon	adult	2	9	5	122	6	3	1
Airport lagoon	juvenile	10		8	7	23	1	
Airport lagoon	tadpoles	9	1		403	1000	300	1
Beaver pond	adult	10	2	2	17	23	8	21
Beaver pond	juvenile	1		2	4	72	47	5
Beaver pond	tadpoles	3	100		604	7863	860	3999

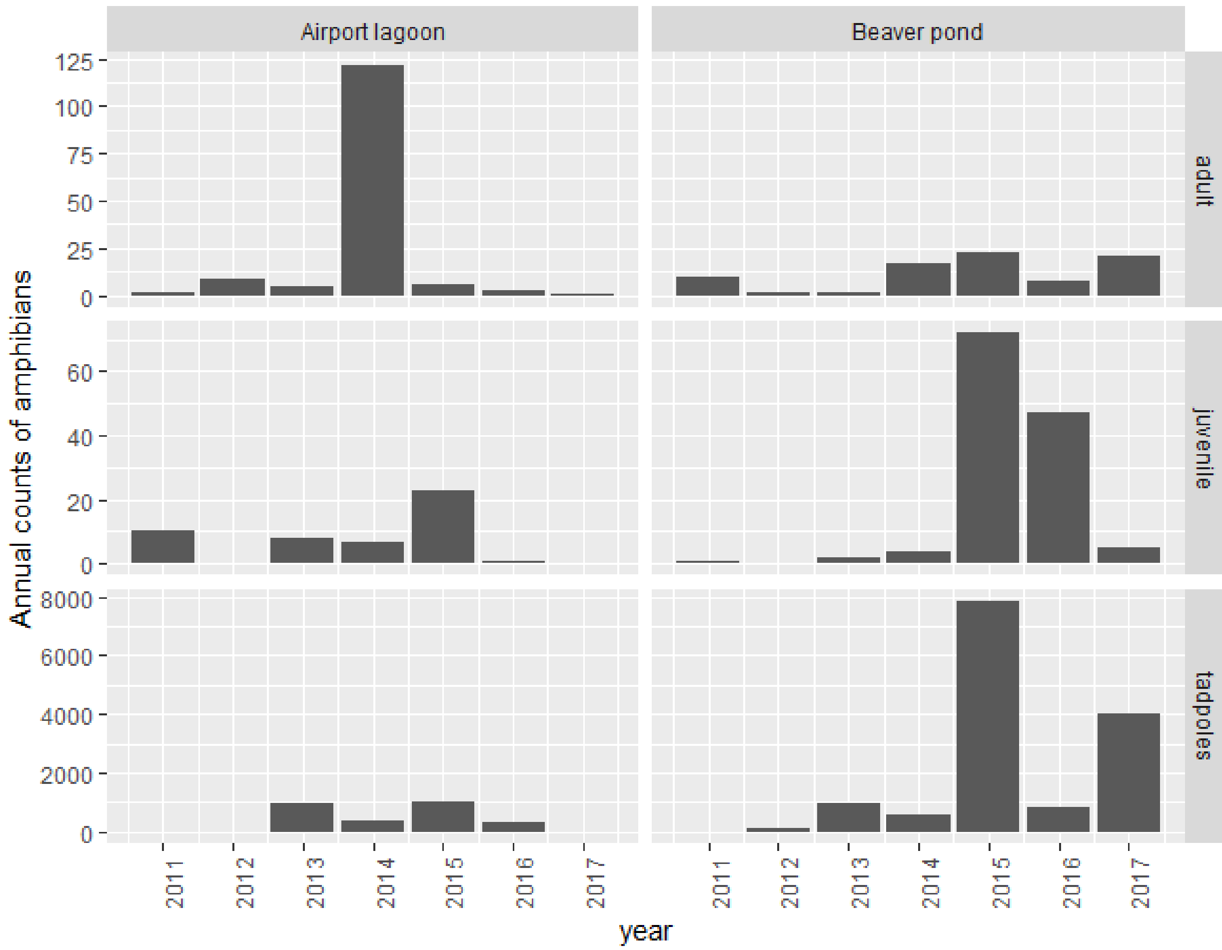

Figure 19: Annual total counts of amphibians at both sites.

<u>Beaver Pond</u>

Beaver Pond was surveyed twice in 2017 on May 19th and May 31st. Amphibian detections at Beaver Pond in 2017 were represented by long-toed salamander (*Ambystoma macrodactylum*), western toad, wood frog (*Lithobates sylvaticus*), boreal frog (*Pseudacris maculata*), and an unknown species of tadpole (Table 11, **Error! Reference source not found.**). Detections in 2017 were near average for the previous 6 years for adults, but the number of tadpoles observed was the second highest since the initiation of this project (only 2015 was higher - Figure 19).

Species detection at Beaver Pond showed a temporal pattern with no amphibians detected on the first survey, western toad and long-toed salamander detected in the highest numbers of the year on the second survey, and wood frog and boreal chorus frog detected on the last survey of the year (Table 11).

Table 11: Amphibian detections at Beaver Pond.

Species Summary – Beaver Pond				
Site	Species	Age Class	2017-05-19	2017-05-31
Beaver pond	long-toed salamander	adult	5	0
Beaver pond	long-toed salamander	tadpoles	1	0
Beaver pond	western toad	adult	16	0
Beaver pond	western toad	tadpoles	1000	2997
Beaver pond	wood frog	juvenile	0	1
Beaver pond	boreal chorus frog	juvenile	0	4
Beaver pond	unknown	tadpoles	1	0

Catch per unit effort at Beaver Pond was the highest recorded of all previous years of the study (0.225 adults / minute) and was well beyond the 7-year mean of 0.087 (±0.085). Only 2012 was similar to this relatively high capture rate at 0.19.

