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Nalcor Energy Lower Churchill Project – Environmental Effects Monitoring Program - Avifauna

Avifauna Environmental Effects Monitoring Program

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Final Report

May 19, 2017

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Overview of the Avifauna EEMP

As part of monitoring requirements and commitments made in the Environmental Impact Statement (EIS) for the Lower Churchill Project (LCP) (Nalcor 2009a, 2009b), a series of Environmental Effects Monitoring Programs (EEMPs) were designed to monitor potential environmental effects of Project construction on wildlife. The Avifauna EEMP represents one component in this series.

The Avifauna EEMP was carried out over the three-year period from 2014-2016, inclusive, and focused on avifauna species richness as well as targeted Common Nighthawk and Surf Scoter/*ashkui* surveys during the breeding period. This report summarizes a series of field, interim, and annual reports associated with the Avifauna EEMP. This report represents the final report of the Avifauna EEMP.

Avifauna Community Responses to a Large-Scale Hydroelectric Generation Project in the Northern Boreal Forest

Abstract

Renewable energy developments are becoming increasingly common and can have direct and indirect effects on avifauna communities. An Environmental Effects Monitoring Program was established during the construction phase of a large-scale hydroelectric development in the Churchill River valley in Labrador, Canada. The monitoring program had four objectives: (1) Quantify the habitat loss within the reservoir impoundment and associated Right-of-Way (RoW); (2) Collect additional information on the distribution and habitat associations of species at risk; (3) Monitor Surf Scoter (*Melanitta perspicillata*) use of *ashkui*; and (4) Assess Project effects on species richness of forest songbirds. Habitat loss was quantified using Ecological Land Classification within the Project footprint. Distribution and habitat associations were described for species at risk observations during targeted and points-count surveys. Point count surveys were conducted inside and outside of the Project footprint within the Churchill River valley. Species richness and ecological factors were compared to baseline studies using generalized linear mixed models and AIC model inference. There was 103 km^2 of habitat loss within the reservoir and 24 km^2 along the RoW. Common Nighthawk (*Chordeiles minor*), Olive-sided Flycatcher (*Contopus cooperi*) and Rusty Blackbird (*Euphagus carolinus*) were observed in preferred habitats. Surf Scoter used *ashkui* during spring staging. Habitat, region, and fire disturbance had a significant effect on species richness of forest songbirds. The Project did not have a significant effect on species richness of forest songbirds. The forest songbirds of the Churchill River valley showed resilience to this anthropogenic disturbance, as has been observed in other boreal forests.

1.0 INTRODUCTION

Understanding how animals respond to environmental change is an important component of any program designed to monitor potential environmental effects associated with renewable energy infrastructure development. Effects of anthropogenic disturbances can influence avifauna populations (Brawn et al. 2001). Anthropogenic disturbances may alter avifauna behaviour, species richness, or abundance, through direct effects, such as, habitat loss (Zhang et al. 2013, Machtans 2006, Brawn et al. 2001, Drapeau et al. 2000) and indirect effects of noise (Bayne et al. 2008), vehicular disturbances (Jack et al. 2015), and increased predation (DeGregorio et al. 2014, Thompson et al. 2008).

An Environmental Effects Monitoring Program (EEMP) was initiated to monitor potential effects from the construction of a large-scale hydroelectric generation project on wildlife in the lower Churchill River valley. Avifauna were identified as a Valued Ecosystem Component (VEC) in the Environmental Assessment for the Lower Churchill Project (the Project) (Nalcor 2009a, 2009b). In 2006 and 2007, a series of three baseline studies related to avifauna were carried out in support of the Project (Minaskuat Inc. 2008a, LGL Limited 2008, Hatch Ltd. 2007). These surveys confirmed a variety of songbird, waterfowl and raptor species in the Project study area, including five species listed under the federal *Species at Risk Act* (*SARA*) (Government of Canada 2002) and/or the *Newfoundland and Labrador Endangered Species Act* (*NLESA*) (Government of Newfoundland and Labrador 2004): Harlequin Duck (*Histrionicus histrionicus)*, Common Nighthawk (*Chordeiles minor*), Olive-sided Flycatcher (*Contopus cooperi*), Gray-cheeked Thrush (*Catharus minimus*), and Rusty Blackbird (*Euphagus carolinus*). Monitoring and follow-up programs identified in the Project Environmental Impact Statement (EIS) (Nalcor 2009a, 2009b) and recommended by the Joint Review Panel (JRP 2011) to address concerns related to avifauna included:

1. Monitoring ashkui formation in the Project area
2. Monitoring direct and indirect impacts on waterfowl
3. Developing a detailed mitigation and monitoring plan for all listed species (e.g., point count surveys)

1.1 Avifauna EEMP Study Objectives

The Avifauna EEMP had the following four study objectives:

1. Quantify the amount of habitat altered and/or lost due to Project activities during the clearing of vegetation associated with the reservoir and the right-of-way (RoW) and relate the habitat loss to habitat quality for avifauna, species at risk, and species of interest (e.g., wetlands sparrows) in the study area
2. Collect additional information on the distribution and habitat associations of species at risk including Common Nighthawk, Olive-sided Flycatcher, Gray-cheeked Thrush, and Rusty Blackbird
3. Monitor Surf Scoter (*Melanitta perspicillata*) use of *ashkui* from Muskrat Falls up to and including Winokapau Lake on the lower Churchill River
4. Assess the effect of the Project on species richness of forest songbirds during the construction phase

Ice conditions/*ashkui* formation and waterfowl (e.g., Surf Scoter) use of *ashkui* in the lower Churchill River valley were monitored during the first year of the Avifauna EEMP in 2014. Monitoring of forest songbirds and listed species was also initiated in 2014, with annual data collection until 2016. This final report addresses the four study objectives by providing the following:

1. Quantification of habitat loss/alteration within the Project footprint and in relation to avifauna and the identified key indicator species
2. Description of observations of distribution and habitat associations for species at risk
3. Summary of Surf Scoter use of *ashkui*
4. Assessment of Project-related effects on forest songbird species richness based on point count data collected from 2014 to 2016 compared to baselines studies from 2006-2007

2.0 STUDY AREA AND METHODS

2.1 Study Area

The study area was situated in central Labrador, between Happy Valley-Goose Bay (N53.29844, W60.35586) and Churchill Falls (N53.53084, W64.00772), Labrador (Figure 2-1). The area is largely characterized by cool and humid summers, and cold winters. Mean annual temperatures range from -13C in the winter to 8.5C in the summer, with a mean annual precipitation ranges from 800 mm to 1,000 mm (Ecological Stratification Working Group 1995). The area is described as an irregular lowland dissected by river valleys, with elevations ranging from near sea level to 500 m above sea level (Ecological Stratification Working Group 1995). Black spruce (*Picea mariana*) is ubiquitous throughout the region, and typically dominates forested upland areas and lichen woodlands (Protected Areas Association of Newfoundland and Labrador 2008). Balsam fir (*Abies balsamea*), birch (*Betula* sp.), and aspen (*Populus* sp.) dominate along richer slopes (Protected Areas Association of Newfoundland and Labrador 2008). Extensive fens and bogs occur in upland and coastal areas.

As the ecological conditions vary with elevation and proximity to the river valleys, the study area was stratified into four regions representative of ecological conditions: (1) Below Muskrat Falls; (2) Above Muskrat Falls; (3) Above Gull Island; and (4) Above Gull Island + (Figure 2-1). The Project footprint for analyses in the Avifauna EEMP had both the reservoir and the interconnecting RoW (HVAC) between Happy Valley-Goose Bay and Churchill Falls (Figure 2-1). The reservoir covers an area of 103 km^2. The RoW has a linear distance of 241 km, with an area of 24 km^2. The Project footprint disturbance to be analyzed during the Avifauna EEMP is the vegetation clearing during the construction phase. As the potential disturbance from the HVDC RoW was similar to the HVAC RoW, only one was included in the Project Footprint in analyses.

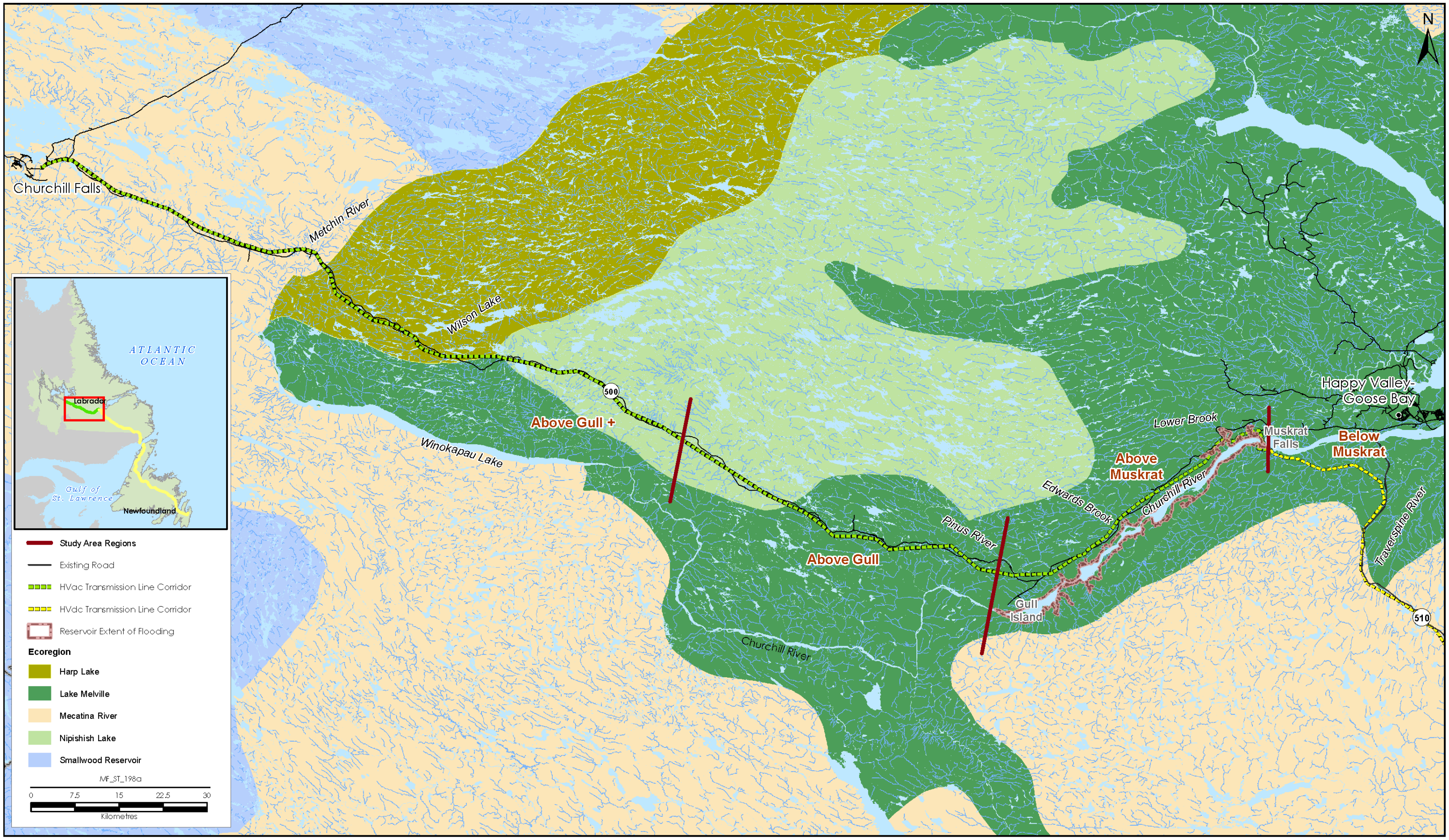

Figure 2-1 Avifauna Environmental Effects Monitoring Program Study Area

2.2 Habitat Loss

Habitat loss was quantified for the Project footprint, which was identified as the zone of potential direct effect from clearing the reservoir and RoW in the Project Area Ecological Land Classification (ELC), during baseline studies (Minaskuat Inc. 2008b). Habitat loss within the reservoir was limited to area that was land based as the timing of study coincided with the construction phase, which did not yet see significant flooding associated with the impoundment. A description of the habitat types (i.e. Ecotypes) identified in the ELC are found in Appendix A. Habitat loss was calculated separately for the reservoir and the RoW, as two detailed ELCs of varying scales were used. The ELC of the AC line between Muskrat Falls and Churchill Falls was a 1.6 km wide corridor at a scale of 1: 50,000. The ELC that was applied to the reservoir measured 2 km from water's edge on both north and south sides of the Churchill River at a scale of 1: 20,000. Habitat loss was determined in each ELC by calculating the percent composition of each habitat type for the ELC in the RoW and the reservoir. Once habitat loss was determined in the reservoir and along the RoW, it was tabulated for the primary habitat of the key indicator species identified in the Avifauna EEMP. The key indicator species are: Canada Goose (*Branta canadensis*); Harlequin Duck; Surf Scoter; Ruffed Grouse (*Bonasa umbellus*); Common Nighthawk; Olive-sided Flycatcher; Gray-cheeked Thrush; Savannah Sparrow (*Passerculus sandwichensis*); Song Sparrow (*Melospiza melodia*); Lincoln's Sparrow (*Melospiza lincolnii*); Swamp Sparrow (*Melospiza georgiana*); and Rusty Blackbird.

2.3 Field Surveys

2.3.1 Species at Risk

Common Nighthawk, Olive-sided Flycatcher, Gray-cheeked Thrush, and Rusty Blackbird were selected as targeted species at risk for the Avifauna EEMP based on the EIS (Nalcor 2009a, 2009b). These targeted species at risk are listed under the federal *SARA* (Government of Canada 2002) and/or *NLESA* (Government of Newfoundland and Labrador 2004). When suitable habitat for the four targeted listed species was encountered, call playback of the species was broadcasted for a two-minute call playback period which was followed by a one-minute listening period. The call playback for the targeted listed species followed the Black-capped Chickadee (*Poecile atricapillus*) playback-listening period) during point count surveys. Incidental observations of any species at risk were documented.

2.3.2 Common Nighthawk Targeted Surveys

Common Nighthawk point count surveys were carried out between Happy Valley-Goose Bay and Gull Island, as well as south along Route 510 from the causeway to the Traverspine River, focusing on breeding and foraging habitats (Figure 2-2).

Surveys followed Stantec's Standard Operating Protocols (SOPs) for Common Nighthawk, as well as, other species of the Nightjar family (Stantec Consulting Ltd. 2010), based upon recommendations from the British Columbia Resource Inventory Committee (BC RIC 1998) and the United States Nightjar Survey Network (US NSN 2012).

Surveys were conducted during mid- to late June, when individuals are more likely to call (BC RIC 1998). Surveys began at sunset and continued until the end of the dusk crepuscular period, or nautical twilight. The nautical twilight period was identified using a sunrise/sunset calculator from the National Research Council of Canada (Government of Canada 2016). Surveys were conducted under favourable weather conditions with temperature above 7°C, winds below 25 km/h on the Beaufort scale, and with either no precipitation to light, intermittent drizzle.

