Bipole III Transmission Project: Mammal Monitoring Program Technical Report Year 5 (2018/19) – Part B

Bipole III Transmission Project
WX17393

Prepared for:

Manitoba Hydro

Licensing and Environmental Assessment, 360 Portage Avenue (5th Floor),
Winnipeg, Manitoba, R3C 0G8

February 2020

Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited
440 Dovercourt Drive
Winnipeg, Manitoba
R3Y 1N4
Canada
T: (204) 488-2997
www.woodplc.com

February 27, 2020
WX17393

Mr. James Matthewson
Senior Environmental Assessment Officer
Manitoba Hydro
Licensing and Environmental Assessment
360 Portage Avenue (5th Floor)
Winnipeg, Manitoba
R3C 0G8

Dear Mr. Matthewson:

Wood Environment & Infrastructure Solutions is pleased to provide the attached 2018/19 Mammals Monitoring Technical Report (Part B) for the Bipole III Transmission Project.

This report (Part B) summarizes mammals monitoring conducted to date with an emphasis on the Year 5 (2018/19) results from woodland caribou satellite telemetry program and associated analyses for the long-term mammals monitoring program. Components associated with aerial and ground surveys have been provided in a separate report – Part A.

We greatly appreciate the opportunity to provide support for the Bipole III Transmission Project. Should you have any questions regarding the study, please do not hesitate to contact us.

Yours sincerely,
Wood Environment & Infrastructure Solutions
a Division of Wood Canada Limited

Al Arsenault

Al Arsenault, M.Sc., CWB®, P.Biol.,
Senior Associate Wildlife Biologist

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Executive Summary

This monitoring report presents an analysis and summary of existing baseline data for mammal VECs potentially affected by the Bipole III Transmission Project ('the Project'). It provides an information base and reporting framework for annual REPORTING of mammal monitoring studies undertaken at two scales (local and landscape) to assess long-term effects of the Project (through each Project phase) on mammals with respect to:

1. Habitat alteration, population ecology and community dynamics;

2. Effectiveness of mitigation measures and management activities; and

3. Progress toward achieving Project commitments and monitoring objectives.

This document reports on monitoring studies undertaken in Year 4 (2017/18 of the long-term mammals monitoring program. Ongoing evaluation of annual monitoring results are intended to inform an adaptive management process by:

1. Providing the necessary information to allow for the implementation of adaptive mitigation measures, when and where necessary, to minimize significant effects (e.g., mortality, disturbance) to local mammal populations;

2. Facilitating modification of the monitoring design to improve rigor, sampling efficiency and/or duration; and

3. Adjusting for unforeseen Project effects encountered.

Based on the commitments outlined by MB Hydro in the Project EIS, the overall objectives of the mammals monitoring program include:

1. Expanding baseline knowledge of select VEC species interacting with the Project including estimates of population distribution, population abundance, habitat use and movement patterns, identification and fidelity of critical habitat sites;

2. Ensuring compliance with regulatory requirements and EIS commitments;

3. Monitoring and measuring VEC responses to the Project Right-of Way (ROW) creation and operation including disturbance / avoidance from sensory disturbance, direct and functional habitat loss, changes in population vital rates or demographics, and/or changes in predator-prey community dynamics;

4. Ensuring that mitigation measures, management activities, and restoration/enhancement measures are implemented;

5. Monitoring the level of success or effectiveness of mitigation measures with respect to reducing ROW effects on VECs; and

6. Identifying, measuring, and then mitigating and monitoring any unforeseen effects.

The report quantifies the Pre-construction baseline condition from 2010 to 2014 and where feasible, data from the Construction phase that was initiated in 2014 has also been evaluated. The following is a summary of key findings.