2.6 Fish Surveys

Airport Lagoon

A total of 1,554 fishes representing 11 species were collected at the Airport Lagoon site over the duration of the sampling program in 2017 (Table 12). The majority of fish were collected by fyke net (1,132), followed by minnow trap (392), and electrofishing (30) (Table 12). The majority of fish were captured during the May sampling session (1,505) with few captures during the July sampling session (49). The overall numbers of fish captured were lower than in the previous four years of the project.

Lake Chub (*Couesius plumbeus*) and Prickly Sculpin (*Cottus asper*) were the most abundant species captured by electrofishing. Redside Shiner (*Richardsonius balteatus*) and Lake Chub were the most abundant species captured by minnow trap. Brassy Minnow (*Hybognathus hankinsoni*) was the most abundant species captured by fyke net. Redside Shiner, Lake Chub, White Sucker (*Catostomus commersonii*), and Largescale Sucker (*C. macrocheilus*) were also abundant in the fyke net catches. Rainbow Trout (*Oncorhynchus mykiss*) and Northern Pikeminnow (*Ptychocheilus oregonensis*) were only capture by fyke net. All other species were captured by more than one method.

Table 12. Summary of fish species captured by method in 2017 at the Airport Lagoon site. [3]

Fish Species Summary for sampling methods.						
Species	**Electrofishing**	**Minnow Trap**		**Fyke Net**		**Totals**
	May	**May**	**July**	**May**	**July**	
Lake Chub	15	112	3	168	2	300
Brassy Minnow	6	12		430		448
Peamouth		1		7	2	10
Northern Pikeminnow				7	1	8
Redside Shiner		206	21	171	10	408
Longnose Sucker	1	17	4	25		47
White Sucker		7		160	1	168
Largescale Sucker		4	2	130		136
Sucker sp.	1	1		1		3

[3] Electrofishing effort in seconds (active sampling), minnow traps and fyke nets in hours (passive sampling). Electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour

Rainbow Trout				15	1	16
Prickly Sculpin	7		2	1		10
Totals	30	360	32	1115	17	1554
Effort	2029	226.5	180.75	40.08	30.6	
CPUE	0.887	1.589	0.177	27.819	0.556	

The total numbers of fish captured at the Airport Lagoon in 2017 was lower than in most previous years and this was reflected in the CPUE (Figure 20) (refer to Appendix 4 for CPUE results for each species by method and year). The electrofishing CPUE was the second lowest observed to date in the program (Figure 20). The low electrofishing CPUE in 2017 is assumed to be a result of the low water temperature on the sampling date (Appendix 5Appendix 5). While the overall electrofishing CPUE was low, the CPUEs for the three most abundant species (Lake Chub, Prickly Sculpin, and Brassy Minnow) were still higher than in pre-construction sampling.