Two-person field teams conducted point count surveys, with each station spaced a minimum of 500 m apart (BC RIC 1998). Upon arrival at a survey location, all light and noise sources were turned off, and observers waited one-minute to allow potential effects from such disturbances to subside. During this time, UTM coordinates, weather, moon phase, noise, and habitat information were recorded. Moon phase was determined before heading into the field using the following website: http://www.timeanddate.com/moon/phases/canada/happy-valley-goose-bay. Any species detected during this period were recorded as incidental observations. The one-minute waiting period was following by a six-minute listening period. During the six-minute listening period, any Common Nighthawk observed or heard were recorded. For each Common Nighthawk observation, the number of individuals, visual or auditory observation, sex, habitat, approximate distance, and angle from the observation point was recorded. A two-minute Common Nighthawk call playback followed the six-minute listening period. A final two-minute listening period (making ten minutes in total) followed the call playback where any Common Nighthawk observations were recorded.

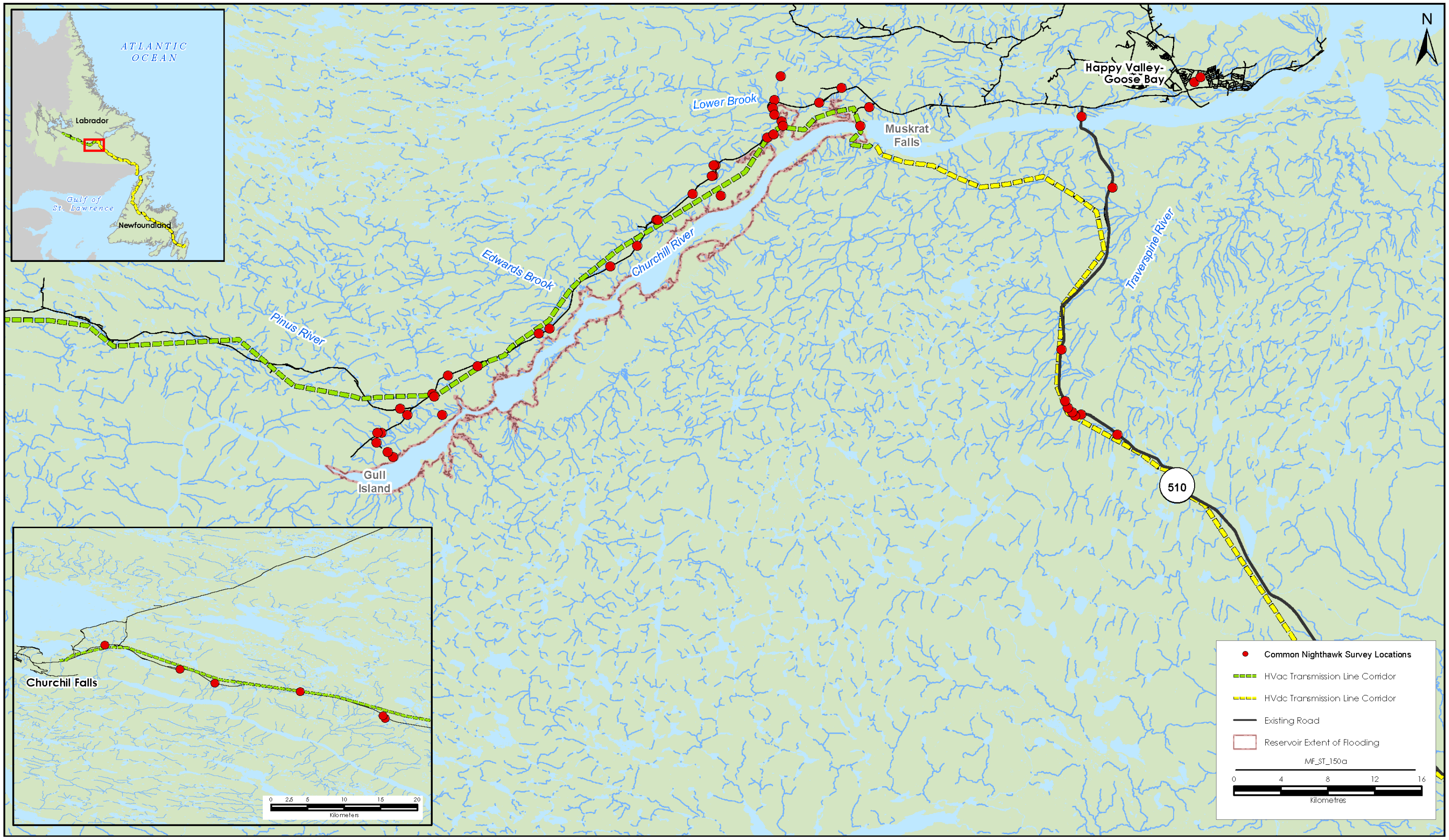

Figure 2-2 Common Nighthawk Targeted Surveys Locations during the Avifauna EEMP 2014-2016. The inset shows survey locations near Churchill Falls.

2.3.3 Surf Scoter and *Ashkui* Surveys

Aerial surveys for Surf Scoter and *ashkui* were conducted over a three-day period between May 30-June 1, 2014 under suitable weather conditions (Stassinu Stantec 2014a). Aerial surveys were conducted from a Bell 206L helicopter flown at 50-75 m above ground level at approximate speeds of 50-100 km/h. The helicopter was equipped with rear bubble windows which enhanced visibility. The survey crew consisted of a front seat observer and navigator, with two rear observers. The pilot also assisted with observations.

The survey area (Figure 2-3) was based on previous baseline surveys conducted in the Churchill River watershed (Minaskuat Inc. 2008a, LGL Limited 2008). Survey routes typically followed along the center of the Churchill River, although in areas where Surf Scoter had been previously identified, the helicopter would make a second pass. Lakes, including Minipi, Anne Marie, Dominion, and Wilson, as well as, small waterbodies within the Churchill River watershed were surveyed to assess whether Surf Scoter had dispersed to breeding areas. Information on ice conditions and locations of *ashkui* along the Churchill River and nearby lakes were recorded.

Aerial survey results were then used to conduct ground cohort behaviour observations of Surf Scoter, where a suitable helicopter landing area and observation location could be identified. The two largest flocks of Surf Scoter were selected for behaviour observations. Observations were made from an elevated position along the river bank with the aid of binoculars, at distances ranging from 200-300 m (Churchill Falls site) to 500-1400 m (Muskrat Falls site). These distances were believed to be sufficient as to not have an impact on Surf Scoter behaviour.

Cohort behaviour observations of Surf Scoter were primarily focused on individual females; however, if factors such as distance, wind, or sun glare prevented observations of an individual, flocks were monitored. Flocked birds tended to act in unison, and the Study Team could only assess diving (i.e., foraging) behaviour. Observations were categorized by recognized behaviours into one of ten categories (Bergen et al. 1989; Alexander and Hair 1979) (Table 2-1). Time activity budgets were created based on recognized behaviour observations of female Surf Scoter at both locations. The time spent diving was calculated for sites where only flocks were observed. Other behaviours of flocked birds were not quantified due to the difficulty of assessing behaviours as the birds tended to act in unison. Regardless of whether an individual or flock was monitored, the total number and sex ratios of Surf Scoter at both sites were recorded. Ground survey data was used to estimate sex ratios to increase accuracy as Surf Scoters tend to dive upon the approach of a helicopter.

Table 2.1 Categories of Recognized Behaviours during Surf Scoter Cohort Surveys

Behaviour	Description
Courtship	Head extend frontward or upward, retract and pump; head nod and bill to breast, lateral to and fro of head. Parties of males possibly competing for female.
Agonism	Aggression to neighboring bird
Alert	Head held upright; bird watching and listening for disturbance or threats
Comfort	Splash bathe, preen and wing flap
Dive	-
Pause	Interval between feeding dives
Surface feed or upend	-
Fly	-
Rest	Not moving; in one spot but not alert
Swim	-
Sources: Bergen et al. 1989; Alexander and Hair 1979	

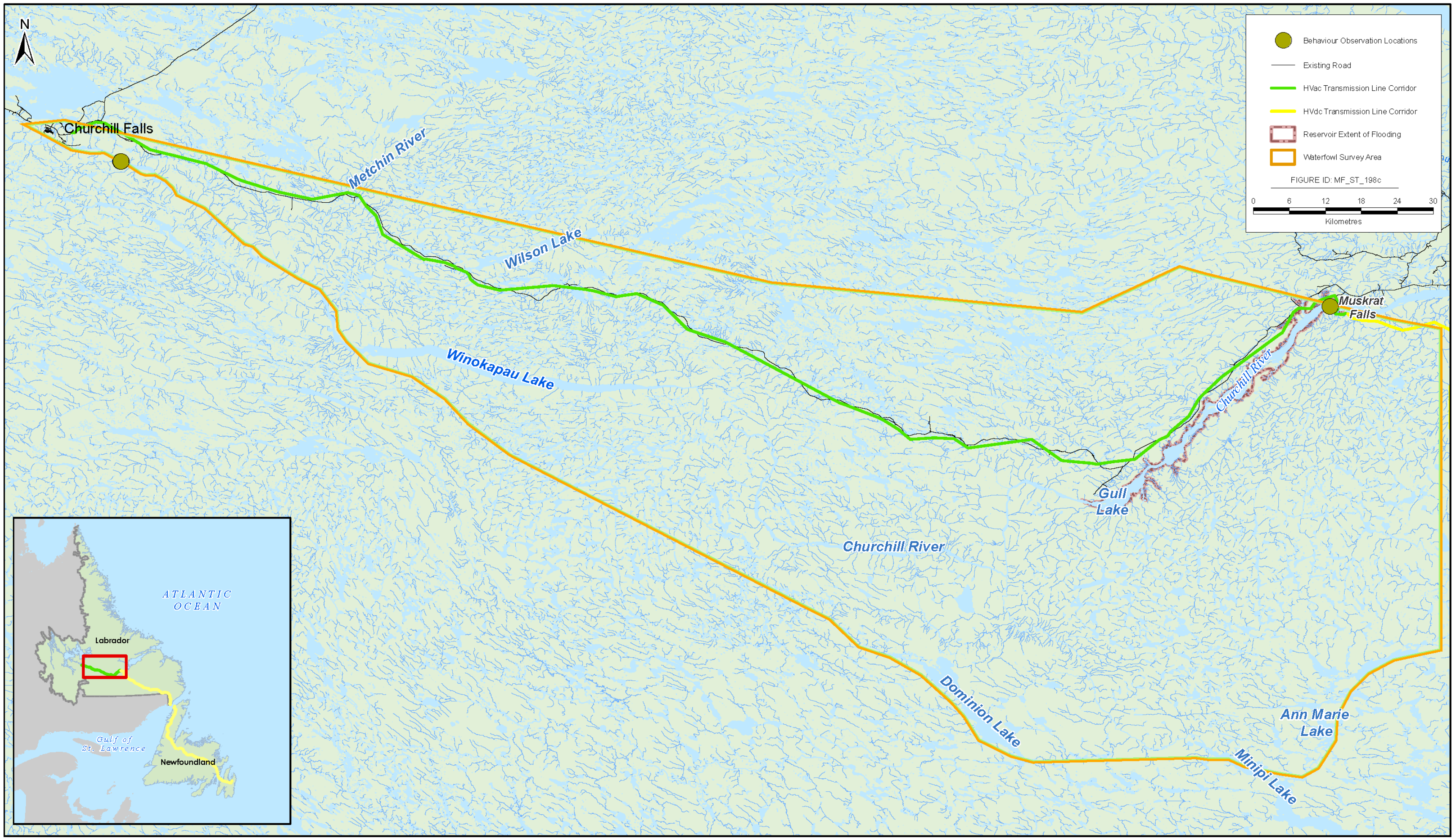

Figure 2-3 Surf Scoter and *Ashkui* Survey Area during the Avifauna EEMP 2014

2.3.4 Forest Songbird Point Counts

The forest songbird point count study area was broken in four sections, based on Project and ecological features: Below Muskrat Falls, Between Muskrat Falls and Gull Island, Above Gull Island, and Above Gull Island + (Figure 2-4a-d). Within these sections, point count locations were previously selected during baseline investigations using areas representative of the habitat types in the larger study area. A total of 346 point count locations were surveyed between 2014-2016.

Survey protocols were designed to follow the Newfoundland and Labrador Boreal Bird Monitoring Protocol Initiative SOP#3 (NLDOMAE 2012). The surveys began no earlier than 30 minutes before sunrise and ended approximately 09h30 local time. Surveys were conducted under suitable weather conditions including: temperatures above freezing, winds less than 25 km/h, little to no precipitation, and visibility of more than 50 m.

Two 2-person field teams conducted the point count surveys, with point count stations spaced at 300 m intervals along a transect. At each point count station, the team recorded on prepared datasheets: date, GPS location, weather conditions, habitat information, and time of survey. (See template in Appendix B).

Surveys consisted of a five-minute listening period followed by a two-minute call playback. All birds heard or observed within the first five minutes were recorded based on the following distance categories: 0-25 m, 25-50 m, 50-100 m, and >100 m. After the five-minute listening period, a Black-capped Chickadee (*Poecile atricapillus*) mobbing call was broadcasted for two minutes using a FoxPro game caller. The broadcast of a black-capped Chickadee mobbing call is standard protocol as per the provincial SOP#3 to elicit calls from birds in the vicinity to account for birds that may not have been vocalizing during point count surveys. Any new species not heard previously during the point count were recorded in a one-minute listening period after the broadcast, including an indication of whether any birds responded to the mobbing call. Incidental observations of birds and other wildlife were recorded during transits between point count stations, but not included in any analyses. As a standardly applied approach, birds and other wildlife species heard or observed during transit between point count stations were recorded as incidental observations to garner further insights into the ecology of the area.