Woodland Caribou

The following is a summary of results of woodland caribou monitoring activities conducted in Year 5 (2018/19) for the satellite telemetry studies,

1. **Telemetry Studies** - Abandonment of traditionally used areas can indicate responses to disturbance. Telemetry data from collared female boreal woodland caribou were used to assess movement behavior, habitat selection and distribution on the landscape relative to the Project. Fidelity is the tendency of animals to remain in, or return to, a particular location at different times of the year and is believed to increase an individual's knowledge of the local environment by increasing their ability to find resources while reducing predation risk. Therefore, the monitoring tasks for this Project are focused on assessing whether there are any shifts in annual or seasonal range use or levels of site fidelity to these areas through Project phases. Responses are measured through site fidelity and resource selection analysis, assessing the zone of influence (ZOI) around the Project, and the extent to which the Project ROW acts as a barrier to movement. Responses by caribou to mitigation measures are also assessed to determine the effectiveness of implemented strategies.

    a) **Home Range and Seasonal Range Analyses** - The average size of home range and seasonal range use for boreal woodland caribou varied among the monitored populations. Charron Lake is located in the boreal shield and the average size of home and over-wintering ranges for the Charron Lake caribou were significantly larger than the other monitored populations in both the Pre-construction, Construction Project phases as well as the first year of Operation. Caribou in the boreal plain ranges including Wabowden, P-bog and N-Reed all had similarly sized annual and seasonal range areas in both the Pre-construction and Construction phases as well as first year of operations.

    b) **Site Fidelity** – Overall, results suggest that winter range use is scale-dependent for some caribou, where females are philopatric to general wintering areas within a larger population range but not necessarily to precise locations within these areas in every year. Conversely, patterns observed from May to September persist across scales suggesting that female caribou are attracted to specific locations during the calving and post-calving period year after year.

       There were no differences in behaviour observed in the Pre-construction phase in the Charron Lake population compared to P-Bog and Wabowden populations during any portion of the year. However, caribou in the N-Reed range demonstrated a lack of fidelity to wintering areas at both the population and seasonal scales in the years where data was available to analyse. No new data for 2019 was available for this range and this pattern should be assessed in the future if additional data becomes available.

       In both the Pre-construction, Construction phases and the first year of Operation, fidelity to calving areas by all collared caribou was strong, suggesting that Project activities were not disruptive to local caribou. Fidelity to wintering areas was also demonstrated during the monitoring period in Wabowden, Charron Lake and P-Bog ranges but was weaker than the levels of fidelity displayed by the same caribou during spring and summer months. Cows collared in the P-Bog range showed a lack of fidelity during late winter during the Construction phase. Reduced fidelity was limited to the more local seasonal scale (i.e., local sites within a monthly use area) and not a more substantial shift at the larger population range scale and only observed during February and March. This result indicates that construction activities may have disturbed caribou in the P-Bog range for a short period of time. This pattern was still present after the first year of Operation, and should continue to be assessed through later stages of the Operation phase to see whether levels of fidelity return to pre-construction levels in late winter.

1. **Zone of Influence (ZOI)** - The distance at which boreal woodland caribou change their behavior, habitat selection and distribution relative to disturbance has been labeled the ZOI; which is an area of reduced caribou occurrence.

   a) In the **Wabowden range**, the Project widened an already pre-existing linear corridor created by the railroad line. Therefore, avoidance of this existing linear feature could have been present prior to the construction of the Project. Results suggest that female boreal caribou avoided the pre-existing linear corridor by approximately 1 to 2 km prior to the Project being constructed. This avoidance did not change during Project construction nor the first year of operations, caribou continued to have reduce occurrences within 2 km of the Project across all seasons.

   b) In the **P-Bog range**, the Project created new linear corridor on the landscape. Results suggest that there has been a short ZOI of approximately 1 to 2 km during the Construction phase and into the first year of operations for most seasons.