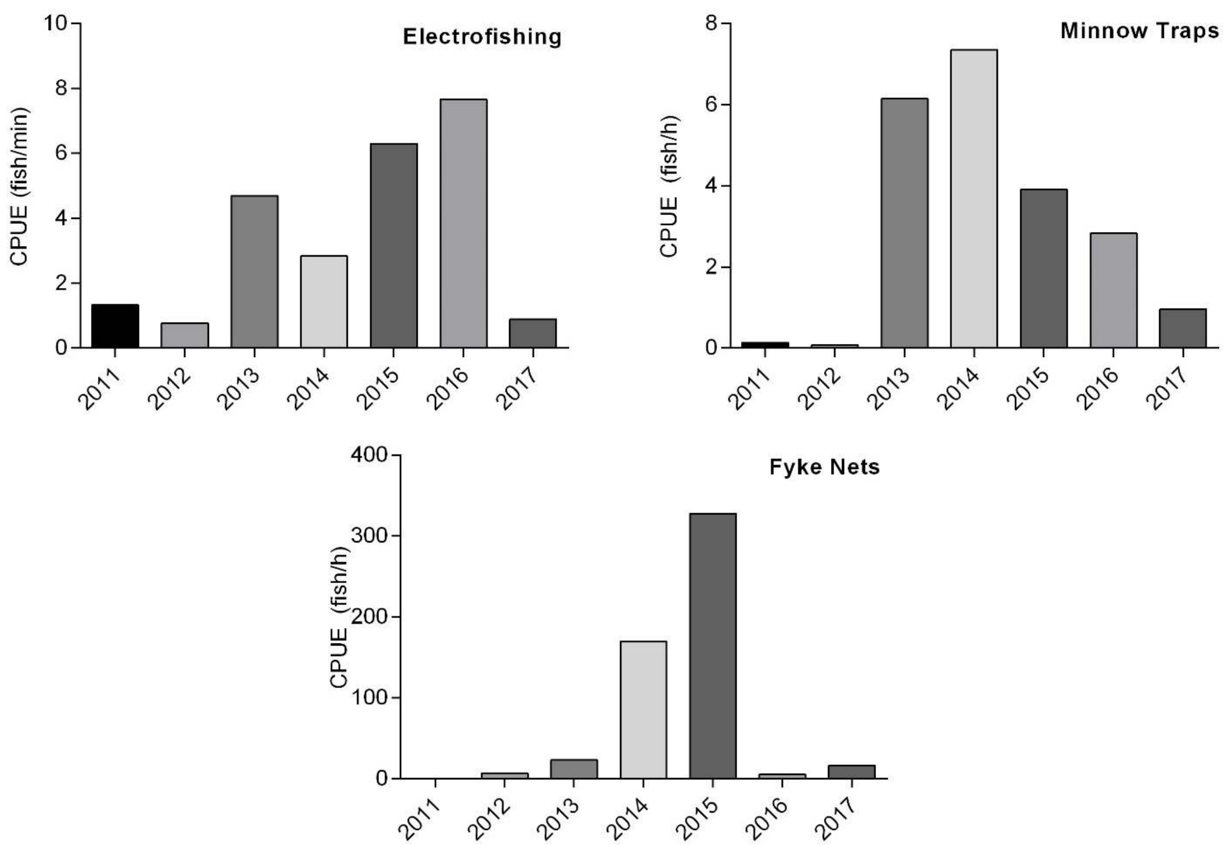

Figure 20. Annual total CPUE for each of the three sampling methods used at the Airport Lagoon site. Construction of the project was completed in spring 2013.

The overall CPUE for both the minnow traps and fyke nets was lower in 2017 compared to recent years (Figure 20). However, unlike the results for electrofishing, the overall CPUE for both minnow traps and fyke nets in 2017 remained higher than the pre-construction results. The minnow trap CPUE by species were also lower for most species in 2017 than in previous years but remained higher than the pre-construction results (Appendix 4). Redside Shiner and Lake Chub continued to be the most abundant species captured by minnow trap in the post-construction period.

The fyke net catches followed the general pattern observed in previous years with the highest catches during the May sampling and lower catches during the July sampling (Table 12). The extremely high catch rates observed in both 2014 and 2015 did not occur in 2017 but the catch rate did increase compared to 2016 (Figure 20). Fyke net catch rates increased for almost all species compared to 2016, with the largest increases observed for Brassy Minnow, White Sucker, and Largescale Sucker (Appendix 4). Brassy Minnow was the most abundant species in 2017 based on the May fyke net catches although this species was not captured in the July sampling.

Although the CPUE at the Airport Lagoon site was generally lower in 2017 compared to previous years the species composition and relative abundance for all species was similar to previous years. Lake Chub, Brassy Minnow, and Redside Shiner continued to be the most common species regardless of capture method. These three species along with juvenile suckers (<70 mm FL) increased in abundance after construction of the project and have generally remained at higher abundances than in the preconstruction period (Figure 21). There was little change in the abundance of other species between the pre- and post-construction periods (Figure 21). However, there do appear to be some increases in abundance (CPUE) for the three sucker species, Rainbow Trout, and Prickly Sculpin after construction of the project.