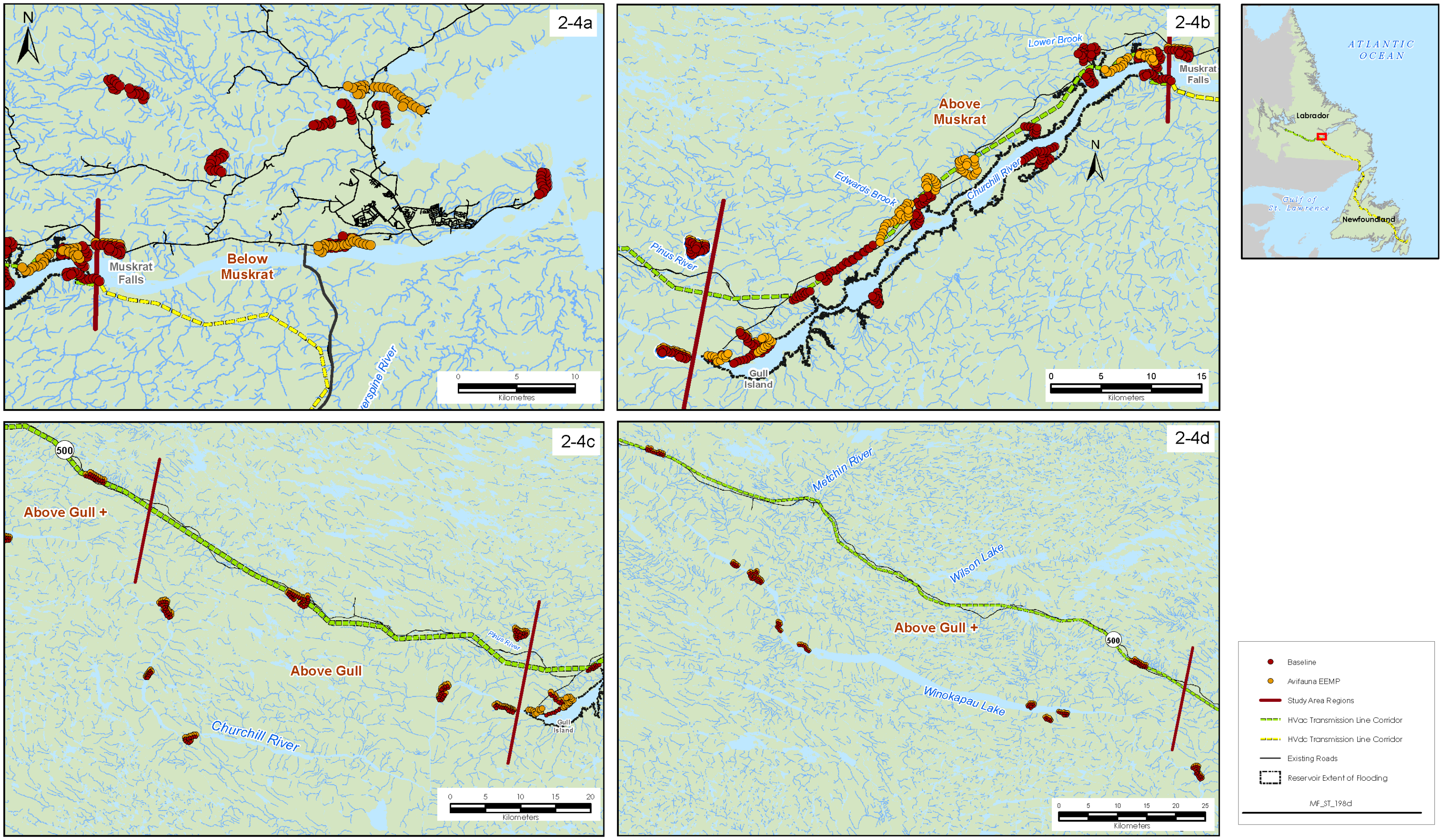

Figure 2-4 Point Count Survey Locations during the Avifauna EEMP (2014-2016) and Baseline Studies (2006-2007)

2.4 Species Richness

2.4.1 Calculating Species Richness

Species richness is defined as the number of species observed in an area. Species richness of breeding avifauna (i.e., passerines and woodpeckers) was determined from point count surveys within habitats of the study area. Only species targeted by point count surveys (i.e., passerines and woodpeckers) were included in the species richness count (Appendix D).

A power analysis was run on baseline and 2014 point count survey data to determine the sample size or number of point counts required to detect an effect of a 25% change in species richness, with a statistical power of 80% and a type I error of 0.05. A generalized linear mixed model (GLMM) with a Poisson distribution was run, with transect identified as a random effect, to account for the point counts nested along a transects using the package 'lme4' in R (Bates et al. 2015). The model included the covoariates of construction year in relation to construction initiation, habitat type, region, minimum distance to watercourse, and the random effect in relation to species richness. The covariates of distance to transmission line and distance to reservoir were confounded with region (i.e., farthest region had largest distance) based on interactions identified via scatterplots and were removed from the model. The data did not show significant overdispersion (i.e., overdispersion is when there is greater variability than predicted in the data resulting in high uncertainty in covariate estimates). The values from baseline studies were used for the covariates were used in the GLMM to run ten simulations of 25, 50, and 100 point counts using the package 'COUNT' in R (Hilbe 2016). The power analysis on baseline data suggested that 50 point count samples per year may be sufficient to detect a 25% change in species richness. A conservative approach was applied to study design and a minimum of 100 point count samples were conducted per year to maximize survey efficiency quantity of data collected. A conservative approach was applied to study design to maximize both survey efficiency and quantity of data collected, therefore a minimum of 100 point count samples were conducted per year to accommodate for any variance that may appear in data during construction and post-construction period. Point counts totaled 108 in 2014, 121 in 2015, and 117 in 2016.

Species richness was calculated per point count including 522 point counts during baseline surveys and 346 point count surveys during the construction period 2014-2016. Habitat types with a minimum of three point count stations were included when calculating species richness (Stantec Consulting Ltd. 2013). Species richness was based on the total of number of species observed during the five-minute listening period, and only for those species recorded <100 m from the observer. Species and species groups omitted from the analysis and justification are as follows (Stantec Consulting Ltd. 2013):

- Waterfowl and waterbirds – their primary habitats are not forests
- Raptors – their territories exceeded point counts protocols
- Species that rarely vocalize and remain often undetected even if present – e.g., grouse and nightjars

- Early nesters as described by Environment Canada (Government of Canada 2014) as they may not be breeding during the timing of point counts – e.g., Gray Jay (Perisoreus canadensis), American Crow (Corvus brachyrhynchos), Common Raven (Corvus corax), White-winged Crossbill (Loxia leucoptera), and Pine Siskin (Spinus pinus)
- Colonial species (all Swallows, except Tree Swallow) – can result in error due to density when extrapolated to larger study area.

General trends in species richness per habitats during baseline and EEMP studies were portrayed in bar graphs and boxplots in R (R Core Team 2016). Bar graphs were used to visually compare average species richness per habitat during baseline and EEMP studies. Boxplots were used to visualize the distribution of the observed species richness. The distribution is based on minimum and maximum species richness described by the "whiskers" below and above the quartiles as well as the median. The median represents were 50% of the species richness values were located above and below. The 1st quartile was 25 % of the lower species richness values. The 3rd quartile was 75 % of the lower species richness values. GLMM in the following section was used to determined statistical significance.

2.4.2 Generalized Linear Mixed Models

A GLMM framework was applied to account for the lack of independence based on the hierarchical structure of point count nested within transects of the study design (Bolker et al. 2009, Zuur et al. 2009). GLMM modelled the relationship between species richness (i.e., response variable) to several Project and environmental covariates (i.e., explanatory variables). The relationship was explained during modelling by parameter estimates based on regression coefficients (slopes) for each covariate. The parameter estimates allowed for interpretation of the strength of the relationship (i.e., larger values for stronger relationships) and whether it is positive (covariate estimate increases with an increase species richness) or negative (covariate estimate decreases with a decrease species richness). Statistical significance was determined for each covariate based on p-values (≤ 0.05 for significance) and confidence intervals (intervals do not bound zero). As species richness was count data, models were fitted to generalized linear mixed models with Poisson error structure using a log-link using the package 'lme4' in R (Bates et al. 2015). The covariates included in the models were: year (categorical); region (categorical); habitat (categorical); Project footprint (categorical); and fire (categorical). Year is defined as either baseline studies (2006-2007) or Project construction period (2014-2016). Region refers to the stratification of the study area into the following four regions representing the variation in environmental conditions: Below Muskrat, Above Muskrat, Above Gull, and Above Gull +, (Figure 2-4). Habitat was classified using Earth Observation for Sustainable Development (EOSD) data at a scale of 1: 250,000 and resolution of 25 m (Government of Canada 2000). A detailed habitat description classification of EOSD data is provided in Appendix C. Habitat composition was described within 100 m buffers around point counts locations to align with species richness measured at that same distance. The targeted 75% habitat dominance was rarely reached due to the large heterogeneity within the landscape configuration. The following three steps were implemented to reach 75% habitat composition: (1) one habitat composed 75%; (2) two habitats composed 75% and were listed in decreasing dominance; and (3) if three or more habitats were required for 75% dominance, it was considered edge habitat and labelled with the habitat of highest composition followed by a "+" sign. Once Habitat composition was determined, it was then grouped into five major habitat classes groups: (1) Coniferous; (2) Edge Habitats; (3) Hardwood Edge, (4) Mixedwood, and (5) Open Habitat (Table 2.2). The Project footprint was used to identify whether point counts were inside or outside of the Project footprint of the reservoir or the AC Line. Fire was added as a covariate classified as pre-fire, 1-year post-fire, and 2-year post-fire. This covariate was added to account potential influence from a fire that had occurred in July of 2014 within the study area near Gull Island during the Avifauna EEMP. The covariates represent different scales. Habitat is at a local-scale, where fire and region are a larger landscape scale of the Churchill River Watershed.

Table 2.2 Habitat Based on Grouping of EOSD Habitat Classes

Habitat	Definition	EOSD Habitat Classes Grouping
Coniferous	Coniferous Dense was in the habitat composition	Coniferous Dense Coniferous Dense/Coniferous Open Coniferous Dense/Coniferous Sparse Coniferous Open/Coniferous Dense Coniferous Sparse/Coniferous Dense
Edge Habitat	3 or more habitat classes were required for 75% dominance	Coniferous Dense+ Coniferous Sparse+ Coniferous Open+ Bryoids+ Exposed Land+ Shrub Low+ Wetland-Shrub+
Hardwood Edge	Broadleaf dense was in dominant in habitat composition	Broadleaf Dense Broadleaf Dense/Shrub Low
Mixedwood	Broadleaf dense was in habitat composition with coniferous habitats	Broadleaf Dense/Coniferous Sparse Coniferous Sparse/Broadleaf Dense
Open Habitat	Coniferous open, coniferous sparse and/or treeless habitats	Bryoids Bryoids/Shrub Low Coniferous Open Coniferous Open/Coniferous Sparse Coniferous Sparse/Coniferous Open Coniferous Sparse/Shrub Low Exposed Land Exposed Land/Bryoids Shrub Low/Bryoids Shrub Low/Coniferous Sparse

Covariates were checked for collinearity using scatterplots and a correlation matrix with the package 'polycor' in R (Fox 2016). The species richness data frequency distribution was plotted using Poisson distribution and compared to a plotted expected frequency distribution of a predicted Poisson distribution. The observed distribution for species richness followed the expected distribution (Figure 2-5). A set of candidate models were developed *a priori* on ecological basis and compared using Akaike's Information Criteria (AIC) (Burnham and Anderson 2002). Models with a $\Delta AIC_i < 2$ and the highest Akaike weight (w_i) were considered the best approximating models in explaining the observed variance in the data. The model with the smallest Δ_{AIC} was considered the overall best approximating model explaining the variance observed in the data. The Akaike weights (w_i) of the parameters were summed across all best approximating models to determine the covariates with the most influence of species richness. The best approximating model was checked for overdispersion (i.e., overdispersion is when there is greater variability than predicted in the data resulting in high uncertainty in covariate estimates). Model interpretation was based on estimates, standard errors, p-values (≤ 0.05 for significance), and confidence intervals of the best approximating model.

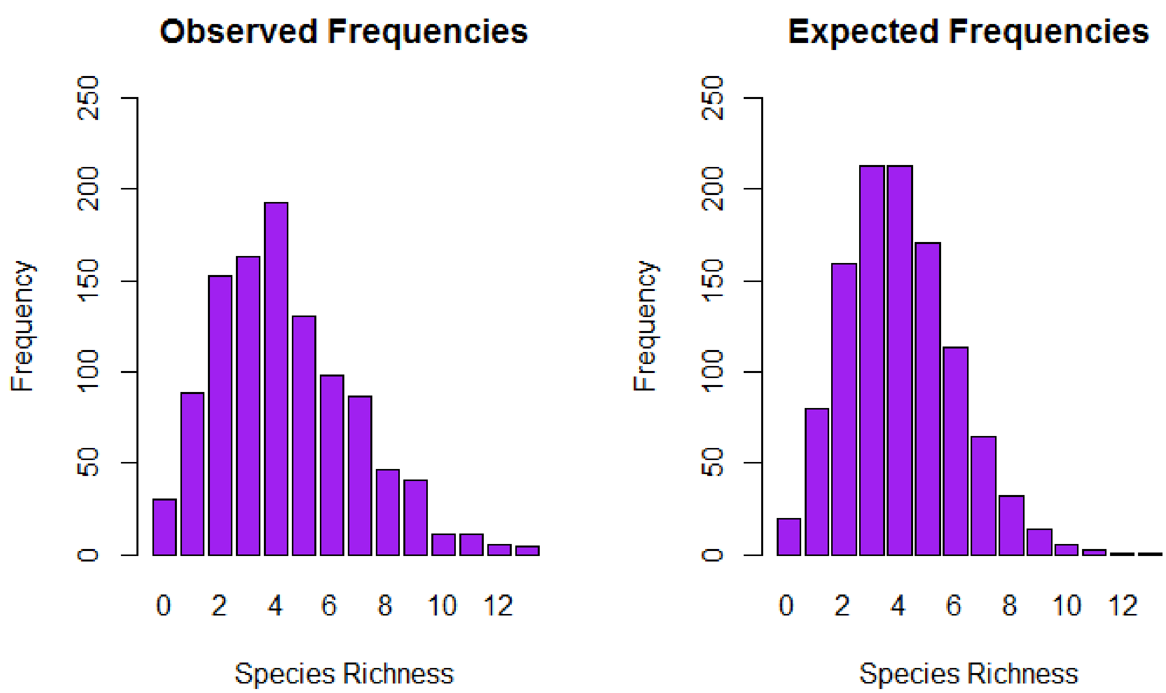

Figure 2-5 Observed Species Richness with a Poisson Distribution to an Expected Poisson Distribution

3.0 RESULTS

3.1 Habitat Loss

The highest habitat loss was black spruce feathermoss followed by fir-white spruce forest, mixedwood forest, gravel bar, and riparian thicket along the Churchill River within the reservoir (Figure 3-1).