Barrier Effects and Crossing Analysis - After the completion of the ZOI analysis, caribou behavior was further assessed on a more local scale by evaluating the extent to which the Project acted as a barrier to local movements. This crossing analysis differs from the ZOI analysis in that it evaluates the local movement responses of individual caribou to Project construction; whereas, the ZOI analysis quantifies the overall avoidance response by all collared caribou in each range.

a) **Wabowden range** - Crossing analysis revealed that there was no significant increase in the level of avoidance from the Pre-construction to Construction phase to the first year of operations by individual caribou; suggesting that the installation of the Project did not significantly increase barriers to movement for caribou. This is likely due to the fact, that a linear corridor was already present on the landscape prior to the initiation of the Project and local caribou may have already exhibited a level of habituation to the corridor.

   Results also revealed that collared caribou crossed the Project in the Wabowden range less frequently than expected. This result suggests that although caribou have not increased avoidance of the ROW during construction, they are still significantly avoiding crossing the ROW.

   Therefore, in the Wabowden range, boreal female woodland caribou do avoid the Project by a buffer of 1 to 2 km throughout the year, irrespective of Project phase. The Project is a semi-permeable barrier to movement, it does not completely prevent local movement on the landscape, however, it does reduce the frequency of caribou moving through the area directly across the ROW. Caribou do not cross the Project as frequently as would be expected by random, however, they still cross on occasion and the frequency of this behavior has not been altered by Construction or Operation to date.

b) **P-Bog range** – Crossing analysis revealed that during the initiation of Construction, individual collared caribou continued to move across the Project in similar locations to those used in the Pre-construction phase and no avoidance was detected. However, in 2017, caribou began to avoid crossing the ROW, suggesting there was lag effect in response to Construction and this avoidance continued in 2018 and in 2019.

The crossing analysis results do not contradict the ZOI results which indicated an overall avoidance buffer of approximately 1 to 2 km by caribou across seasons. Overall, collared caribou do not occur frequently within 1 to 2 km of the Project. However, caribou who decided to cross Project, are doing so less frequently than would be expected randomly. Results indicate that the Project has not been a complete barrier to local movements and may be the result of effective installation of vegetation mitigation areas.

Vegetation Mitigation - The effectiveness of the vegetation mitigation areas was assessed for the P-Bog range where detailed data currently exists on the location of where vegetation mitigation was applied. From 2016 to 2018 caribou in the P-Bog range crossed the ROW at mitigated areas more frequently than non-mitigated areas. However, from 2018 to 2019 caribou did not choose to use the mitigation areas as often as was predicted and/or as observed in previous years. This current result could be a reflection of low sample size (only one year of data for Operations phase) or could suggest that caribou may not as strongly prefer these mitigated areas now that construction is completed, and sensory disturbance is reduced. This pattern should continue to be evaluated as more data accumulates. Collared female boreal woodland caribou cross at mitigated areas more frequently than non-mitigated areas.

In the Wabowden range, vegetation mitigation was applied along the entire length of the ROW (within caribou range boundaries). Consequently, a statistical comparison of mitigated versus non-mitigated vegetation areas cannot be undertaken. However, given that caribou continue to cross the ROW in the Wabowden range (and with consideration of the results of the P-Bog range) it can be assumed that caribou are benefitting from the mitigative effect of vegetation leave areas along the segment of the ROW.

Movement Paths and High Use Areas - Movement paths were quantified using Brownian Bridge Movement Models (BBMM's) were used to identify population level movement paths during each Project phase and plotted in relation to the ROW. These population level utilization distributions were used to identify high, medium and low use areas used by caribou within each range area (Figures 5-1-32 and 5-1-33).