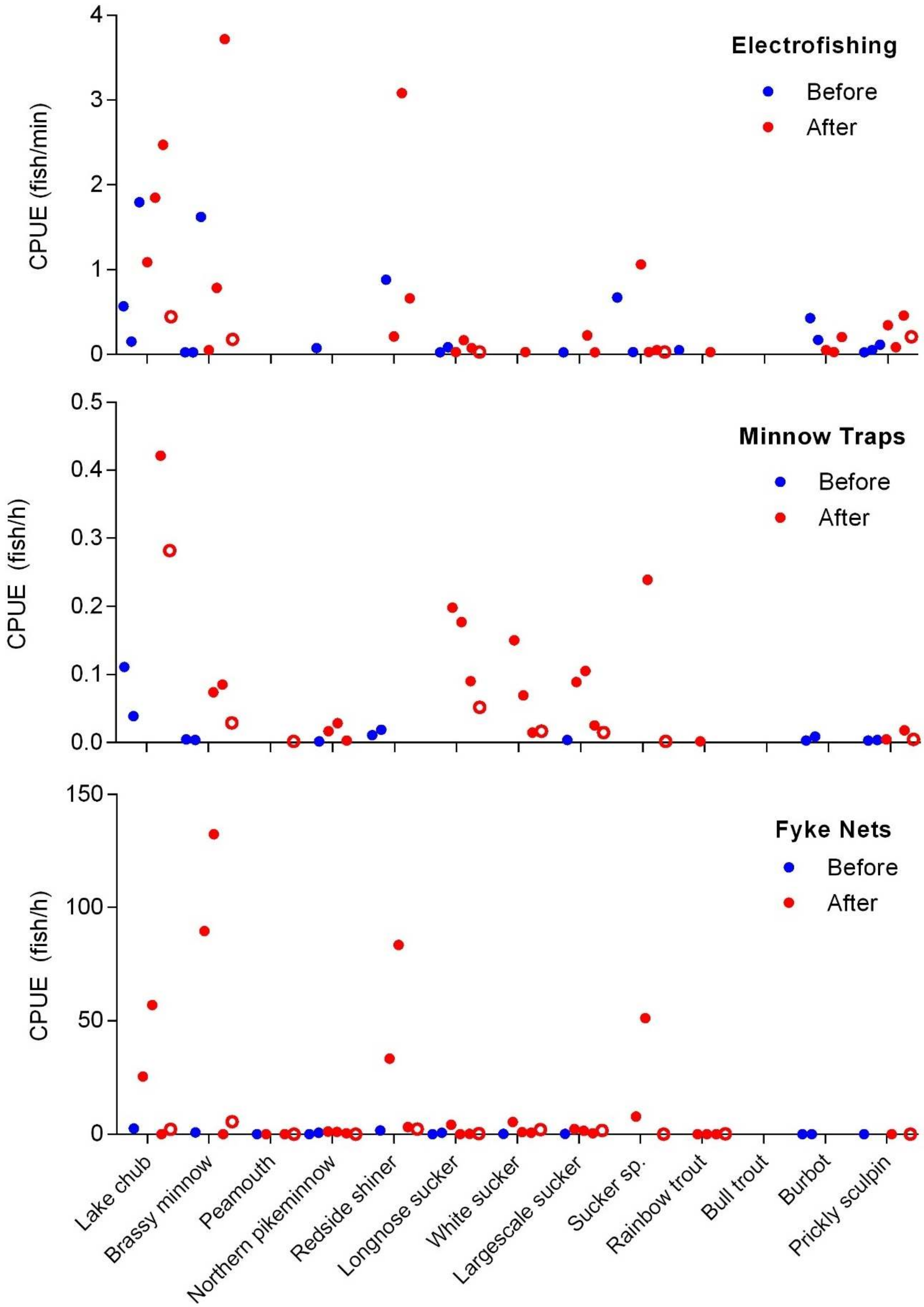

Figure 21. Changes in CPUE by sampling method and species before and after construction of the Airport Lagoon project in 2013. Note the different scale and units for CPUE (y-axis) for each method. Open red circles are the 2017 results.

Beaver Pond

Consistent with sampling results from previous years, few fish were captured during sampling at the Beaver Pond site. A total of 14 fish representing six species were collected over the duration of the sampling program in 2017 (Table 13). The most fish were collected by electrofishing (6 fish), followed by minnow trap (5 fish), and fyke net (3 fish) (Table 13). More than half of fish were captured during the May sampling session (8 fish) with fewer captures during the July sampling session (6 fish). Fish were captured throughout the site including upstream and downstream of the impoundment.

The 2017 electrofishing at the Beaver Pond was completed at a similar reservoir elevation to previous spring sampling at this site. Therefore, the electrofishing transect downstream of the berm started above the stream outlet into the reservoir. As in previous years, a large school of small fish was observed at the outlet but not sampled. The Rainbow Trout captured by electrofishing are the first record of this species at the Beaver Pond site during this sampling program. An additional three Rainbow trout were observed but not captured on the electrofishing transect downstream of the berm. The three Prickly Sculpins were captured on the electrofishing transect upstream of the berm.

The total CPUE for all sampling methods in 2017 was low but within the range of values for previous sampling at this site (Figure 22). The total CPUE at this site has been variable over the duration of the monitoring program and there were no apparent changes associated with construction of the project in 2014 (Figure 22). There was also no apparent changes observed when the pre- and post-construction values were plotted for individual species and sampling methods (Figure 23). The results from electrofishing and minnow trapping suggest there may be an increase in Prickly Sculpin and Redside Shiner. This is also supported by the observation of schools of juvenile Redside Shiner in 2017 at this site although none were captured. However, due to the variability in catches at this site and the low numbers of fish collected, additional data will be required to confirm if these changes are associated with the project.

Table 13. Summary of fish species captured by method in 2017 at the Beaver Pond site. [4]

Fish Species Summary for sampling methods.					
Species	**Electrofishing**	**Minnow Trap**		**Fyke Net**	**Totals**
	May	**May**	**July**	**July**	
Peamouth			1		1
Northern Pikeminnow				2	2

[4] Electrofishing effort in seconds (active sampling), minnow traps and fyke nets in hours (passive sampling). Electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour

Largescale Sucker		1		1	2
Sucker sp.		1			1
Rainbow Trout	3				3
Prickly Sculpin	3		2		5
Totals	6	2	3	3	14
Effort[1]	1099	108.94	137.03	23.42	
CPUE[2]	0.328	0.018	0.022	0.128	