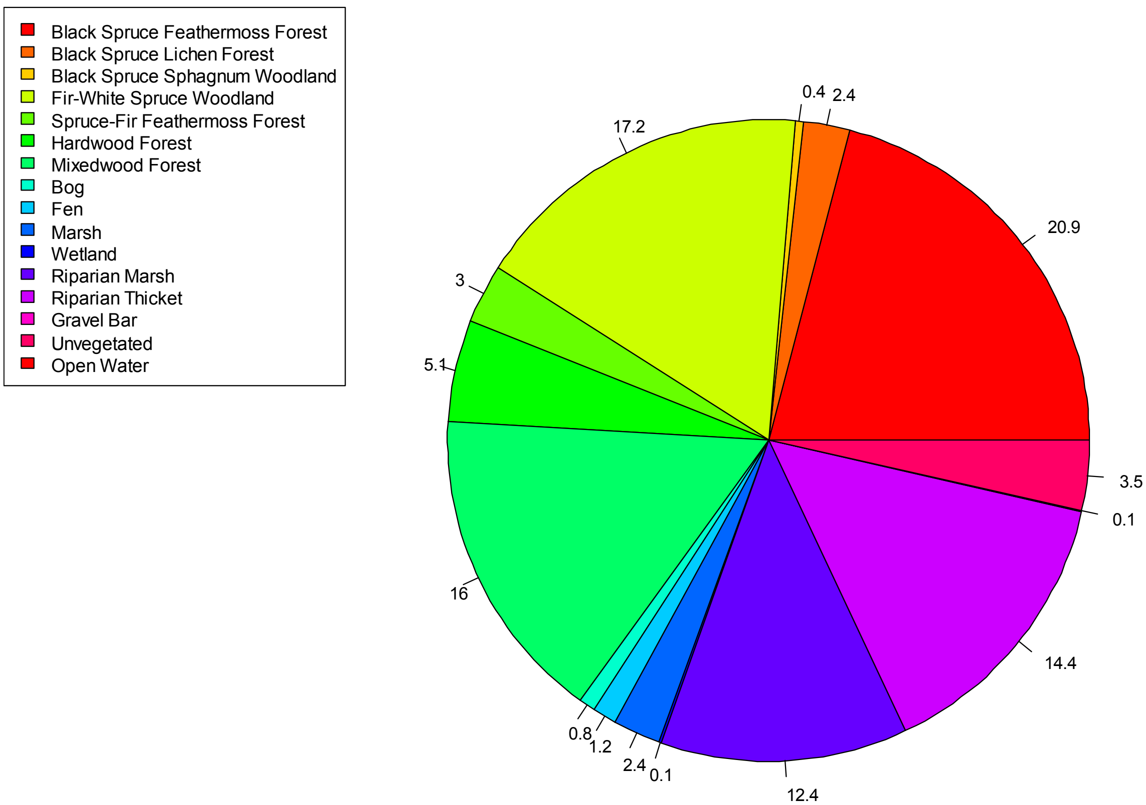

Figure 3-1 Habitat Loss (%) Described Using Project Area ELC Data in the Reservoir

Black spruce lichen forest was the most habitat loss along the transmission line (Figure 3-2). Moderate habitat loss included black spruce feathermoss lichen, wetland, and black spruce on bedrock outcropping (Figure 3-2).

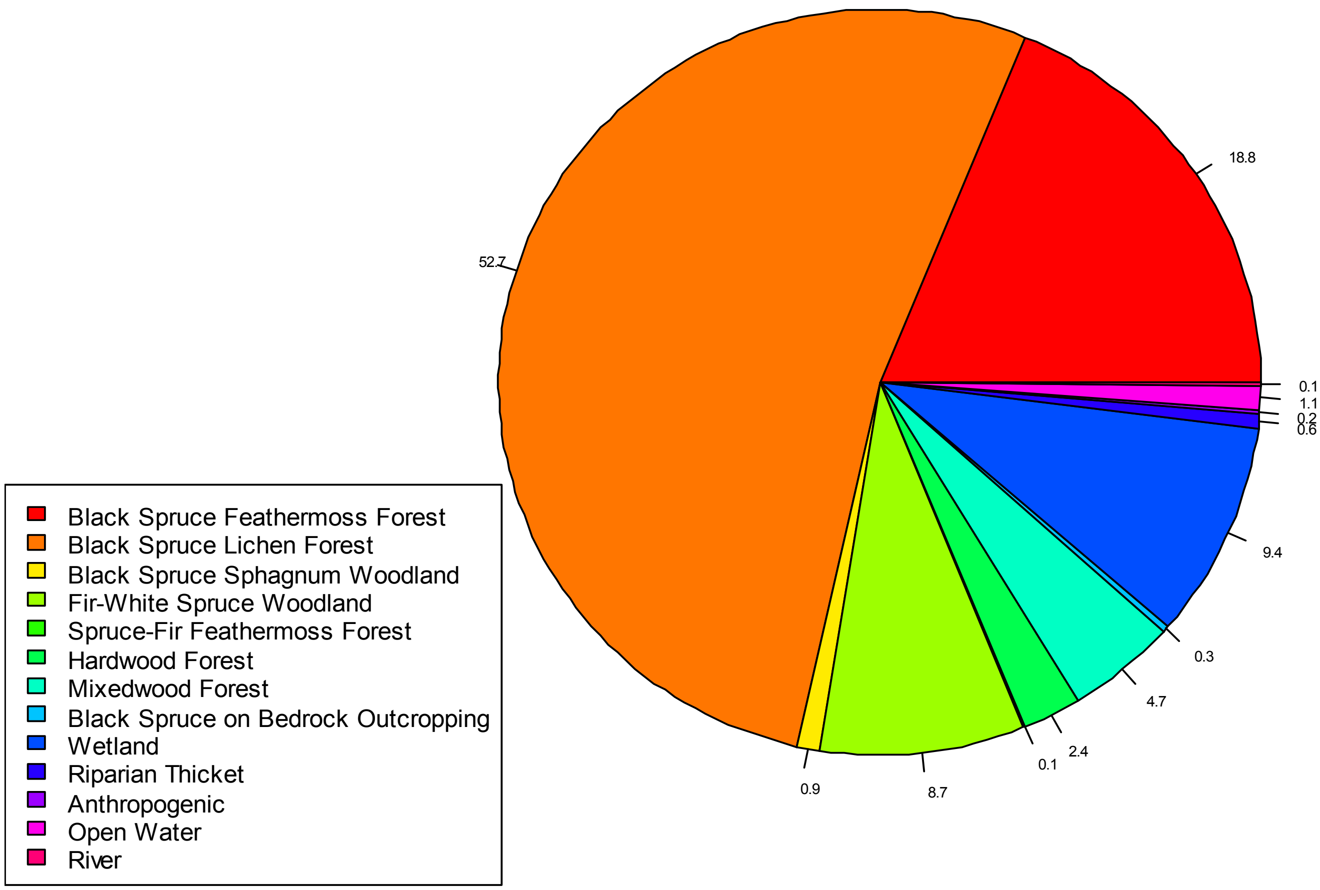

Figure 3-2 Habitat Loss (%) Described Using Project Area ELC Data along the Right-of Way (AC Line)

An estimate of primary habitat loss for each species at risk and key indicator species in both the reservoir and along the RoW was created based on planned construction activities (Table 3.1). Savannah Sparrow lost the largest primary habitat (82%) along the RoW especially, and 57% within the RoW. Gray-cheeked Thrush lost 40% of primary habitat in the reservoir and 34% along the RoW. Lincoln's Sparrow lost 30% primary habitat within reservoir, but only 15% primary habitat lost along the RoW. Ruffed Grouse lost 20% of primary habitat within the reservoir, but less along RoW (7%). The following species lost comparable amounts of primary habitat within the reservoir and along the RoW: Canada Goose (17% and 11%); Common Nighthawk (15% and 9%); Olive-sided Flycatcher (15% and 14%), Swamp Sparrow (7% and 11%), Song Sparrow (13% and 9%) and Rusty Blackbird (16% and 9%). Of all the species, Harlequin Duck lost the lowest amount of primary habitat along the RoW (0.5%), but 13% within the reservoir. Surf Scoter had a small loss of 3% within the reservoir and more loss along the RoW (10%).

Table 3.1 Key Indicator Species Related to Primary Habitat Loss Within the Project Footprint

Scientific Name	Common Name	Primary Habitat	Habitat Loss Within the Reservoir (%)	Habitat Loss Within the Right-of-Way (%)
Branta Canadensis	Canada Goose	Areas with nearby water such as lakes, ponds, larger streams, marshes, muskegs, and wet hummocky areas[1]	17	11
Histrionicus histrionicus	Harlequin Duck	Fast-flowing streams with riparian vegetation cover on banks and islands[2]	13	0.5
Melanitta perspicillata	Surf Scoter	Midsized lakes, slow wide rivers early spring and moving to wetlands and mid-small lakes[3]	3	10
Bonasa umbellus	Ruffed Grouse	Primarily trembling aspen forests but also mixed forests of trembling aspen, white spruce, and white birch[4]	20	7
Chordeiles minor	Common Nighthawk	Burns and burn edges, cleared forests, open forest, rock outcrops, or anthropogenic sites for ground nesting; wetland areas for foraging on insects[5]	15	9
Contopus cooperi	Olive-sided Flycatcher	Open areas (e.g., forest clearings, wetlands, burns) containing mature trees and large numbers of dead trees[6]	15	14

Scientific Name	Common Name	Primary Habitat	Habitat Loss Within the Reservoir (%)	Habitat Loss Within the Right-of-Way (%)
Catharus minimus	Gray-cheeked Thrush	A variety of mature forest types including white spruce, wet spruce, and dry spruce adjacent to wetland or riparian habitat[7]	40	34
Passerculus sandwichensis	Savannah Sparrow	Open areas such as fields and sedge bogs. Areas with dwarf willows and birches and feeding in conifers in northern ranges[8]	57	82
Melospiza melodia	Song Sparrow	Primarily shrubs and riparian habitats[9]	13	9
Melospiza lincolnii	Lincoln's Sparrow	Riparian habitats with dense shrub varying from willow shrubs, mixed deciduous such as trembling aspen, mixed shrub-willows, and black spruce-larch bogs[10]	30	14
Melospiza georgiana	Swamp Sparrow	Wet bogs or fens with open water with sedges and low shrubs of sweet gale and willows and wet sphagnum bogs with leatherleaf and scattered, small black spruce-larch with open water. They can occur in freshwater marshes with sedges, grasses, and cattails bordered by willows and alders[11]	7	11
Euphagus carolinus	Rusty Blackbird	Primarily occupies forest wetlands, such as slow-moving streams, peat bogs, sedge meadows, marshes, swamps, beaver ponds, and pasture edges[12]	16	9

Source:

1. Mowbray et al. 2002
2. Robertson and Goudie 1999
3. Anderson et al. 2015
4. Rusch et al. 2000
5. Brigham et al. 2011
6. Altman and Sallabanks 2012
7. Lowther et al. 2001
8. Wheelwright and Rising 2008
9. Arcese et al. 2002
10. Ammon 1995
11. Mowbray 1997
12. Avery 2013

3.2 Species at Risk

Through the application of field surveys both targeted and opportunistic, a total of five Common Nighthawks were documented, one male and four unknown sex (Table 3.2). The male was identified from booming sounds made during courtship display in a burn. For the individuals of unknown sex, one observation was in a wetland habitat and the other three were in a burn and a gravel pit. The study area had an estimated 7% primary habitat in the reservoir and 9% along the RoW for Common Nighthawk (Table 3.3).

While there were no observations of Gray-cheeked Thrush during surveys, this species was recorded during the baseline studies (Minaskuat Inc. 2008a). The study area had an estimated 34% primary habitat in both the reservoir and along the RoW for Gray-cheeked Thrush (Table 3.3).

Olive-sided Flycatcher had three individuals recorded, one during point counts and two incidental (Table 3.3). The observations were in black spruce with some open canopy. Mature coniferous forest is considered primary habitat if gaps with dead trees are present (Altman and Sallabanks 2012). The study area had an estimated 7% primary habitat in the reservoir and 14% along the RoW for Olive-sided Flycatcher (Table 3.3).

Rusty Blackbird had fifteen observations (Table 3.2). There were several indications of breeding individuals such as a pair with a juvenile, a pair, a pair with nesting material, an individual with nesting material, and two individuals carrying food. The observations were mostly within or adjacent to primary habitat of wetland shrub areas (Table 3.1). A Rusty Blackbird was observed in black spruce lichen woodland with no adjacent primary habitat, so it is assumed that the individual was only passing through. The study area had an estimated 10% primary habitat in the reservoir and 9% along the RoW for Rusty Blackbird (Table 3.3).

There were no Harlequin Duck observations during the EEMPs. Bank Swallow (*Riparia riparia*) was identified during Common Nighthawk surveys in 2014 (Stassinu Stantec 2014a). Although Bank Swallow was not targeted as a species at risk for the Avifauna EEMP as it is not listed under *NLESA*, it is mentioned here as it is threatened under *SARA* at the federal level (Government of Canada 2002).

Table 3.2 Species at Risk Observations during the Avifauna EEMP, 2014-2016

Date	Coordinates (UTM, NAD 83)		Species	Habitat	Observation (Number)
	Easting	Northing			
June 18, 2014	[redacted]	[redacted]	Olive-sided Flycatcher (*Contopus cooperi*)	Black Spruce	Auditory (1)
June 18, 2014	[redacted]	[redacted]	Olive-sided Flycatcher (*Contopus cooperi*)	Black Spruce	Auditory (1)
June 18, 2014	[redacted]	[redacted]	Olive-sided Flycatcher (*Contopus cooperi*)	Black Spruce	Auditory (1)
June 7, 2015	[redacted]	[redacted]	Common Nighthawk (*Chordeiles minor*)	Sandy Area bordered by black spruce-dwarf birch	Auditory (Peent call) and Visual (1)
June 15, 2015	[redacted]	[redacted]	Common Nighthawk (*Chordeiles minor*)	Treed (black spruce-larch) bog	Visual (1)
June 21, 2015	[redacted]	[redacted]	Common Nighthawk (*Chordeiles minor*)	Gravel pit bordered by mixedwood	Auditory (Peent call) and Visual (1)
June 21, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Black Spruce Lichen Woodland	Auditory (1)
June 24, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Disturbed (RoW; adjacent wetland)	Auditory and Visual (3): pair and a juvenile
June 24, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Wetland	Auditory and Visual (2): pair flyover after point count
June 24, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Wetland	Auditory (1)
June 25, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Disturbed (RoW; adjacent water/wetlands)	Auditory and Visual (1)
June 25, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Disturbed (RoW; adjacent water/wetlands)	Auditory (1); thought to be the same individuals as observed at point count location in the column above
June 25, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Wetland	Visual (1): Individual with material in beak, possibly moss

Date	Coordinates (UTM, NAD 83)		Species	Habitat	Observation (Number)
	Easting	Northing			
June 25, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Black Spruce (adjacent water/wetlands)	Auditory and Visual (2): pair with nesting material
June 26, 2016	[redacted]	[redacted]	Rusty Blackbird (*Euphagus carolinus*)	Disturbed (RoW; adjacent water/wetlands)	Auditory (1)
June 26, 2016	[redacted]	[redacted]	Rusty Blackbird (Euphagus carolinus)	Wetland	Auditory and Visual (1): Individual carrying food
June 26, 2016	[redacted]	[redacted]	Rusty Blackbird (Euphagus carolinus)	Black Spruce Lichen Woodland (adjacent wetlands)	Auditory and Visual (1): Individual carrying food
July 8, 2016	[redacted]	[redacted]	Common Nighthawk (*Chordeiles minor*)	Burn (2012)	Auditory (2): 1 male with flight display "boom" and 1 unknown sex (peent call)

Table 3.3 Species at Risk and Their Habitats in the Study Area

Scientific Name	Common Name	Status	Habitat	Occurrence in the Study Area
Chordeiles minor	Common Nighthawk	Threatened under *SARA* and *NLESA*	Burns and burn edges, cleared forests, open forest, rock outcrops, or anthropogenic sites for ground nesting; wetland areas for foraging on insects[1]	Incidental observations during baseline surveys in 2006 (number unconfirmed), five observations during targeted surveys in 2015 and 2016, and one during area nest searches in 2014. Suitable primary habitat estimated to comprise 7% in the reservoir and 9% along the RoW (AC Line).
Contopus cooperi	Olive-sided Flycatcher	Threatened under *SARA* and *NLESA*	Open areas (e.g., forest clearings, wetlands, burns) containing mature trees and large numbers of dead trees[2]	Four observations during baseline surveys in 2006 and 2007, one during point count surveys and two as incidentals in 2014, and one nesting and subsequent family group during area nest searches in 2016. Suitable primary habitat estimated to comprise 7% in the reservoir and 14% along the RoW (AC Line).
Catharus minimus	Gray-cheeked Thrush	Threatened under *NLESA*	A variety of mature forest types including white spruce, wet spruce, and dry spruce adjacent to wetland or riparian habitat[3]	Nine observations during baseline surveys in 2006 and 2007. Suitable primary habitat estimated to comprise 34% in the reservoir and 34% along the RoW (AC Line).
Euphagus carolinus	Rusty Blackbird	Special Concern under *SARA*; Vulnerable under *NLESA*	Primarily occupies forest wetlands, such as slow-moving streams, peat bogs, sedge meadows, marshes, swamps, beaver ponds, and pasture edges[4]	16 observations during baseline surveys in 2006 and 2007, fifteen during point count surveys and seven during area nest searches in 2014. Suitable primary habitat estimated to comprise 10% in the reservoir and 9% along the RoW (AC Line).