In both the Wabowden range (Figure 5-1-32) and the P-Bog range (Figure 5-1-33), the distribution of annual high use areas have not appreciably changed since the Pre-construction period. The distributions associated with the first year of operations are smaller but that is reflecting the smaller sample size of locations, as only one year of data has accumulated. These results suggest that overall caribou have not abandoned preferred high use areas as a result of the Project. These distributions are supported by the site fidelity analysis which has not detected significant changes in levels of fidelity at local or population scales to range areas in most instances. The exception being the late winter period in the P-Bog range

Monitoring and Mitigation Recommendations

Based on the results of the 2018/19 (Year 5) report, the following are mitigation and monitoring recommendations for Year 5 and beyond:

Woodland Caribou Telemetry Study - Continue to acquire boreal woodland caribou telemetry locations in each monitored caribou study area to evaluate behavioural responses to the Project during the Operations phase, to evaluate effectiveness of the vegetation leave areas, and to monitor adult female boreal woodland caribou mortality and survival rates. Maintain an average sample of 20 collars/study area.

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List of Acronyms

BACI	Before-After-Control-Impact (Design)
CMR	Capture-Mark-Recapture
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
EIS	Environmental Impact Statement
ELC	Ecological Land Classification
EOSD	Earth Observatory for Sustainable Development
ESS	Environmentally Sensitive Sites
GHA	Game Hunting Area
kV	kilovolt
MB Hydro	Manitoba Hydro
MB Gov	Government of Manitoba
MMU	Moose Population Monitoring Unit
NGS	Non-invasive Genetic Sampling
N-Reed	The Reed portion of the Naosap-Reed boreal woodland caribou population
P-Bog	The Bog portion of the Pasquia-Bog boreal woodland caribou population
RCM	Retrospective Comparative Monitoring (Design)
RMNP	Riding Mountain National Park
RSF	Resource Selection Function
ROW	Project Right-of-Way
VEC	Valued Ecosystem Component
WMA	Wildlife Management Area
ZOI	(Project) Zone of Influence

1.0 Introduction

On August 14, 2013, the Government of Manitoba (MB Gov) granted an Environment Act License (EA License; MB Gov 2013) to Manitoba Hydro (MB Hydro) for the Construction, Operation, and maintenance of the Bipole III Transmission Project (the 'Project'). Mechanized clearing for the Project began during the winter of 2013/14. Clearing delays were encountered in the N1 and N4 construction segments during the winter of 2014/15 (Monitoring Year 1), and in N4 in 2015/16 (Monitoring Year 2), which impaired full implementation of ground-based mammal monitoring field programs as originally planned. Construction was completed in July 2018. The Project is now in the Operation phase.

Project-related concerns about wildlife were focused largely on caribou, moose and migratory birds (CEC 2013). The Bipole III Environmental Impact Statement (EIS), technical report addendums, and regulatory review documents identify several predicted effects on wildlife VECs. These effects vary by scale and Project phase. Construction and operation of the Project potentially affects several disturbance sensitive mammalian species. Mammal valued ecosystem components (mammal VECs) selected for effects monitoring were specified in the (EIS and related documents. These include boreal woodland caribou, forest-tundra woodland caribou, barren-ground caribou, moose, elk, white-tailed deer, grey wolf, black bear and furbearers (beaver, wolf, wolverine and marten in particular). These mammal VEC's were selected because of their ecological, cultural, and economic importance, and their sensitivity to Project-related stressors. The Bipole III mammals monitoring program study design assesses population effects on select mammal VECs, disturbance thresholds (i.e., disturbance / displacement / avoidance) relative to mammal VEC responses within the Project ZOI, as well as altered mortality risk (i.e., increased disease risk, altered harvest and/or predation mortality). The focus of effects monitoring varies by mammal VEC and Project construction segment.

Potential significant residual effects (i.e., after mitigations are applied) include direct habitat loss, functional habitat loss, sensory disturbance, altered mortality risk, and/or altered predator-prey dynamics. MB Hydro committed to implementing mitigation strategies intended to offset potential and predicted Project effects, as well as monitoring to assess the effectiveness of mitigations and predicted effects. Types of ecological monitoring implemented to gather and analyze data include baseline, implementation, effectiveness and compliance monitoring. Once construction began, monitoring emphasis switched to effectiveness and compliance monitoring; baseline monitoring continued in areas adjacent to the impact areas and reference areas outside the zone of influence (ZOI) of the Project. The monitoring program identifies and measures potential effects on these species, informs the mitigation strategy, and monitors effectiveness of the strategy. A passive adaptive management framework was implemented to deal with uncertainties as they arise; poorly performing mitigation strategies or monitoring techniques are modified or replaced where warranted.