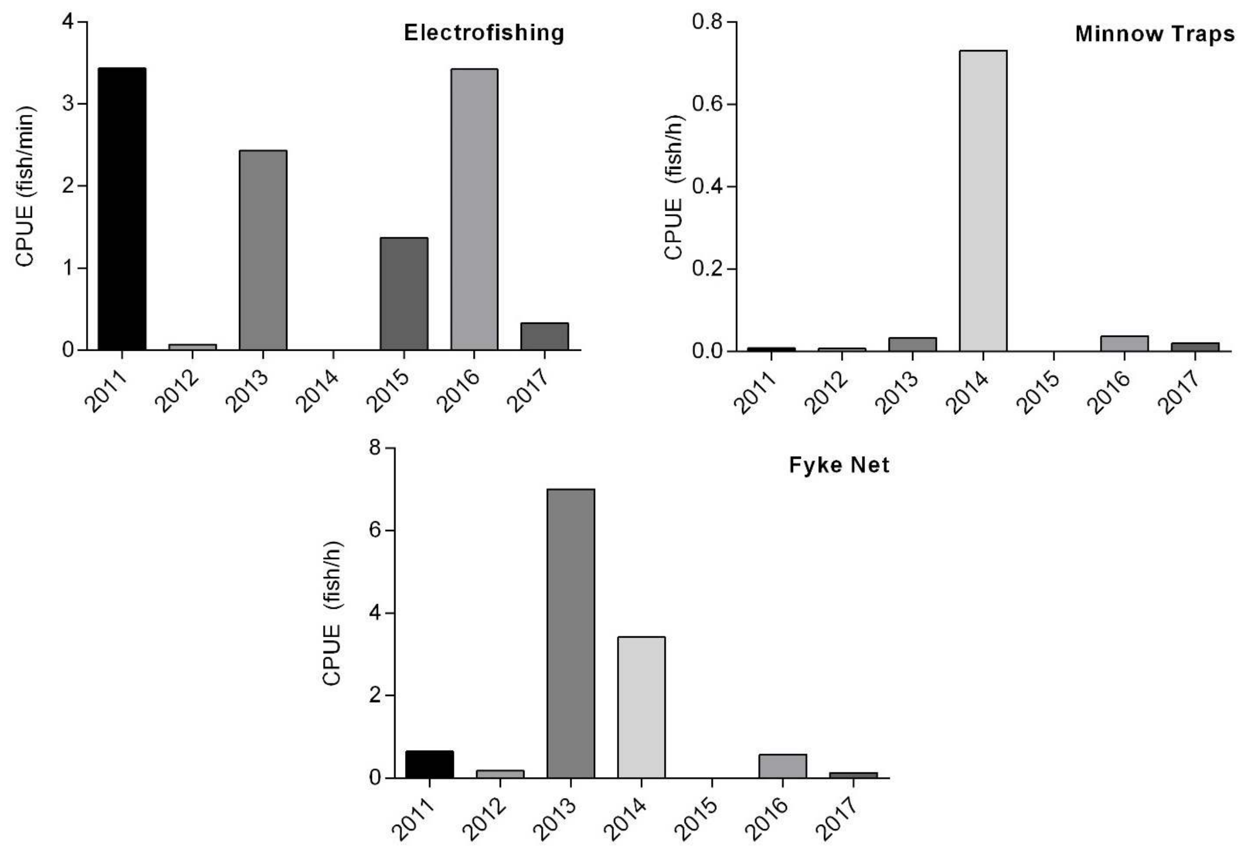

Figure 22. Annual total CPUE for each of the three sampling methods used at the Beaver Pond site. Construction of the project was completed in spring 2014.

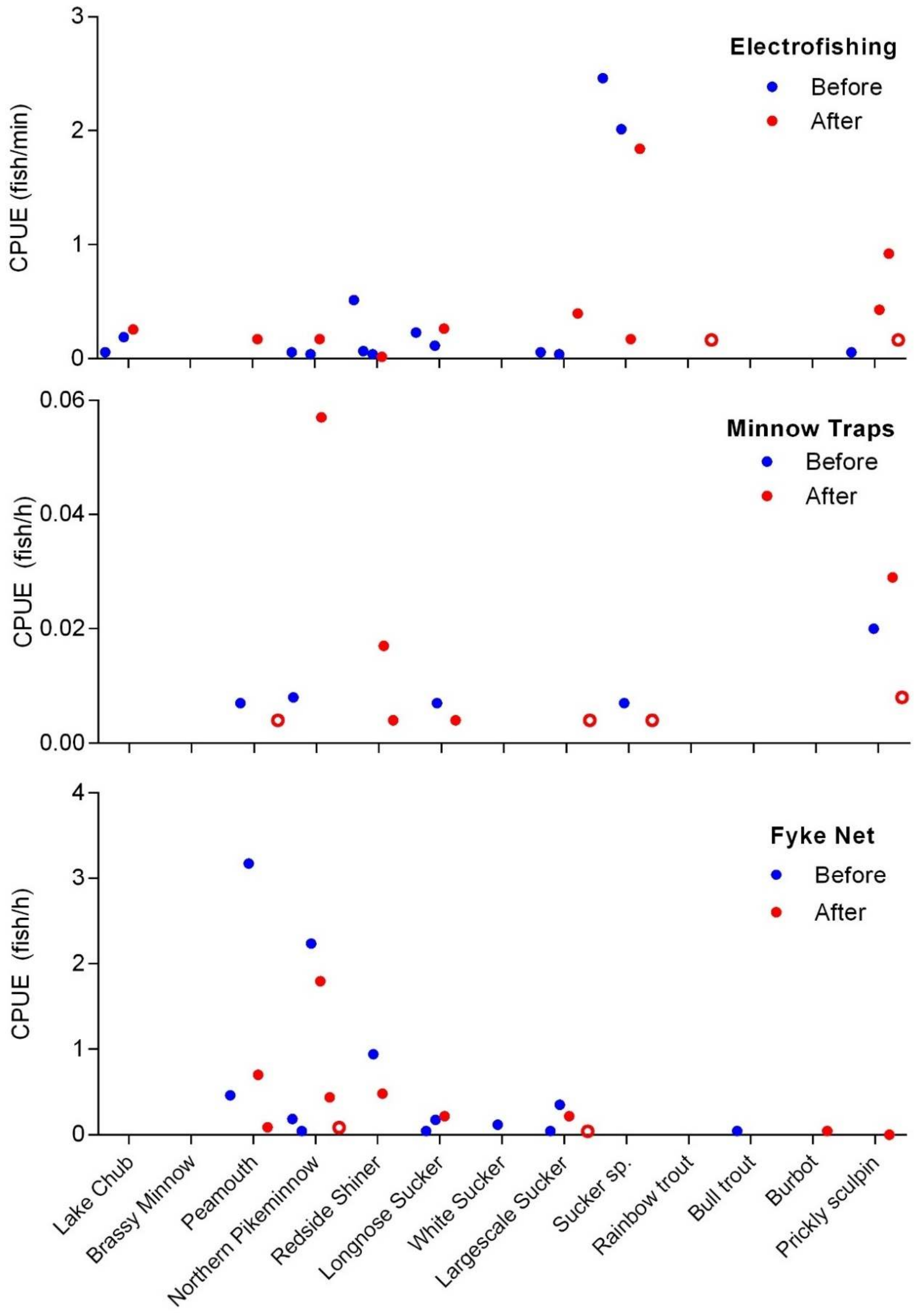

Figure 23. Changes in CPUE by sampling method and species before and after construction of the Beaver Pond project in 2014. Note the different scale and units for CPUE (y-axis) for each method. Open red circles are the 2017 results