Notes:

1. *SARA* – Species at Risk Act, *NLESA* – Newfoundland and Labrador Endangered Species Act.
2. Estimate of primary habitat is based on the regional Ecological Land Classification (ELC) conducted in support of the Project.
3. Other listed species that may occur in the Project area include Bank Swallow (*Riparia riparia*) and Harlequin Duck (*Histrionicus histrionicus)*

Source:

1. Brigham et al. 2011
2. Altman and Sallabanks 2012
3. Lowther et al. 2001
4. Avery 2013

3.3 Surf Scoter and *Ashkui*

The Churchill River was mostly ice-covered at the time of surveys. Gull Lake was ice-covered except for an area where the stronger currents had cut an open channel. The western portion (half to two-thirds) of Lake Winokapau was ice-covered, except for isolated areas along the shoreline and the occasional channel extending into the lake. Ice coverage on the larger lakes and smaller waterbodies outside the Churchill River Valley was variable. Anne Marie Lake was completely ice-free. The eastern portion of Minipi Lake was ice-free, but the southern portion was still ice-covered. Most of Dominion Lake was ice-covered apart for a small area at its southern end and a ribbon of open water along its western shore. Wilson Lake was also largely ice-covered, with areas of open water generally confined to the shoreline and areas of high energy (e.g., constrictions in the lake). Most small waterbodies surveyed were open.

Overall 325 Surf Scoters were recorded during the aerials surveys: 34 males, 26 females, and 265 unknown. Surf Scoter observed along the Churchill River included 114 individuals (one pair and 112 unknown sex). Surf Scoters at Anne Marie Lake totaled 65 individuals (three males, one female, 45 unknown sex, and eight pairs), where Minipi Lake had 56 individuals (one male and 41 unknown, and seven pairs). Dominion Lake had 15 individuals (seven males, two females, and six unknown) with no pairs observed. There were no observations made on Wilson Lake as it was mostly ice-covered. Small waterbodies had smaller numbers scattered across the watershed for a total of 75 individuals (61 unknown sex, and seven pairs).

The sections of the Churchill River occupied by Surf Scoter were wide and slow-moving. The flocks observed at Anne Marie and Minipi Lakes indicated that these birds were in a pre-breeding stage, while the numerous small groups noted indicated that at least some birds were preparing for dispersal and breeding. The presence of lone males in other areas indicated that nest initiation had likely already begun. Pairs of Surf Scoters were infrequently observed on smaller waterbodies which further indicated that some dispersion to breeding lakes had occurred.

The two larger flocks of Surf Scoter near Muskrat Falls and Churchill Falls (Figure 2-3) were selected as cohorts to conduct recognized behaviours surveys to estimate sex-ratios and complete the time activity budgets (Table 3.4). The flocks were observed during 6.98 hours over three days.

Table 3.4 Cohorts of Surf Scoter Surveyed for Recognized Behaviours Observations

Location	Date	Cohort	Observation Time (hrs)
Churchill Falls	May 30, 2014	female	3.5
Muskrat Falls (North Spur)	May 31,2014	female	1.5
		flock	1.1
	June 1, 2014	flock	0.88

Surf Scoters numbered 22 individuals (May 31) and 41 (June 1) at The Muskrat Falls site. Sex-ratios of 5:1 (May 31) and 7:1 (June 1) were estimated. The Churchill Falls site had 35 individuals with an estimated sex-ratio of 10.25:1. Females showed similar behaviours over time at both sites (Figures 3-3 and 3-4). Females were swimming and diving most of the time. Some time was spent paused, in comfort, and resting. Less than 1% of the time, females were alert, in agonism, or courting. Flocks spent 21.7% (May 31) and 28.1% (June 1) of the time diving at Muskrat Falls, which was slightly lower than observed for females.

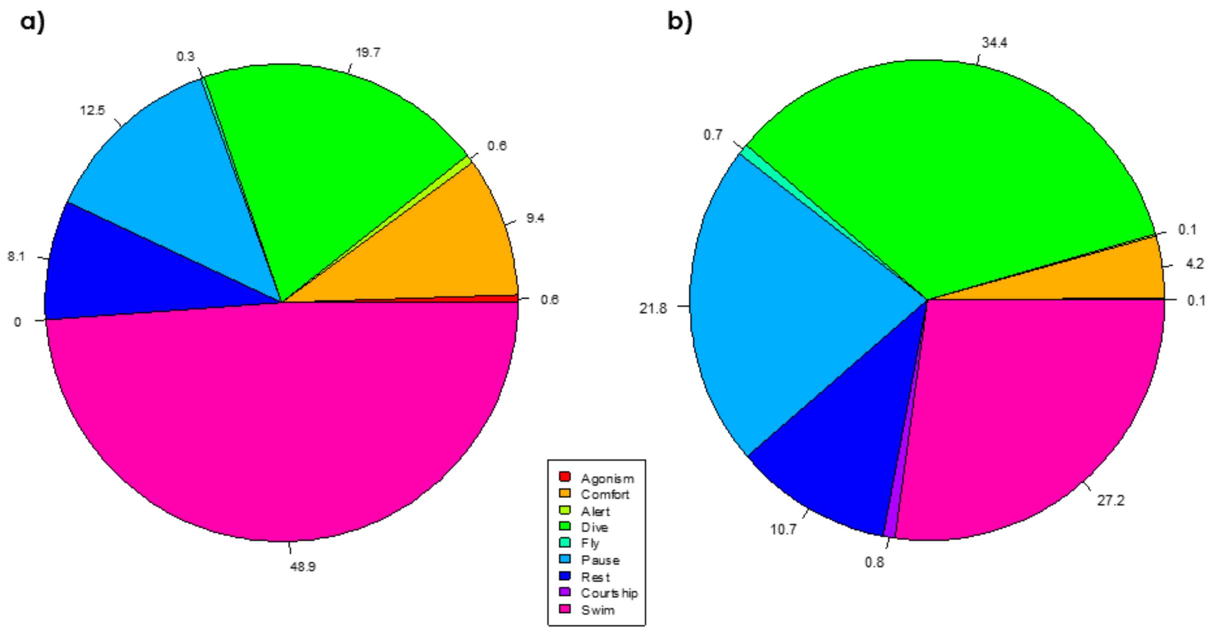

Figure 3-3 Time Activity Budget (% of observation period) of Female Surf Scoter Cohort at a) the Muskrat Falls Site and b) Churchill Falls Site

Canada Goose, identified as a key indicator species, was recorded as incidental observations during Surf Scoter surveys. Incidental observations included a pair and ten individuals near Pinus River, seven individuals near Minipi Lake, two individuals downstream of the confluence of Metchin and Churchill Rivers, and nine individuals downstream of the confluence of Portage and Churchill Rivers. Although Harlequin Duck was another waterfowl key indicator species, it was not observed during surveys.

3.4 Species Richness

A total of 63 species were observed over the duration of the Avifauna EEMP (Appendix D). Overall, species richness across all four regions was higher in the baseline studies compared to the Avifauna EEMP (Figure 3-5). The only exceptions were species richness in open habitats in the above Gulls Island region and coniferous habitats in the above Gull Island + region in the Avifauna EEMP. Species richness was higher in above and below Muskrat Falls regions than above Gull Island and above Gull Island + regions (Figure 3-5).

The distribution of the species richness was smaller overall in the Avifauna EEMP than in baseline studies (Figure 3-6). Species richness in the baseline had more values in the 50-100% quantiles, where the Avifauna EEMP had more values of species richness in the 0-50% quantiles.

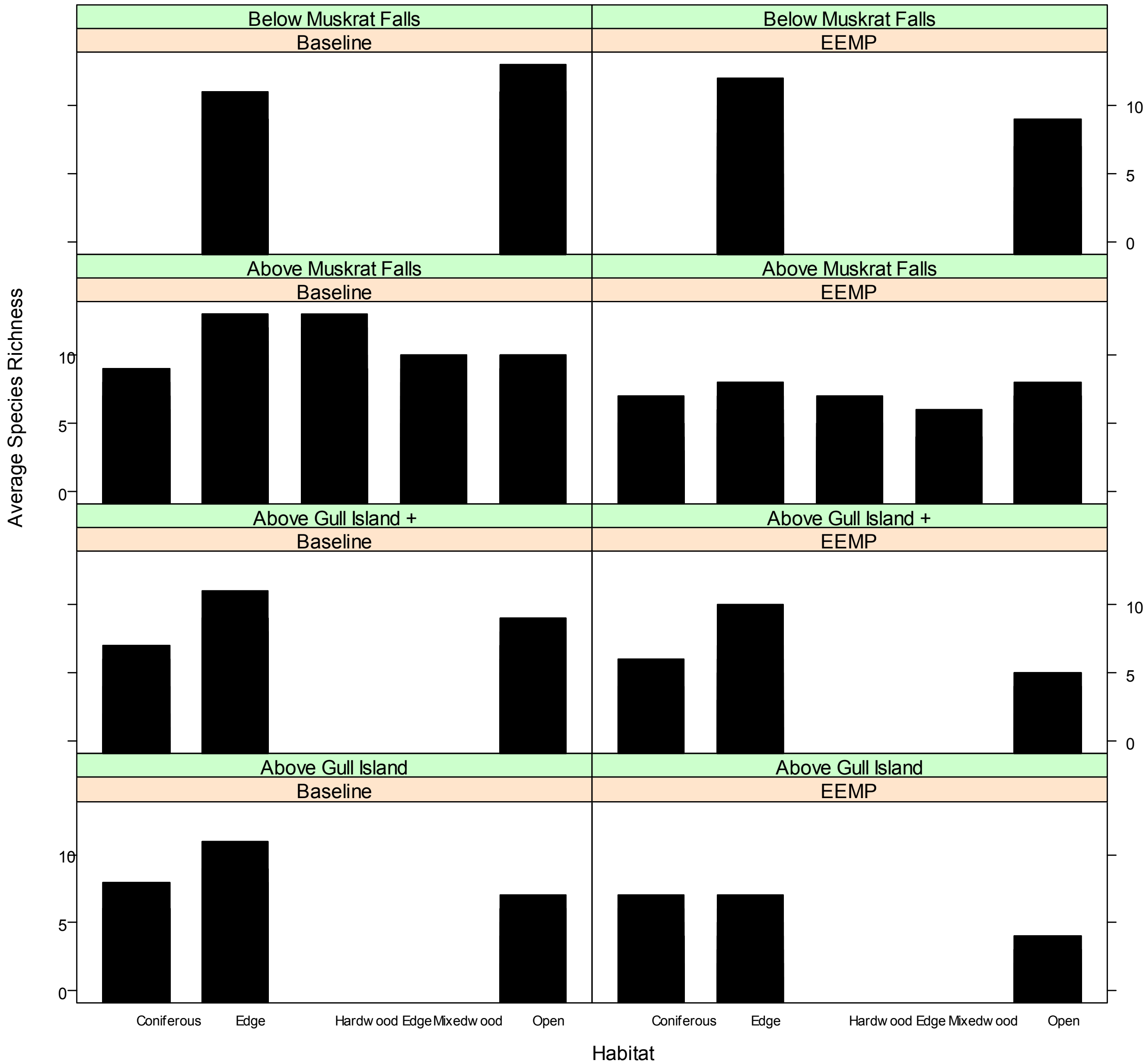

Figure 3-4 **Species Richness (Average Number of Species) by Habitat Type during Baseline Studies (2006-2007) and Avifauna EEMP (2014-2016)**

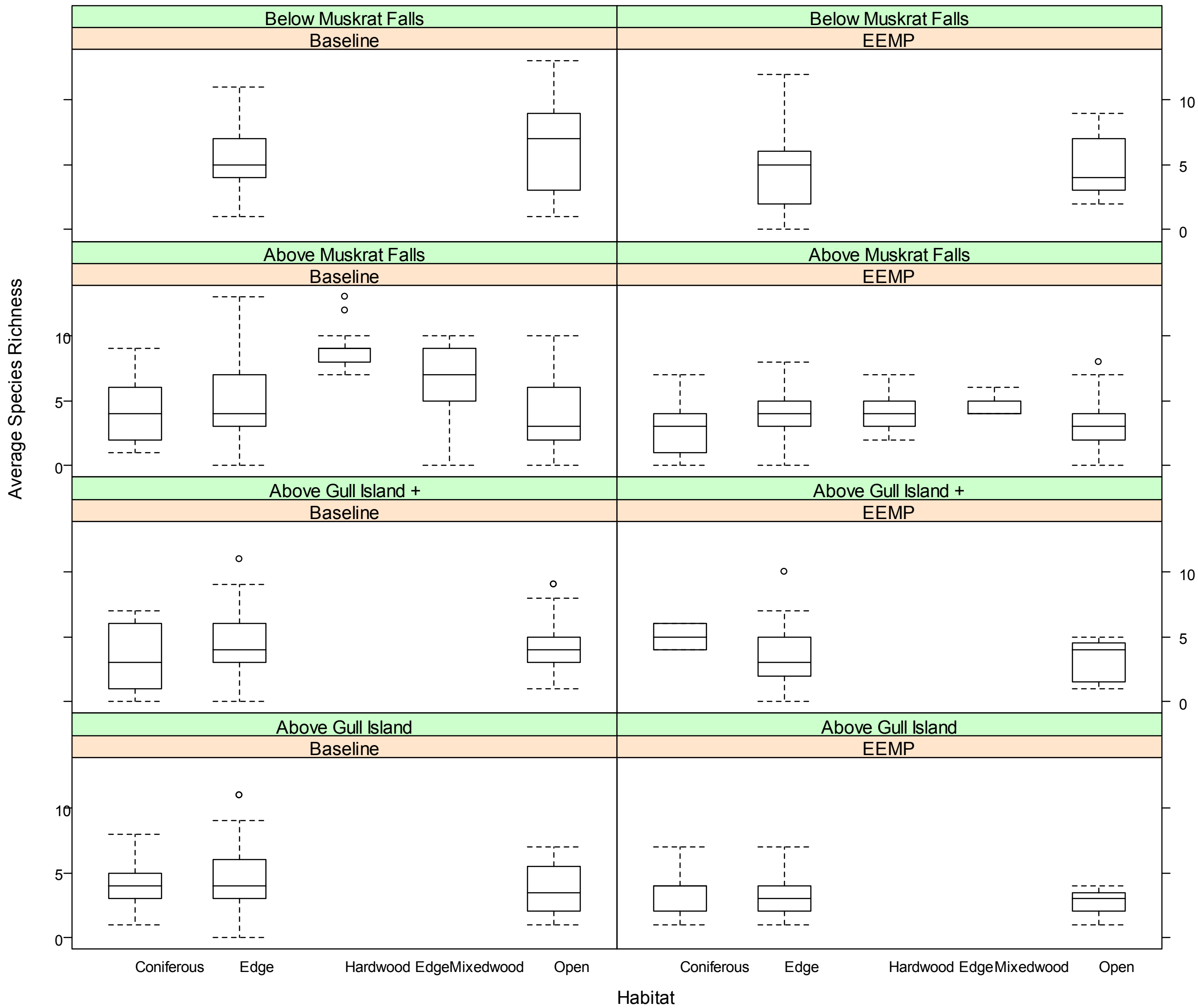

Figure 3-5 Species Richness (Average Number of Species) by Habitat Type during Baseline Studies (2006-2007) and Avifauna EEMP (2014-2016)