This monitoring report (Part B) presents an analysis and summary of existing monitoring program data for the woodland caribou satellite telemetry program component. The remaining components are provided in a separate report *Mammals Monitoring Program Technical Report Year 5 (2018/19) – Part A* (hereafter "Part A").

2.0 Monitoring Objectives and Framework

The Bipole III mammals monitoring program was designed with multiple objectives per mammal VEC in mind, and with the intent to examine spatio-temporal behavioral responses, as well as population level responses of each mammal VEC at multiple scales as warranted. Monitoring programs should consider disturbance factors at coarse (landscape) and fine (local) scales with respect to effects on species occurrence, persistence and viability, and to inform mitigations and management interventions (Haufler et al. 2002, Christiansen et al. 2015). Long-term effects of human disturbance on population status requires long-term monitoring and a means of demonstrating a causal relationship between exposure to disturbance and effects on population demography (Christiansen et al. 2015). This is because human development may influence population abundance but not resource selection for some species (Keim et al. 2011). Short-term direct effects are relatively easy to measure and can be directly linked to the disturbance source but are often not placed into context to understand demographic relevance (Christiansen et al. 2015). Indirect effects and lag effects are more difficult to relate to the disturbance source.

The Bipole III mammal monitoring program uses multiple indicators per mammal VEC to assess potential effects. Counts, indices, population estimates, and habitat selection lie at the core of monitoring programs because they provide guidance for species management, measuring effect of management activities or disturbance, documenting compliance with regulatory requirements and detecting incipient change (Gibbs et al. 1998). Estimates of animal abundance and composition are needed to monitor small or at-risk populations (Antao et al. 2011, Hansen et al. 2015, Joseph et al. 2006), to manage harvested species (Lounsberry et al. 2015, McCullough 1999), and to quantify population responses to inform defensible management decisions. Robust estimates of mammal abundance can be obtained using capture-mark-recapture (CMR) methods (Amstrup et al. 2005, Otis et al. 1978). Current population abundance is a function of past abundance and the demographic processes of survival, productivity, immigration and emigration (Skalski et al. 2005). The amount of resource use by a species is a function of both their resource selection and population abundance (Keim et al. 2011).

Mammals commonly exhibit sex and age-specific differences in life history strategies, home range sizes, habitat use patterns and cause-specific mortality rates (Caughley 1966, Cederlund & Sand 1994), which can be affected differently by disturbance (Laurian et al. 2008, Polfus et al. 2011) and season. Any disturbance is likely to vary spatially and temporally, with effects on mammals also being inherently variable with respect to species, their susceptibility to disturbance, exposure to disturbance, seasonal distribution and their behavioral response (Christiansen et al. 2015, Clutton-Brock et al. 1987). Therefore, where such information exists or is being collected, the Bipole III monitoring program takes into account factors such as seasonality, age and sex to control to understand the variation in measured Project responses.

Mammal-habitat relationships are fundamental to mammal ecology because of their central role in species distribution and biogeography, population dynamics, state and vital rates and individual life histories and behavioral ecology (Aldridge & Boyce 2008, Allen 1999, Cooper & Millspaugh 1999, Leblond et al. 2014).

2.1 Objectives

Based on the commitments outlined by MB Hydro in the Project EIS, the overall objectives of the mammals monitoring program include:

1. Expanding baseline knowledge of select mammal VECs interacting with the Project including estimates of population distribution, population abundance, habitat use and movement patterns, identification and fidelity of critical habitat sites.

Ensuring compliance with regulatory requirements and EIS commitments.