4.0 CLOSING

This Work was performed in accordance with BCO 77193 between Hemmera Envirochem Inc. (Hemmera), a wholly owned subsidiary of Ausenco Engineering Canada Inc. (Ausenco), and BC Hydro (Client), dated July 23rd, 2019 (Contract). This Report has been prepared by Hemmera, based on fieldwork conducted by Cooper Beauchesne and Associates Ltd., for sole benefit and use by BC Hydro. In performing this Work, Hemmera has relied in good faith on information provided by Cooper Beauchesne and Associates, and has assumed that the information provided by those individuals is both complete and accurate. This Work was performed to current industry standard practice for similar environmental work, within the relevant jurisdiction and same locale. The findings presented herein should be considered within the context of the scope of work and project terms of reference; further, the findings are time sensitive and are considered valid only at the time the Report was produced. The conclusions and recommendations contained in this Report are based upon the applicable guidelines, regulations, and legislation existing at the time the Report was produced; any changes in the regulatory regime may alter the conclusions and/or recommendations.

We have appreciated the opportunity of working with you on this project and trust that this report is satisfactory to your requirements. Please feel free to contact the undersigned regarding any questions or further information that you may require.

Report prepared by:

Hemmera Envirochem Inc.

FINAL

Ryan Gill, R.P.Bio

Biologist

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6.0 APPENDICES

APPENDIX A

Tables

Appendix 1. Annual waterbird survey species totals.

Species Detected Annually – Waterbird Surveys									
Site	Species	2011	2012	2013	2014	2015	2016	2017	7-year total
Airport Lagoon	American Golden-Plover						1		1
	American Robin				1				1
	American Wigeon	37	41	46	47	65	52	23	311
	Bald Eagle			1					1
	Barrow's Goldeneye	4	1	17	6				28
	Belted Kingfisher			1					1
	Bonaparte's Gull				4	9	5	7	25
	Bufflehead	9	5	23	8	4	6	6	61
	Blue-winged Teal	5	1	19	11	15	8	1	60
	Canada Goose	71	55	34	19	50	26	20	275
	Canvasback		2		1		5	1	9
	Cinnamon Teal	1		1					2
	Common Goldeneye				3				3
	Common Loon		2		3	3	4	1	13
	Common Merganser		10	13		6	4	13	46
	Gadwall					4	9		13
	Greater Scaup				1		1		2
	Greater Yellowlegs		12	3	10	28	2	2	57
	Greater White-fronted Goose	1							1
	Green-winged Teal	6	28	92	28	34	20	4	212
	Hooded Merganser		2		1	1		1	5
	Killdeer		7	8	16	10	22	6	69
	Long-billed Dowitcher		68		8	4	31		111
	Least Sandpiper					2	16		18
	Lesser Scaup	18	6		9	4		2	39
	Lesser Yellowlegs	1	20	8	21	7	19	5	81
	Mallard	14	12	89	97	25	11	20	268

	Northern Pintail	1	15	12	32	26	12		98
	Northern Shoveller	9	16	8	17	10	31	6	97
	Osprey				3	3			6
	Pectoral Sandpiper				3		2		5
	Ring-billed Gull				12	8			20
	Red-breasted Merganser				1				1
	Redhead					2			2
	Ring-necked Duck	41	99	33	35	28	8	4	248
	Red-necked Grebe	7	1						8
	Semipalmated Plover		7	1		1	2	6	17
	Semipalmated Sandpiper		7	5	3		1		16
	Solitary Sandpiper							1	1
	Spotted Sandpiper		4	5	5	7	3	7	31
	Trumpeter Swan				1		2		3
	Unidentified Larus Gull						1		1
	Unidentified Shorebird						4		4
	Unidentified Yellowlegs						1		1
	Wilson's Phalarope				2	3			5
Beaver Pond	Bufflehead							1	1
	Canada Goose	4				4	4	2	14
	Killdeer		1					2	3
	Mallard	2					1		3
	Semipalmated Plover		1						1
	Spotted Sandpiper					6	1	2	9

Appendix 2. Annual Point count species totals.

Species Detected Annually – Point Count Surveys									
Site	Species	2011	2012	2013	2014	2015	2016	2017	7-year total
Airport lagoon	Alder Flycatcher	5	10	2	4	6	3		30
	American Crow	1	3	4	28	9	18	5	68
	American Redstart	17	8	4	12	14	13	10	78
	American Robin	37	28	26	32	18	30	23	194
	Bank Swallow			17					17
	Barn Swallow		1				5	13	19
	Black-capped Chickadee	1	1		5		2	2	11
	Belted Kingfisher			1	3	8	4	3	19
	Brown-headed Cowbird	3	12	1			2	2	20
	Blackpoll Warbler			1	3				4
	Brewer's Blackbird				1				1
	Cassin's Vireo		1						1
	Cedar Waxwing	4	48	2	3				57
	Chipping Sparrow	16	15	10	10	16	11	10	88
	Common Raven	2	6		3	6	16	20	53
	Common Yellowthroat	1	2	2	1	1			7
	Dark-eyed Junco	14	15	11	21	17	19	16	113
	Dusky Flycatcher	2	4			7	8	7	28
	European Starling						1		1
	Golden-crowned Kinglet	3		6				1	10
	Hammond's Flycatcher	13	9	9				2	33
	Hermit Thrush		1			4	1		6
	Least Flycatcher	8	1	13	4	2	2	12	42
	Lincoln's Sparrow	21	10	11	9	17	13	10	91
	Magnolia Warbler	18	2	6		2	2	5	35
	MacGillivray's Warbler	2	2					3	7
	Mountain Bluebird		4	3	5		2		14