A series of candidate models (Table 3.5) were run using AIC to determine if any environmental and Project covariates significantly explained the declining trend observed in species richness. Both model 13 and the global model had an AIC value < 2 and together explained approximately 90% of the observed species richness based on Akaike Weights (Tables 3.5 and 3.6). The covariates of region, habitat, and fire were in both models, but the covariates of Project footprint and year were only in the global model. Model 13 explained 49% of the observed species richness, where the global model explained 40%. Model 13 explained approximately 1.2 times the variance of observed species richness than the Global Model based on the evidence ratio of the Akaike weights (0.498/0.408; Table 3.6). Region, habitat, and fire covariates explained approximately twofold more variance of the observed species richness than the covariates of Project footprint and year based on evidence ratios from the sum of the Akaike weights (0.906/0.408; Table 3.7). Therefore, Year and Project footprint did not have a significant effect. Model 13 was accepted as the best approximating model. There were no issues with overdispersion.

Region, habitat, and fire were shown to influence the observed species richness (Tables 3.6, 3.7, and 3.8). Below Muskrat Falls had a significantly higher species richness ($z = 2.35$; p-value < 0.05) than Above Muskrat Falls. Species richness did not vary in Above Gull Island ($z = 0.85$; p-value > 0.05) and Above Gull Island + ($z = 0.45$; p-value > 0.05). Hardwood Edge ($z = 2.92$; p-value <0.01) and Mixedwood ($z = 2.27$; p-value < 0.05) had significantly higher species richness than Coniferous habitats but did not vary in Edge ($z = 1.68$; p-value > 0.05) and Open habitats ($z = 0.057$; p-value > 0.05). There was a significant decrease in species richness 1-year post-fire in 2015 ($z = -3.95$; p-value <0.001) and 2-years post-fire in 2016 ($z = -2.76$; p-value <0.01) compared to pre-fire. Further, the decrease in species richness in 2015,1-year post-fire, showed a higher significant decrease than in 2016, 2-years post-fire (Table 3.8). The significant values were confirmed by 95% confidence intervals which did not bound zero (Table 3.8).

Table 3.5 Set of Candidate Models used to Determine Explanatory Variables for Species Richness during AIC

Model	Response Variable	Explanatory Variable(s)	Random Effect
Global Model	Species Richness	Year + Region + Habitat + Project Footprint	Transect
Model 2	Species Richness	Region + Habitat	Transect
Model 3	Species Richness	Region + Project Footprint	Transect
Model 4	Species Richness	Year + Region	Transect
Model 5	Species Richness	Year + Habitat	Transect
Model 6	Species Richness	Year + Project Footprint	Transect
Model 7	Species Richness	Habitat + Project Footprint	Transect
Model 8	Species Richness	Year + Region + Habitat	Transect
Model 9	Species Richness	Year + Region + Project Footprint	Transect
Model 10	Species Richness	Region + Habitat + Project Footprint	Transect
Model 11	Species Richness	Region + Fire	Transect
Model 12	Species Richness	Habitat + Fire	Transect
Model 13	Species Richness	Region + Habitat + Fire	Transect

Table 3.6 Model Inference of Candidate Models Using AIC

Model	AIC_i	Δi	Akaike Weights (w_i)
Model 13	1263.0	0	0.498
Global Model	1263.4	0.4	0.408
Model 12	1266.4	3.4	0.0910
Model 8	1274.4	11.4	0.00166
Model 5	1277.2	14.2	4.11×10^{-4}
Model 11	1278.6	15.6	2.04×10^{-4}
Model 10	1281.0	18.0	6.15×10^{-5}
Model 2	1283.6	20.6	1.68×10^{-5}
Model 7	1285.4	22.4	6.82×10^{-6}
Model 9	1286.0	23.0	5.05×10^{-6}
Model 4	1289.6	26.6	8.35×10^{-6}
Model 6	1289.8	26.8	7.55×10^{-6}
Model 3	1292.8	29.8	1.69×10^{-6}

Table 3.7 Covariate Importance Based on AIC Weights of Best Approximating Models

Models	Akaike Weights (w_i) of the Covariates				
	Year	Region	Habitat	Project Footprint	Fire
Model 13	0	0.498	0.498	0	0.498
Global Model	0.408	0.408	0.408	0.408	0.408
Sum of Akaike Weights (Σw_i)	0.408	0.906	0.906	0.408	0.906

Table 3.8 Covariate Estimates and Standard Errors for Species Richness of the Best Approximating Model

Covariates	Estimate	Standard Error	Lower Confidence Interval (95%)	Upper Confidence Interval (95%)
Intercept	1.33	0.078	1.17	1.48
Region 2: Below Muskrat	***0.19**	**0.084**	**0.028**	**0.36**
Region 3: Above Gull Island	0.080	0.094	-0.10	0.26
Region 4: Above Gull Island +	0.043	0.094	-0.14	0.23
Habitat: Edge	0.10	0.064	-0.016	0.23
Habitat: Hardwood Edge	****0.41**	**0.14**	**0.13**	**0.68**
Habitat: Mixedwood	***0.28**	**0.12**	**0.037**	**0.53**
Habitat: Open	0.0040	0.070	-0.13	0.14
Fire: 1-year post fire	*****-0.27**	**0.070**	**-0.41**	**-0.14**
Fire: 2-years post fire	****-0.29**	**0.10**	**-0.51**	**-0.085**

Notes:
1. Estimates based on species richness values during baseline, coniferous habitats, above Muskrat Falls, inside Project footprint, and Pre-fire
2. Bolded text represents significant values ($p < 0.05$) where increasing degree significance is shown by * = $p < 0.05$; ** = $p < 0.01$; and *** = $p < 0.001$
3. The random effect of transect had a variance of 0.0639 and a standard deviation of 0.259

4.0 DISCUSSION

The Avifauna EEMP was established during the construction phase of the Project as per EIS requirements following baselines studies. The Avifauna EEMP addressed the four study objectives related to habitat loss, species at risk, Surf Scoter Ashkui use, and the potential Project effect of a change in species richness.

4.1 Habitat Loss

Habitat loss within the reservoir was primarily riparian, and forests of mixedwood, hardwood, and coniferous within the regions of above and below Muskrat Falls. These habitats are unique to the Muskrat Falls and Gull Island low elevation regions, uncommon elsewhere in the Churchill River valley (Minaskuat Inc. 2008b). Species richness was highest among these habitats during the Avifauna EEMP (Figure 3-5) and baseline studies (Minaskuat Inc. 2008a). Spring staging areas such as *ashkui* used by migrating waterfowl will be altered and predicted to form in upper tributaries (Hatch Ltd. 2011). Migrating waterfowl observed using *ashkui* include the indicator species of Canada Goose and Surf Scoter during the Avifauna EEMP (Stassinu Stantec 2014a) and Harlequin Duck during baseline (LGL Limited 2008). Olive-sided Flycatcher, Song Sparrow, Swamp Sparrow observations were limited to point counts located below and above muskrat fall during the Avifauna EEMP (Stassinu Stantec 2014a, 2015a, 2016a). Ruffed Grouse was observed within the reservoir, and adjacent to the reservoir near Gull Island rapids (Stassinu Stantec 2014a, 2015a, 2016a). Lincoln's Sparrow and Savannah Sparrow were observed in the reservoir as well as along the transmission line (Stassinu Stantec 2014a, 2015a, 2016a). Similarly, Lincoln's Sparrow and Swamp Sparrow were amongst most abundant breeding songbirds based on index of density in riparian and wetlands in baseline studies (Minaskuat Inc. 2008a).

Most habitat loss along the RoW was coniferous and wetland habitats. Black spruce lichen woodland comprised most of the coniferous habitats lost. These habitats had some of the highest species richness for the regions of above Gull Island and above Gull Island + (Figure 3-5); however, these habitats are the most common habitats available in both regions (Minaskuat Inc. 2008b). Black spruce lichen woodland had lowest species, abundance, and density of breeding songbirds in baselines studies (Minaskuat Inc. 2008a). Waterfowl key indicator species were not observed in the regions of above Gull Island and above Gull Island +. Common Nighthawk was observed in, burns, bogs, and anthropogenic (i.e., gravel pit) areas (Stassinu Stantec 2015a, 2016a). Lincoln's Sparrow and Savannah Sparrow were observed in point counts near the RoW (Stassinu Stantec 2014a, 2015a, 2016a). Rusty Blackbird was observed in wetlands near the RoW (Stassinu Stantec 2016a).

Anthropogenic development related to energy infrastructure often results in an alteration of the landscape through habitat loss and fragmentation as one of the main direct project effects (Brawn et al. 2001, Farwell et al. 2016). Reservoir impoundment of a fen in Quebec resulted in an increase in abundance of waterbirds and some high nesters within cavities such as Tree Swallow

(Lariviere and Lepage 2000). Contrary to waterbirds within the same reservoir impoundment in Quebec, passerines that were low nesters, and shrub species decreased in abundance, with significant decreases in Savannah Sparrow and Swamp Sparrow and lack of observations post-flooding for species observed pre-flooding Common Yellowthroat (*Geothlypis trichas*), Wilson's Warbler (*Cardellina pusilla*), Song Sparrow, and Lincoln's Sparrow (Lariviere and Lepage 2000).

4.2 Species at Risk

Species at Risk known to occur in the study area are Common Nighthawk, Olive-sided Flycatcher, and Rusty Blackbird, all of which were observed during the breeding season. Gray-cheeked Thrush were not observed during targeted point count surveys in known Gray-cheeked Thrush habitats.

The main breeding range of Common Nighthawk in the province is central/southern Labrador, which is within our study area (COSEWIC 2007a). COSEWIC's recovery strategy lists the main threats to Common Nighthawk (decreased insect prey and habitat loss/alteration) of medium concern (Environment Canada 2016a). Common Nighthawk was observed in primary habitats (Brigham et al. 2011) during the Avifauna EEMP. Booming sound during courtship display was observed in 2016 by a male Common Nighthawk as evidence of breeding behaviour. Common Nighthawk was seen in both breeding and foraging habitats within the breeding season. They were observed in a recent burn (2012) near Gull Island as would be expected based on their preferences of disturbed habitats (COSEWIC 2007a, Brigham et al. 2011). The cleared area along the RoW may provide breeding habitats (Brigham et al. 2011), although there were no observations during the Avifauna EEMP (Stassinu Stantec 2014a, 2015a, and 2016a) or during the application of mitigation strategies related to the Avifauna Management Plan (Stassinu Stantec 2014b, 2015b, and 2016b).

The Olive-sided Flycatcher breeds in the boreal forest region in open areas of early successional stands (Altman and Sallabanks 2012). Habitat loss/alteration from energy and mining activities is considered a medium concern for Olive-sided Flycatcher (Environment Canada 2016b). Primary habitat was found in the study area and Olive-sided Flycatcher was recorded in point count surveys during baseline studies (Minaskuat Inc. 2008a) and the Avifauna EEMP (Stassinu Stantec 2014a). Breeding evidence included an active nest found during nest search surveys of the Avifauna Management Plan (Stassinu Stantec 2016b). The nest was in a balsam fir tree in an open coniferous stand with dead tree snags. Later in the season during nest surveys, a family group was identified near the nest location (Stassinu Stantec 2016b). Nest success is known to be high for Olive-sided Flycatcher, but unknown for fledging success (COSEWIC 2007b). Olive-sided Flycatcher has been found in cleared areas elsewhere in its range if snags or residual trees remain for foraging/nesting, albeit at a lower breeding success than naturally open areas (Altman and Sallabanks 2012; COSEWIC 2007b). The cleared area in the project footprint may provide habitat if some snags or residual trees are present.

Gray-cheek Thrush breed in northern boreal forests including Newfoundland and Labrador (Lowther et al. 2001). Threats to this species are difficult to define due to the limited data, but it is thought that habitat loss from industrial logging particularly on the island of Newfoundland may have a similar influence (SSAC 2010). There is limited data available for the distribution of this species in Labrador, but available data suggests Gray-cheeked Thrush is abundant and widespread (SSAC 2010). There was primary habitat available of mature coniferous forests in the study area (Table 3.4; Lowther et al. 2001). Gray-cheeked Thrush was previously documented in the study area during baseline studies (Minaskuat Inc. 2008a). Gray-cheeked Thrush was not observed during implementation of the Avifauna EEMP (Stassinu Stantec 2014a, 2015a, and 2016a) or Avifauna Management Plan (Stassinu Stantec 2014b, 2015b, and 2016b).

Rusty Blackbird's northern breeding range includes Labrador (Avery 2013). Habitat loss of wetlands is considered the cause of the population decline, with hydroelectric reservoirs listed as one of the main threats in eastern Canada for Rusty Blackbird (COSEWIC 2006). Habitat loss due to forest clearing and anthropogenic changes in surface hydrology are considered medium concern for Rusty Blackbird (Environment Canada 2015). Primary habitat for Rusty Blackbird was available in the study area and was recorded during baseline studies (Minaskuat Inc. 2008a), nest searches (Stassinu Stantec 2014b), and Avifauna EEMP (Stassinu Stantec 2014a, 2015a, and 2016a). Most of the observations were in or near primary habitat; one observation was a fly through in black spruce lichen woodland. In its primary habitat, Rusty Blackbird demonstrated behaviours indicative of breeding, such as, a pair with a juvenile, a pair, a pair with nesting material, an individual with nesting material, and two individuals carrying food (Stassinu Stantec 2016a).