Monitoring and measuring select mammal VEC responses to ROW creation and operation including disturbance/avoidance from sensory disturbance, direct and functional habitat loss, changes in population vital rates or demographics, and/or changes in predator-prey community dynamics.

Ensuring that mitigation measures, management activities, and restoration / enhancement measures are implemented.

Monitoring the level of success or effectiveness of mitigation measures with respect to reducing ROW effects on mammal VECs.

Identifying, measuring, and then mitigating and monitoring any unforeseen effects.

There are species-specific monitoring objectives and parameters, which are summarized below.

2.1.1 Caribou

Caribou monitoring plan objectives (Table 2-1-1) are to:

1. Expand baseline knowledge of distribution, abundance and population characteristics of boreal woodland caribou interacting with the Project.
2. Investigate Project influence on woodland caribou at local and range (P-Bog, Wabowden, N-Reed and Charron Lake) scales.
3. Assess effectiveness of mitigation measures.
4. Investigate the influence of Project effects on mortality (predation and/or hunting and/or vehicle collisions) on boreal woodland caribou (P-Bog, N-Reed, Wabowden, Charron Lake populations), forest-tundra woodland caribou (Penn Islands and Cape Churchill populations) and barren-ground (Qamanirjuaq) caribou populations interacting with the Project.

2.1.2 Adaptive Management Framework

Monitoring is a key component of adaptive management. A passive adaptive management framework was adopted for the overall mammals monitoring program to allow for an ongoing evaluation of monitoring results as they relate to the effectiveness of the mitigation strategies and monitoring methods. This information will also be used to inform the associated adjustments required to improve effectiveness, and involves:

1. Providing the necessary information to plan, modify and/or implement adaptive mitigation measures, when and where necessary, to minimize mortality and/or disturbance to local mammal populations;
2. Modification of the mammals monitoring design to improve rigor, efficiency and/or duration; and

3. Adjust for unforeseen Project effects encountered.

In addition, active adaptive management is applied with respect to evaluating habitat mitigations applied to boreal woodland caribou corridors by using different clearing prescriptions in each range.

Project activities will cause direct and indirect changes to mammal VEC habitats through direct and/or functional habitat loss or gain. These changes can then alter wildlife population or community dynamics through altered population vital rates, state, range occupancy, predator-prey dynamics, disease and parasite transmission risk and human–wildlife encounters. Population and community level effects are strongly linked through recruitment and mortality rates via predator-prey, hunter/trapper and disease transmission dynamics. Consequently, key monitoring activities and the assessment of Project effects have been categorized into: 1) habitat effects; 2) population effects; and 3) community effects (Section 2.2).

Monitoring objectives are simultaneously met for multiple components (habitat, population and community) through integrated field and analytical approaches. Types of ecological monitoring implemented to gather and analyze data on mammal VECs largely include:

1. **Baseline monitoring** is intended to identify temporal and spatial variability within an ecosystem, biological community, or population in order to understand the historical range of variability prior to disturbance by Bipole III. Baseline monitoring will continue in areas prior to construction and clearing the ROW. After construction, baseline monitoring will be focused in reference areas outside of the Project ZOI.

2. **Effects monitoring** investigates the influence (extent and magnitude) of disturbance-related Project effects on the habitat, population and/or community level components for each mammal VEC. Reference or control sites will be used where feasible to allow for effects of the Project to be disseminated from natural variation. Assessment of pre-disturbance condition to post-disturbance is used to assess Project effects and mitigation effectiveness.

3. **Effectiveness monitoring** is conducted by measuring or estimating the effectiveness of mitigation measures, management activities, habitat restoration and enhancement measures. Where mitigation measures are not providing adequate protection for mammal VECs or their habitat, monitoring results will be used through a passive adaptive management framework to modify or identify new strategies to employ.