	Northern Waterthrush	16	12	14	11	7	14	20	94
	Northern Rough-winged Swallow	2							2
	Northern Rough-winged Swallow			1	4		2	1	8
	Orange-crowned Warbler	13	29	5	23	16	14	13	113
	Olive-sided Flycatcher						1		1
	Pine Siskin	3	72	9					84
	Purple Finch			1					1
	Red-breasted Nuthatch	8	1			4	1	1	15
	Ruby-crowned Kinglet	20	5	8	7	7	5	5	57
	Red-eyed Vireo		1						1
	Rusty Blackbird						1		1
	Ruffed Grouse				3			5	8
	Red-winged Blackbird				1	1			2
	Savannah Sparrow	10	8		15	14	2		49
	Song Sparrow	4	7	9	5	3		5	33
	Swainson's Thrush	19	4	12	14	7	8	22	86
	Tennessee Warbler	23	13	7	14	10	19	22	108
	Townsend's Warbler						1		1
	Tree Swallow	18	39	26	16	38	32	52	221
	Varied Thrush				1			1	2
	Violet-green Swallow	10	4				18		32
	Warbling Vireo	15	6	14	9	5	12	5	66
	White-crowned Sparrow	3					2	2	7
	Western Tanager	1	6	4	1	3	5	1	21
	Western Wood-Pewee	5	1	5			1	4	16
	Wilson's Warbler	3	7	1	10	2	2	7	32
	Winter Wren		1						1
	White-throated Sparrow	9	3	18	3	13	10	14	70
	Yellow-headed Blackbird				1				1

	Yellow-rumped Warbler	7	12	23	13	19	11	14	99
	Yellow Warbler	15	9	9	19	8	5	3	68
Beaver pond	Alder Flycatcher	5	2						7
	American Redstart	9	8	9	4	8	4	3	45
	American Robin	3	3	2	2	2	3	2	17
	Black-capped Chickadee		1						1
	Belted Kingfisher						1		1
	Brown-headed Cowbird	1							1
	Boreal Chickadee	1							1
	Chipping Sparrow	2	5	3	1	2	2	1	16
	Common Raven	1	1	1		1			4
	Dark-eyed Junco		2	8	7	3	2	4	26
	Dusky Flycatcher	3	4	3	5	2	1	2	20
	Golden-crowned Kinglet			1				1	2
	Hammond's Flycatcher		1	3	2				6
	Least Flycatcher					1			1
	Lincoln's Sparrow	1					3	1	5
	Magnolia Warbler					2			2
	Northern Waterthrush	2	1	5	5	2		5	20
	Orange-crowned Warbler	7	12	9	4	4	2	1	39
	Olive-sided Flycatcher		1						1
	Pine Siskin		2					1	3
	Purple Finch			1					1
	Ruby-crowned Kinglet				3	1			4
	Red-eyed Vireo			2					2
	Rusty Blackbird					1			1
	Ruffed Grouse					1	2	4	7
	Song Sparrow						1		1
	Swainson's Thrush	5	3	4	3		1	1	17
	Tennessee Warbler		4	3	4		4		15

	Tree Swallow	3	1			5	2		11
	Varied Thrush	1							1
	Warbling Vireo	8	14	8	2	5	1	7	45
	Western Wood-Pewee			2					2
	Wilson's Warbler	3	2	6	1			2	14
	White-throated Sparrow	1	2	2	2	1	2	3	13
	Yellow-rumped Warbler	5	1	8	4	4	3	4	29
	Yellow Warbler		1		3				4

Appendix 3. Results from amphibian surveys in 2017.

Species Summary – Amphibian Surveys						
Survey Date	Site	Transect Name	Detection Easting	Detection Northing	Species	Number*
2017-05-31	Beaver pond	BP-A-01	479279	6148300	A-ANBO	-
2017-05-31	Beaver pond	BP-A-01	479317	6148255	A-ANBO	-
2017-05-31	Beaver pond	BP-A-01	479389	6148239	A-ANBO	-
2017-05-31	Beaver pond	BP-A-01	479391	6148245	A-LISY	1
2017-05-31	Beaver pond	BP-A-01	479391	6148245	A-PSMA	1
2017-05-31	Beaver pond	BP-A-01	479393	6148213	A-PSMA	3
2017-05-21	Airport lagoon	28	492594	6126812	A-ANBO	1
2017-05-19	Beaver pond	BP-A-01	479277	6148311	A-ANBO	1
2017-05-19	Beaver pond	BP-A-01	479330	6148244	A-ANBO	1
2017-05-19	Beaver pond	BP-A-01	479345	6148235	A-AMMA	1
2017-05-19	Beaver pond	BP-A-01	479389	6148236	A-AMMA	4
2017-05-19	Beaver pond	BP-A-01	479387	6148244	A-ANBO	-
2017-05-19	Beaver pond	BP-A-01	479407	6148254	A-ANBO	15
2017-05-19	Beaver pond	BP-A-01	479407	6148254	A-AMMA	1
2017-05-19	Beaver pond	BP-A-01	479399	6148240	UNKN	1
2017-05-02	Airport lagoon	25	492471	6126952	UNKN	1

*- indicates that the number of individuals was not recorded.

Appendix 4. Fish CPUE[1] by method and species at the Airport Lagoon and Beaver Pond sites for 2011 – 2017 (Years 1-7).