4.3 Surf Scoter and *Ashkui*

Ashkui are defined as open areas early in spring and recognized as important to staging waterfowl (Sable et al. 2006, Nalcor 2009a, 2009b). *Ashkui* formation tends to occur within turbulent waters, and are known to occur at Muskrat Falls and confluences of rivers along the Churchill River (Minaskuat Inc. 2009). The Surf Scoter surveys during the Avifauna EEMP documented the continued used of *ashkui* near Muskrat Falls and the confluences of the Metchin River, as well as the west end of Lake Winokapau and downstream of the tailrace at Churchill Falls. Baseline studies (LGL Limited 2008) also showed large aggregations of Surf Scoter using *ashkui* at these same locations as observed during the Avifauna EEMP. Surf Scoter are known to have a migrating behaviour of aggregated sexes during spring staging prior to moving inland to breeding wetlands (Anderson et al. 2015).

Following post-construction, the reservoir is expected to be ice-covered with incoming ice accumulation at the upstream end of the reservoir (Hatch Ltd. 2011). It is also predicted that the ice generating reach will extend upstream to the outlet of Lake Winokapau (Hatch Ltd. 2011). The reservoir is expected to shift the locations of tributaries, and associated formation *ashkui* (Nalcor 2009a, 2009b). The joint review panel did conclude that the reservoir would result in a habitat loss for waterfowl which use *ashkui* during spring staging, but likely not significantly based on the availability of alternate *ashkui* locations upstream (JRP 2011).

4.4 Species Richness

There was a decline in species richness across most habitats and regions within our study area that was best explained through statistical models by the effects of a forest fire that occurred during the construction phase of this Project. Project footprint did not have a significant effect on species richness.

We saw higher species richness in mixedwood and hardwood habitats than coniferous, open, and edge habitats as observed elsewhere in northern boreal forests (Machtans and Latour 2003). Previous surveys in our study area reported a strong relationship between bird species and vegetation characteristics near Goose Bay (Simon et al. 2002). In contrast to our finding of an effect of fire but not vegetation clearing, other studies within the study area saw similar species richness on burned and logged stands, but a higher density on burned stands (Simon et al. 2002). In Northern Quebec, local habitat structure and composition explained bird communities, with no effect of scale (Lemaitre et al. 2012).

Fire is important in the regeneration of boreal forests and can influence bird communities through successional patterns over time based on guild preferences (Lindenmayer et al. 2016, Mahon et al. 2016). Forests regenerating after fire increases habitat qualities for species such as Olive-sided Flycatcher and Black-backed Woodpecker (*Picoides arcticus*), but decreases it for species associated with mature coniferous species such as Boreal Chickadee (*Poecile hudsonicus*) (Imbeau et al. 1999, Lowe et al. 2012, Mahon et al. 2016). Olive-sided Flycatcher and Black-backed Woodpecker do occur within our study area and may respond positively to this recently created habitat. However, species in our study area preferring mature forest, such as, Gray-cheeked Thrush and Boreal Chickadee may be negatively impacted. Species richness was shown to decrease after a severe fire, and environmental conditions pre- and post-fire also influence species richness on the landscape (Lindenmayer et al. 2014). A study on Quebec's North Shore showed a response in bird composition associated to habitat preferences based on local and landscape variables linked to successional patterns since fire and stand density (Lowe et al. 2012). Lowe et al. (2012) did not find a significant direct effect of time since fire, but rather habitat structure and composition post-fire and associated successional patterns seem to influence species richness, which would indicate an indirect effect of fire disturbance.

Our results suggested that species richness was influenced at a local scale by habitats, and by environmental conditions and natural disturbance from a forest fire within regions at a larger landscape scale. Avifauna species have shown a response to habitat characteristics at multiple scales, where both generalists and specialists were found across common and rare habitats (Mahon et al. 2016). Stephens et al. (2016) showed that bird communities patterns were correlated to environmental variables where climate, geography, and habitat were important at three scales from local to landscape. Environmental factors influenced avifauna communities at a local scale more strongly than at other scales; however, landscape-scale factors also had a substantial influence that was independent of local scale factors (Cushman and McGarigal 2004). Zhoa et al. (2013) found both landscape disturbances and stand characteristics explained species richness, but landscape disturbances explained more variance than stand characteristics.

Project footprint did not have a significant effect on species richness. This could be an expression of plasticity based on previous exposure to natural disturbances and an overall highly heterogeneous landscape, or due to a change in species but not a change in the number of species based on guilds.

Boreal birds may show some resiliency to anthropogenic disturbance based on previous exposures to natural disturbance of the boreal forest as there was a negligible effect on species richness on post-harvested sites (Schmiegelow et al. 1997). Northern boreal forests typically demonstrate a high disturbance regime, and as such, a large proportion of the occurring bird species show generalist behaviours (Machtans and Latour 2003, Mahon et al. 2016). In studies areas like that of this Project which appear to have naturally high edge habitats, an effect on species richness from vegetation clearing in comparison to a heterogeneous landscape mosaic may not be significantly detectable. Boreal songbirds have shown resilience to anthropogenic disturbances such as forest harvests in Newfoundland (Whitaker et al. 2008). In Northwestern Ontario, there was no variation found in species richness in areas disturbed by forest harvests and fire (Wyshynski and Nudds 2009). The habitats across the four regions within our study area showed high landscape heterogeneity and associated high edge habitat. There may be individual or species-specific responses to anthropogenic disturbances that may or may not show avoidance behaviours and/or adaptability (Brawn et al. 2001, Smith and Dwyer 2016, Terraube et al. 2016) that would not be detected at the community level that we conducted our study. Further, the response of bird communities may either be negative or positive depending on the species traits and how these newly created edge habitats play into the larger landscape mosaic and heterogeneity (Brawn et al. 2001, Terraube et al. 2016). Smith and Dwyer (2016) conducted a review of the existing literature which suggests that the magnitude and mechanisms of direct and indirect effects of renewable energy infrastructure and the associated power lines on birds are site- and species-specific. There may also be a re-distribution of displaced guilds as the forest succession progresses based on potential indirect effects of species-specific sensitivities (Farwell et al. 2016) such as noise (Bayne et al. 2008).

Species richness has been observed to decline for mature forest species but increase for early successional or edge species within cleared project footprints for renewable energy such as shale gas (Barton et al. 2016, Farwell et al. 2016). Both local habitat and landscape level disturbances influenced bird communities, where forest harvested areas saw higher abundance of early successional species and lower abundance of mature forest species (Drapeau et al. 2000). Vegetation clearing alters habitats and successional patterns which in turn may influence the bird community to assemble per guilds, such as species that prefer early succession to old-growth or mature forests (Brawn et al. 2001, LeBlanc et al. 2010, Zhao et al. 2013, Barton et al. 2016, Kellner et al. 2016). There is evidence that species richness changing continuously and most rapidly within early successional forests compared to mid- and mature forests (Duguid et al. 2016). Zhang et al. 2013 found a positive response to human footprint across guilds (i.e., guild is defined as any group of species that exploit the same resource in a similar way) and posited that it may have contributed to increased heterogeneity in the larger landscape mosaic resulting in the positive response. A study in western Labrador shows an increase in early successional species following a forest harvest (Simon et al. 2000). In contrast, species richness did not differ in post-fire and post-harvested sites in Quebec, but species abundance was higher on post-harvested sites (Imbeau et al. 1999). Species richness did not vary between cleared and burned stands seven years post-disturbance, however bird abundance was significantly influenced by residual tree composition and configuration post-disturbance (Stuart-Smith et al. 2006). Burned stands had lower structural complexity within vegetation layers from ground cover, understory, and overstory with lower regenerating residual trees than logged stands (Stuart-Smith et al. 2006). Burned stands did have higher snags, snag cavities, and coniferous regenerating stems (Stuart-Smith et al. 2006).

Within the early successional forest species, the vegetation structure composition remaining post-harvest appears to influence the response as downed wood may provide foraging or escape cover (Grodsky et al. 2016). In the vegetation clearing process during the Project construction phase, there were patches of smaller non-merchantable timber left standing, but the downed wood/slash was mulched. The mulched areas appeared to attract early successional species, notably Dark-eyed Junco (*Junco hyemalis*) and White-throated Sparrow (*Zonotrichia albicollis*) (Stassinu Stantec 2014b, 2015b, and 2016b). In Quebec, Dark-eyed Junco and White-throated Sparrow were also associated with post-disturbance stands (Imbeau et al. 1999). Within an area of forest harvest with riparian buffers, some early successional species such as White-throated Sparrow were found in clearcuts but also in the edges of habitats or open habitats in uncleared areas which was thought to have attributed to the lack of detection of the effect of harvesting (Chizinski et al. 2011).

In some instances, species richness present in regenerating or fragmented forests caused by anthropogenic disturbances does not vary significantly from undisturbed sites, however, species may have lower reproductive and survival success primarily due to an increased exposure to predators (Brawn et al. 2001, DeGregorio et al. 2014) and habitat loss (Van Wilgenburg et al. 2013, Hethcoat and Chalfoun 2015). A study in northwestern Newfoundland found no negative effect of forest harvest on breeding success of White-throated Sparrow (*Zonotrichia albicollis*), Yellow-rumped Warblers (*Setophaga coronata*), and Blackpoll Warblers (*Setophaga striata*) to resources distribution within high landscape heterogeneity (Dalley et al. 2009).

Mitigative measures were implemented based on EIS commitments and recommendations during the construction phase of the Project. Best management practices were applied as mitigation measure during planning of the RoW to avoid environmentally sensitive areas as feasible. Another mitigation measure during the breeding season was the implementation of the Avifauna Management Plan within the Project construction phase.

5.0 CONCLUSIONS

There was direct habitat loss for some avifauna species associated with the Project footprint within the reservoir and along the RoW. Species at risk distribution and habitat associations, described for EEMP observations of Common Nighthawk, Olive-sided Flycatcher, and Rusty Blackbird, aligned with known habitat preferences. Surf Scoter continued to use *ashkui* during spring staging as was observed during baseline studies. Habitat, region, and fire disturbance had a significant effect on species richness of forest songbirds. During the Avifauna EEMP, The Project's construction phase did not have a significant effect on species richness of forest songbirds. The forest songbirds of the Churchill River valley showed resilience to this anthropogenic disturbance as has been observed in other boreal forests.

5.1 Limitations and Assumptions

There were no fine scale habitat data available to the study team that covered the entire study area. As such, local habitat structure, based on age classes, stand height, and canopy cover which have been shown to be important for bird species, was not included in our study. Instead, a Coarser scale EOSD data was used as it offered the only complete coverage of habitat at the local scale in the study area. Given the geographic extent of the study area, it was deemed important to have a consistent set of habitat data at a local scale. Other have detected habitat influence at local scales using coarser scale habitat type classes (Cushman and McGarigal 2004).

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APPENDIX A

Ecological Land Classification (ELC)

Table A.1 Ecological Land Classification (ELC) Habitat Descriptions

Habitat Classification	Habitat Classification Description[1]
Black Spruce/Lichen Woodland	Black spruce (*Picea mariana*) is the dominant tree species. Shrub layer stunted black spruce and Labrador tea (*Rhododendron groenlandicum*). *Cladina* lichens make up the ground cover, but red-stemmed feathermoss (*Pleurozium schreberi*) within the black spruce understory.
Black Spruce/Sphagnum Woodland	Transition between coniferous forest and bogs or fens with poor drainage. Trees are generally open stunted black spruce. Shrub layer is mostly ericaceous shrubs such as leather leaf (*Chamaedaphne calyculata*) and Labrador tea. The ground cover is *Sphagnum* mosses with sedges, forbs, and other mosses.
Marsh	Marshes are along shores of ox bow lakes and confluences of the Churchill River and tributaries, with seasonal flooding and ice scouring. There are no trees. Shrub layer is sparse sweet gale (*Myrica gale*) and speckled alder (*Alnus incana*). Ground cover is primarily bulrushes, rushes, sedges, and grasses.
Black Spruce on Outcropping	Black spruce within exposed bedrock on crests of hills and ridges. Shrub layer is stunted black spruce, dwarf birch (*Betula glandulosa*), and dwarf bilberry (*Vaccinium caespitosum*). The ground cover is mostly lichens along with black crowberry (*Empetrum nigrum*) and red-stemmed feathermoss.
Fen	Unpatterned and patterned fens. Trees consists of sparse balsam fir (*Abies balsamea*) and larch (*Larix laricina*). Shrub layer is also sparse, composed mostly of leather leaf, specked alder, and sweet gale. Ground cover is variable, supporting *Sphagnum spp.*, sedges, and grasses.
Low Shrub Bog (Bog)	Unpatterned and patterned (string) bogs are the most common type of wetland in the study area. Bogs are peat lands within depressions or gradual slopes. Sparse tree cover of black spruce and larch. Shrub layer is also sparse primarily leatherleaf and pale laurel (*Kalmia polifolia*). Ground vegetation is most commonly *Sphagnum spp*. and Sedge spp.
Riparian Meadow (Riparian Marsh)	Mainly along the shores of large rivers with relatively large flood plains. There is no tree cover. The shrub layer is generally less than 2 m tall and consists mostly of sweet gale, speckled alder, and red-osier dogwood (*Cornus stolonifera*). The ground vegetation is generally dominated by blue-joint reedgrass (*Calamagrostis canadensis*), tall meadow rue (*Thalictrum pubescens*), and dwarf red raspberry (*Rubus pubescens*).
Black Spruce/Feathermoss	Tree cover is moderately dense black spruce dominant. The shrub layer is mainly Labrador tea, velvetleaf blueberry (*Vaccinium myrtilloides*), and regenerating black spruce. Ground vegetation is a moss carpet primarily of red-stemmed feathermoss.
Mixedwood	Tree cover is dense mixture of heart-leaved paper birch (*Betula cordifolia*), balsam fir, and black spruce. Shrub layer is composed of mixture of tall shrubs including green alder (*Alnus viridis*) and squashberry (*Viburnum edule*) along with regenerating balsam fir and black spruce. Ground vegetation is also a mixture of mosses (dominant mosses: red-stemmed feathermoss, stair-step moss (*Hylocomium splendens*) and knight's plume moss (*Ptilium crista-castrensis*)) with forbs and pteridophytes including bunchberry (*Cornus Canadensis*), twinflower (*Linnaea borealis*) and stiff clubmoss (*Lycopodium annotinum*).

Habitat Classification	Habitat Classification Description[1]
Fir-White Spruce Woodland	Tree cover is dense balsam fir and white spruce, with some heart-leaved paper birch. The shrub layer is advanced regenerating balsam fir with speckled alder and squashberry. Ground vegetation is a mixture of mosses (dominant mosses: stair-step moss and red-stemmed feathermoss) with forbs including bunchberry, twinflower (*Linnaea borealis*), wild-lily-of-the-valley (*Maianthemum canadense*), naked bishop's cap (*Mitella nuda*) and northern starflower (*Trientalis borealis*).
Hardwood	Tree cover is a dense mixture of heart-leaved paper birch, white birch (*Betula papyrifera*), trembling aspen (*Populus tremuloides*), balsam popular (*Populus balsamifera*), balsam fir, white spruce, and black spruce. Shrub layer is generally tall shrubs of speckled alder and squashberry with advanced regenerating balsam fir, black spruce, and heat-leaved paper birch. Ground vegetation is a mixture of forbs such as bunchberry, creeping snowberry (*Gaultheria hispidula*), twinflower, and northern starflower with small patches moss primarily of red-stemmed feathermoss.
Spruce-Fir Feathermoss	Tree cover is moderately dense black spruce and balsam fir. Shrub layer is advanced regenerating black spruce and balsam fir. Ground vegetation is a moss carpet mixture of red-stemmed feathermoss, knight's plume moss, and stair-step moss with some *Sphagnum spp.*
Riparian Thicket	Sparse tree cover of heart-leaved paper birch, white spruce, and balsam fir. Shrub layer is dense mixture of speckled alder, Willow (*Salix Spp.*), sweet gale, red-osier dogwood, and red raspberry (*Rubus idaeus*). Ground vegetation is composed of blue-joint reedgrass, dwarf red raspberry, tall meadow-rue, and swamp aster (*Symphyotrichum puniceus*).