4. **Implementation monitoring** will be undertaken to ensure that mitigation measures were implemented as specified in the EIS, technical reports and EA License and that activities are compliant with applicable provincial and federal environmental legislation. Implementation monitoring is used to track the implementation of mitigation measures, management activities, and ecological restoration and enhancement measures identified in the EIS commitments. This inspection is largely completed by environmental inspectors overseeing the construction of the ROW.

Based on the commitments outlined by MB Hydro in the Bipole III EIS, associated technical reports, and the EA License, there are species specific monitoring commitments unique to each mammal VEC that are incorporated into the study design. In particular, moose and boreal woodland caribou have comprehensive and detailed monitoring objectives which are provided in the methods section of this report (Section 4.0).

2.2 Study Design

To achieve the principal purpose of the follow-up mammals monitoring program for the Bipole III Transmission Project, key monitoring activities and the assessment of predicted and potential Project effects were grouped under three main components (Figure 2-3-1):

1. Habitat Effects;
2. Population Effects; and
3. Community Effects.

All monitoring objectives and parameters for each mammal VEC fall under one or more of these three components. Biological systems are highly complex and interrelated and all three components share common indicators, as well as field and analytical methods. Consequently, monitoring objectives can be simultaneously met for multiple components through integrated field and analytical approaches.

Project activities will cause direct and indirect changes to mammal VEC habitats through functional habitat loss or gain (Figure 2-3-1). These changes can then alter wildlife population or community dynamics through altered population vital rates, state, annual/seasonal range distributions, predator- prey dynamics, disease and parasite transmission risk and human-wildlife encounters. Population and community level effects are strongly linked through recruitment and mortality rates via predator-prey, hunter harvest, and disease transmission dynamics (Figure 2-3-1).

Central to the conservation of mammal populations and community ecology is an understanding of factors contributing to spatial and temporal variation in the state (distribution and abundance) and demographics (population structure and vital rates) of mammals, as well as understanding of the disturbance threshold responses of species sensitive to project effects. This understanding is achieved through monitoring to measure disturbance effects and detect incipient change (Gibbs et al. 1998). Population monitoring has two explicit roles; it provides information on population state and it contributes to knowledge of effects of management actions (e.g., mitigations) on populations. Habitat monitoring is concerned with monitoring key habitat attributes (structure, composition) over time and contributes to understanding the ecological response of habitat to disturbance and management actions (restoration efforts, mitigations). Population and habitat monitoring are both required to understand project disturbance and mitigation effects on wildlife-habitat relationships and ultimately on community dynamics and ecosystem integrity.

Study designs were developed for each mammal VEC based on monitoring commitments and available data from the EIS and addendum technical reports. Additional details pertaining to these designs are provided in an addendum (Arsenault & Hazell 2014 a and b) to the Bipole III Transmission Project Biophysical Monitoring Plan (Manitoba Hydro 2015) and are also provided in detail in the methods section of this report for each VEC (Section 4.0).

Scale of assessment has a strong influence on the probability of detecting effects (Polfus et al. 2011, Vistnes & Nellemann 2008). At local, seasonal, and/or population scales, the monitoring program examines Project effects on the abundance and distribution of mammal VECs. The exact scale(s) of assessment are specific for each unique VEC. In collaboration with MB Gov, boreal woodland caribou and moose are monitored at the population range (landscape) scale, as well as the local scale. Wolves and wolverine are primarily assessed at a larger landscape scale because of their wide-ranging nature. The remaining mammal VECs are small fur bearing mammals assessed solely at the local scale. Telemetry studies and non-invasive genetic sampling methods are implemented to monitor boreal woodland caribou populations interacting with the Project, as well as a reference range.

A moose monitoring plan is evolving for the Project and currently includes winter population surveys of the sensitive moose ranges, moose distribution surveys concurrent with boreal woodland caribou recruitment surveys, and local occurrence along the Project ROW using a combination of methods including remote IR cameras at access points and along the ROW, winter ground transects, and as a component of the multi-species aerial survey of N1 through C1 construction segments. A study design for a moose telemetry study was proposed and developed in consultation with MB Gov during Year 1 (2014/15) for implementation in Year 2 (2015/16) of the mammals monitoring program but was not implemented in response to local public consultation conducted by MB Gov in 2015. A non-invasive genetic sampling design was then proposed as an alternative to the moose telemetry study, but was not supported for implementation by MB Gov.