Airport Lagoon

Species summary – fish sampling 2017																
		Species														
Method	**Year**	**Lake Chub**	**Brassy Minnow**	**Peamouth**	**Northern Pikeminnow**	**Redside Shiner**	**Longnose Sucker**	**White Sucker**	**Largescale Sucker**	**Sucker sp.**	**Rainbow Trout**	**Bull Trout**	**Burbot**	**Prickly Sculpin**	**Slimy Sculpin**	**Total**
Electrofish	2011	0.567	0.026							0.670	0.052			0.026		1.340
	2012	0.151	0.025		0.075		0.025		0.025				0.427	0.050		0.780
	2013	1.794	1.623			0.883	0.085			0.028			0.171	0.114		4.699
	2014	1.087	0.053			0.212	0.027			1.061			0.053	0.345		2.837
	2015	1.848	0.784			3.081	0.168	0.028	0.224	0.028	0.028		0.028	0.084		6.303
	2016	2.47	3.718			0.662	0.076		0.025	0.051			0.204	0.458		7.666
	2017	0.444	0.177				0.030			0.030				0.207		0.887
Minnow Trap	2011	0.111	0.005			0.011							0.003	0.003	0.003	0.134
	2012	0.039	0.004		0.002	0.019			0.004				0.009	0.004		0.080
	2013	1.357	4.674		0.017	0.033	0.037		0.012	0.012						6.143
	2014	2.138	2.320		0.017	1.742	0.198	0.150	0.089	0.689	0.002			0.005		7.351
	2015	2.124	0.074		0.029	1.097	0.177	0.069	0.105	0.239						3.913
	2016	0.421	0.085		0.003	2.172	0.090	0.015	0.025					0.018		2.829
	2017	0.282	0.029	0.002		0.557	0.052	0.017	0.015	0.002				0.005		0.963
Fyke Net	2011				0.050		0.025						0.025			0.101

	2012	2.538	0.810	0.015	0.657	1.727	0.734	0.214	0.138				0.107			6.925
	2013	8.796	6.990		0.722	6.301	0.164		0.066							23.039
	2014	25.478	89.545	0.063	1.132	33.291	4.165	5.495	2.365	7.801	0.025					169.351
	2015	56.985	132.457		1.104	83.445	0.087	0.929	1.597	51.191	0.087			0.073		327.955
	2016	0.104	0.026	0.013	0.414	3.222	0.168	0.647	0.375		0.065					5.034
	2017	2.2	5.565	0.116	0.104	2.342	0.324	2.084	1.682	0.013	0.207			0.013		16.016

[1] – Electrofishing CPUE = fish/minute; minnow trap and fyke net CPUE = fish/hour

Beaver Pond

Species summary – fish sampling 2017															
		Species													
Method	**Year**	**Lake Chub**	**Brassy Minnow**	**Peamouth**	**Northern Pikeminnow**	**Redside Shiner**	**Longnose Sucker**	**White Sucker**	**Largescale Sucker**	**Sucker sp.**	**Rainbow Trout**	**Bull trout**	**Burbot**	**Prickly Sculpin**	**Total**
Electrofish	2011	0.057			0.057	0.515	0.229		0.057	2.462				0.057	3.435
	2012					0.067									0.067
	2013	0.190			0.038	0.038	0.114		0.038	2.013					2.430
	2014														
	2015	0.2568		0.1712	0.171	0.171				0.171				0.428	1.369
	2016						0.263		0.395	1.842				0.921	3.421
	2017										0.164			0.164	0.328
Minnow Trap	2011				0.008										0.008
	2012			0.007											0.007
	2013						0.007			0.007				0.020	0.033
	2014				0.057	0.017									0.073
	2015														-
	2016					0.004	0.004							0.029	0.037
	2017			0.004					0.004	0.004				0.008	0.02
Fyke Net	2011			0.460	0.184										0.644
	2012				0.044		0.044		0.044			0.044			0.176

	2013			3.176	2.235	0.941	0.176	0.118	0.353						7
	2014			0.701	1.796	0.482	0.219		0.219						3.417
	2105														
	2016			0.088	0.438								0.044		0.569
	2017				0.085				0.043						0.128

Appendix 5. Water quality data collected during fish sampling at the Airport Lagoon and Beaver Pond sites in 2017.

Water quality summary							
Site	**Date**	**Location**	**Temperature (°C)**	**Conductivity (µS/cm)**	**pH**	**Dissolved Oxygen (mg/L)**	**Secchi Depth (m)**
Airport Lagoon	May 17	stream (EF4)	9.6	134.1	7.55	11.04	n/a
	May 18	surface (upper end)	13.5	143.4	6.6	8.9	1.3
		bottom (upper end	11.9	140.5	7.43	8.54	
		surface (log boom)	12.6	138.0	7.82	8.69	1.1
		mid-water (2 m, log boom)	11.8	135.5	7.73	7.83	
	July 26	surface (upper pond)	19.7	126.9	7.83	7.48	2.63
		bottom (upper pond)	17.3	132.2	7.07	6.53	
		surface (log boom)	18.5	117.9	7.89	7.57	2.7
		bottom (log boom)	17.2	97.7	7.62	6.03	
Beaver Pond	May 19	upper stream	15.5	49.0	6.21	7.89	n/a
		surface (at berm)	15.0	60.1	7.02	8.13	-
		bottom (at berm)	14.1	59.6	6.97	9.97	
	July 27	surface (inside berm)	16.2	94.3	7.67	7.38	-
		bottom	15.0	92.3	6.99	6.67	

		(inside berm)					
		surface (log boom)	16.4	94.4	7.65	7.5	1.53
		bottom (log boom)	15.7	94.0	7.68	7.75	