Source:

1 – Minaskuat Inc. 2008b

Notes:

4. Habitat referred to as Ecotype in the report

APPENDIX B

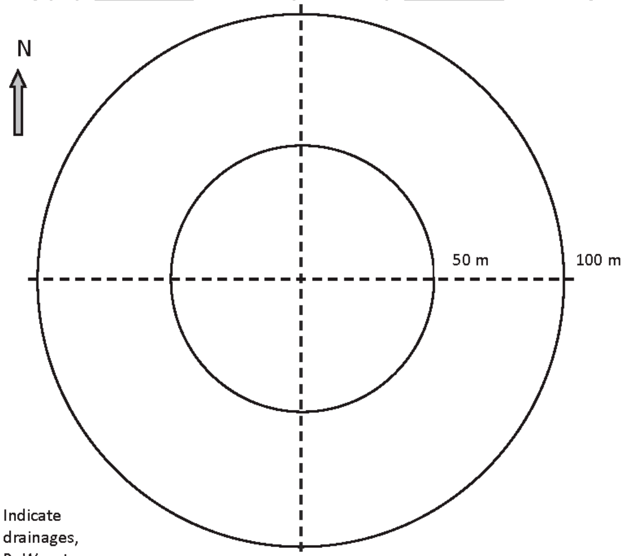
Field Datasheet Template

Forest Breeding Bird Survey

Project Name: __________________ **Project Number:** ___________ **Biologist:** ________________ **Date:** _________

Start time: ______ **UTM Zone:** ___ **Easting:** ___________ **Northing:** ____________ **Waypoint:** ______________

Temp(°C): ________ **Wind** (Beaufort)**:** ________ **Precipitation:** ____________________ **Cloud cover:** _______%



Indicate drainages, RoWs, etc.

Noise: ___ **Ecosite Phase:** ___ **Struc. Stage:** ___

Photos: __________________________________

Dominant vegetation:		**Species**	**% of layer**
Tree canopy	Primary		
	Secondary		
Total canopy cover		%	
Shrub layer	Primary		
	Secondary		
High (>3m) shrub cover		%	
Low (<3m) shrub cover		%	
Ground cover	Primary		
	Secondary		
Snag density within 100 m		N / L / M / H	
Coarse woody debris		Y / N	

Other notes: ______________________________

____

Species	#	Sex	Age[1]	Seen	Heard	Dist. (m)	Bearing[2]	Inc.[3]	Fly-by	Behaviour / comments

1 – adult (A), juvenile (J), or unknown (U)
2 – only required for species of management concern
3 – check off this column if the observation is an incidental (>100 m from observation point, or before/after the count)

APPENDIX C

Earth Observation for Sustainable Development (EOSD)
Land Cover Classifications

Table C.1 Earth Observation for Sustainable Development (EOSD) Land Cover Classifications

Habitat Classification	Habitat Classification Description[1]
No Data	-
Cloud	-
Shadow	-
Snow/Ice	Glacier/Snow
Rock/Rubble	Bedrock, rubble, talus, blockfield, rubbley mine spoils, or lava beds
Exposed Land	<5 % vegetation. River sediments, exposed soils, pond or lake sediments, reservoir margins, beaches, landings, burned areas, road surfaces, mudflat sediments, cutbanks, moraines, gravel pits, tailings, railway surfaces, buildings and parking, or other non-vegetated surfaces.
Water	Lakes, reservoirs, rivers, streams, or salt water.
Shrub-Tall	At least 20% ground cover which is at least one-third shrub. Average shrub height ≥ 2 m.
Shrub-Low	At least 20% ground cover which is at least one-third shrub. Average shrub height < 2 m
Herb	Vascular plant without woody stem (grasses, crops, forbs, graminoids). Minimum of 20% ground cover **or** one-third of total vegetation must be herb.
Bryoids	Bryophytes (mosses, liverworts, and hornworts) and lichen (foliose or fruticose, not crustose). Minimum of 20% ground cover **or** one-third of total vegetation must be a bryophyte or lichen.
Wetland – Coniferous	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is coniferous.
Wetland – Broadleaf	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is broadleaf.
Wetland – Mixedwood	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is mixedwood.
Wetland – Shrub – Tall	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is tall shrub.
Wetland – Shrub – Low	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is low shrub.
Wetland – Herb	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is herb.

Habitat Classification	Habitat Classification Description[1]
Wetland – Bryoid	Land with a water table near, at, or above the soil surface for enough time to promote wetland or aquatic processes. The majority of vegetation is bryoid.
Coniferous – Dense	> 60% crown closure. Coniferous trees are 75% or more of total basal area.
Coniferous – Open	26-60% crown closure. Coniferous trees are 75% or more of total basal area.
Coniferous – Sparse	10-25% crown closure. Coniferous trees are 75% or more of total basal area.
Broadleaf – Dense	> 60% crown closure. Broadleaf trees are 75% or more of total basal area.
Broadleaf – Open	26-60% crown closure. Broadleaf trees are 75% or more of total basal area.
Broadleaf – Sparse	10-25% crown closure. Broadleaf trees are 75% or more of total basal area.
Mixedwood – Dense	> 60% crown closure. Neither coniferous or broadleaf account for 75% or more of total basal area.
Mixedwood – Open	26-60% crown closure. Neither coniferous or broadleaf account for 75% or more of total basal area.
Mixedwood – Sparse	10-25% crown closure. Neither coniferous or broadleaf account for 75% or more of total basal area.

Source:

1. Table 3 in Wulder and Nelson 2003

APPENDIX D

List of Observed Species, 2014-2016 Point Count Surveys

Table D.1 Species List Observed during Point Count Surveys, 2014-2016

Common Name	Scientific Name	Number of Observations during Point Counts	Included in Species Richness Calculation[2]
Canada Goose	*Branta canadensis*	15	No
American Green-winged Teal	*Anas crecca*	Incidental Only	No
Common Merganser	*Mergus merganser*	Incidental Only	No
Ruffed Grouse	*Bonasa umbellus*	2	No
Common Loon	*Gavia immer*	2	No
Merlin	*Falco columbarius*	1	No
Red-tailed Hawk	*Buteo jamaicensis*	Incidental Only	No
Osprey	*Pandion haliaetus*	4	No
Solitary Sandpiper	*Tringa solitaria*	2	No
Spotted Sandpiper	*Actitis macularius*	7	No
Greater Yellowlegs	*Tringa melanoleuca*	6	No
Wilson's Snipe	*Gallinago delicata*	1	No
Yellow-bellied Sapsucker	*Sphyrapicus varius*	2	Yes
Downy Woodpecker	*Picoides pubescens*	1	Yes
American Three-toed Woodpecker	*Picoides dorsalis*	4	Yes
Black-backed Woodpecker	*Picoides arcticus*	3	Yes
Northern Flicker	*Colaptes auratus*	1	Yes
Olive-sided Flycatcher	*Contopus cooperi*	1	Yes
Yellow-bellied Flycatcher	*Empidonax flaviventris*	29	Yes
Alder Flycatcher	*Empidonax alnorum*	27	Yes
Least Flycatcher	*Empidonax minimus*	21	Yes
Philadelphia Vireo	*Vireo philadelphicus*	3	Yes
Red-eyed Vireo	*Vireo olivaceus*	1	Yes
Gray Jay	*Perisoreus canadensis*	112	No
American Crow	*Corvus brachyrhyncos*	8	No
Common Raven	*Corvus corax*	8	No
Bank Swallow	*Riparia riparia*	15	No

Common Name	Scientific Name	Number of Observations during Point Counts	Included in Species Richness Calculation[2]
Boreal Chickadee	*Poecile hudsonicus*	15	Yes
Red-breasted Nuthatch	*Sitta canadensis*	17	Yes
Brown Creeper	*Certhia americana*	Incidental Only	No
Winter Wren	*Troglodytes hiemalis*	6	Yes
Golden-crowned Kinglet	*Regulus satrapa*	1	Yes
Ruby-crowned Kinglet	*Regulus calendula*	189	Yes
Swainson's Thrush	*Catharus ustulatus*	310	Yes
Hermit Thrush	*Catharus guttatus*	27	Yes
American Robin	*Turdus migratorius*	80	Yes
Northern Waterthrush	*Parkesia noveboracensis*	67	Yes
Tennessee Warbler	*Oreothylpis peregrina*	154	Yes
Orange-crowned Warbler	*Oreothylpis celata*	23	Yes
Mourning Warbler	*Geothylpis philadelphia*	1	Yes
Common Yellowthroat	*Geothlypis trichas*	Incidental Only	No
American Redstart	*Setophaga ruticilla*	6	Yes
Cape May Warbler	*Setophaga tigrina*	13	Yes
Magnolia Warbler	*Setophaga magnolia*	22	Yes
Yellow Warbler	*Setophaga petechia*	30	Yes
Blackpoll Warbler	*Setophaga striata*	11	Yes
Palm Warbler	*Setophaga palmarum*	5	Yes
Yellow-rumped Warbler	*Setophaga coronata*	168	Yes
Black-throated Green Warbler	*Setophaga virens*	101	Yes
Wilson's Warbler	*Cardellina pusilla*	12	Yes
Savannah Sparrow	*Passerculus sandwichensis*	5	Yes
Fox Sparrow	*Passerella iliaca*	99	Yes
Song Sparrow	*Melospiza melodia*	1	Yes
Lincoln's Sparrow	*Melospiza lincolnii*	16	Yes
White-throated Sparrow	*Zonotrichia albicollis*	109	Yes
White-crowned Sparrow	*Zonotrichia leucophrys*	3	Yes

Common Name	Scientific Name	Number of Observations during Point Counts	Included in Species Richness Calculation[2]
Dark-eyed Junco	*Junco hyemalis*	249	Yes
Rusty Blackbird	*Euphagus carolinus*	5	Yes
Pine Grosbeak	*Pinicola enucleator*	4	Yes
Purple Finch	*Haemorhous purpureus*	1	Yes
White-winged Crossbill	*Loxia leucoptera*	19	No
Common Redpoll	*Acanthis flammea*	1	Yes
Pine Siskin	*Spinus pinus*	18	No
TOTAL	**63**	**2064**	**43**

Notes:

1. The number of point count records is based on the five-minute listening period, and only birds recorded <100 m from the observer, unless otherwise indicated.
2. Only those species targeted by point count surveys were included in the analysis of species richness. This primarily included passerines and woodpeckers [refer to Section 2.4 and Stantec Consulting Ltd. (2013)]
3. Incidental observations include flyovers, observations greater than 100 m from the observer, observations during the Black-capped Chickadee (*Poecile atricapillus*) mobbing call, and between point counts.

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DOCUMENT REVIEW
Comment Sheet

Completed by LCP Representative				**Completed by LCPDCC**
Document Title:				Record Number:
Nalcor Energy Lower Churchill Project, Environmental Effects Monitoring Program - Avifauna				
NE-LCP Document Number:	Revision:	3RD Party Document Number:	Revision:	Transmittal Number:
LCP-SC-CD-0000-EV-RP-0119-01				
LCP Department of Origin:		Purchase Order/Contract Number:		Transmittal Date:
Distribute Comment Sheet to:		Date returned to LCPDCC		

LCP Representative:	Lead Reviewer:
Jackie Wells	Jackie Wells

Comments:

Item No.	Section/Paragraph /Page/Sheet	Comment	Response	Status
1	Section 2.1, 2nd paragraph, 2nd sentence, Page 3	Replace “Happy Valley-Goose Bay” with “Muskrat Falls”		
2	Section 2.1, 2nd paragraph, last sentence, Page 3	Delete this sentence.		
3	Section 2.4.1, 2nd paragraph, 3rd sentence, Page 13	“covoariates” should be “covariates”		
4	Section 2.4.1, 3rd paragraph, 4th bullet, Page 14	Species names should be in italics for all species listed		

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DOCUMENT REVIEW
Comment Sheet (Cont'd)

Comments:

Item No.	Section/Paragraph /Page/Sheet	Comment	Response	Status
5	Section 2.4.1, 4th paragraph, 1st sentence, Page 14	"habitats" should be "habitat"		
6	Section 2.4.1, 4th paragraph, last sentence, Page 14	"determined" should be "determine"		
7	Section 2.4.2, 1st paragraph, 11th sentence, Page 14	"buffers around point counts" should be "buffers around point count"		
8	Section 2.4.2, 1st sentence, Page 16	Are there two "l's" in "collinearity"?		
9	Section 2.4.2, 4th sentence, Page 16	"…developed *a priori* on ecological basis…" should be "…developed *a priori* on an ecological basis…"		
10	Section 3.1, 3rd paragraph, 2nd sentence, Page 19	"and 57% within the RoW" should be "and 57% within the reservoir"		
11	Section 3.2, 1st paragraph, 2nd sentence, Page 21	"..courtship display in a burn" should be "..courtship display in a burn area"		
12	Section 3.2, 4th paragraph, 3rd sentence, Page 21	should "(Table 3.1)" be "(Table 3.2)"		
13	Section 3.2, Table 3.2, Rows 11 and 12, last Column, Page 22	Row 12 has text "thought to be the same individuals" (plural). Why the "s" when Row 11 says there was one individual? Typo I think.		
14	Section 3.3, 5th paragraph, 1st sentence, Page 26	"… at The Muskrat Falls site" should be "… at the Muskrat Falls site"		

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DOCUMENT REVIEW
Comment Sheet (Cont'd)

Comments:

Item No.	Section/Paragraph /Page/Sheet	Comment	Response	Status
15	Section 3.4, 1st paragraph, 3rd sentence, Page 27	"Gulls Island" should be "Gull Island"		
16	Section 3.4, 2nd paragraph, 1st sentence, Page 27	Should "(Figure 3-6)" be "(Figure 3-4)"		
17	Section 3.4, 3rd paragraph, 5th sentence, Page 29	"Global Model" should be "global model"		
18	Section 4.1, last paragraph, last sentence, Page 34	"…observed pre-flooding Common Yellowthroat.." should be "…observed pre-flooding: Common Yellowthroat.."		
39	Section 5.0, 5th sentence, Page 39	"During the Avifauna EEMP, The Project's…" should be "During the Avifauna EEMP, the Project's…"		
40	Section 5.1, last sentence, Page 39	Should "Other" be "Others"?		

NE-LCP Lead Reviewer:________________________ Date: ________________________

For Contractor:____________________________ Date: ________________________

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