To test mammal VEC specific hypothesis, a Before-After Control-Impact (BACI) study design (McComb et al. 2010) was applied where pre-existing and/or reference data permitted. Where feasible, the ZOI around the Project will be determined for each mammal VEC and used as the minimum boundary between impacted and non-impacted areas. For mammal VECs where reference / control site and/or comprehensive pre-construction data are not available, effects monitoring will be documented through temporal analysis focused on characterizing long-term trends, involving comparison of pre-disturbance versus post-disturbance within a Retrospective Comparative Monitoring (RCM) design (McComb et al. 2010) or analogous alternative. The Project intersects the Prairie, Boreal Plain, Boreal Shield and Hudson Plain ecozones (Figure 2-3-2). As mammalian communities may have different characteristics across different ecozones, survey locations have been selected to collect data across a diversity of habitat types within the ecozones where significant Project effects for particular mammal VECs are anticipated. Locations, methods, and study area extent employed during pre-construction surveys have been incorporated where feasible to facilitate comparisons of before and after impact.

It should be noted that true replication in natural systems is often impossible. Designs involving treatment and control at large scales is impractical because of natural variation; ecosystems are dynamic. It is not possible to design monitoring programs to measure the dynamics of every species and every ecosystem process (Christensen et al. 1996). Also, gathering data in relation to patterns of ownership, access to areas and sampling technique limitations and biases are additional issues that complicate large scale study design and analysis, and should be reflected in any interpretations or conclusions (Christensen et al. 1996). The design, development and maintenance of monitoring programs requires commitment and long-term vision (Christensen et al. 1996).

Table 2-1-1: Monitoring Activities for Caribou

Phase	Task	Environmental Indicator	Site Location	Duration	Frequency	Timing	Measurable Parameter
Construction Post-construction	Population monitoring	Change in population state (viability, structure, abundance)	P-Bog, N-Reed, Wabowden, Charron Lake (reference) woodland caribou ranges	≤25 years or until suitable knowledge acquired	3 year intervals	Winter	Significant range (landscape) scale change in population abundance, structure, growth rate and/or viability
Post-construction	Distribution monitoring	Change in distribution (core use areas) or movements (barrier effects)	P-Bog, N-Reed, Wabowden, Charron Lake (reference) woodland caribou ranges	4 years via telemetry study (maintain 20 collars/range)	Annual, continuous via telemetry study	Year round via telemetry study	Range and local scale Project-related range contraction, barrier effects altered site fidelity levels, altered Project ROW use and zone of influence (ZOI).
Construction Post-construction	Mortality investigation, calf recruitment survey	Change in collared adult female mortality, vehicle collisions, calf recruitment	P-Bog, N-Reed, Wabowden, Charron Lake (reference) woodland caribou ranges	Up to 4 years	Annual via telemetry study and aerial surveys	Year round via telemetry study	Range and local scale changes in mortality or recruitment rate relative to historical trend
Construction Post-construction	Functional habitat availability monitoring via telemetry studies and systematic surveys	Change in occurrence, prevalence, distribution, movements and/or habitat use	P-Bog, N-Reed, Wabowden, Charron Lake (reference) woodland caribou ranges	3 years via telemetry studies in combination with aerial, surveys	Annual, continuous via telemetry study	Year round via telemetry study	Detection of a zone of influence affecting occurrence or prevalence
Construction Post-construction	Aerial distribution surveys, IR camera studies, winter ground transects,	Altered predator-prey dynamics	P-Bog, N-Reed, Wabowden, Charron Lake (reference) woodland caribou ranges	Minimum 2 years post-construction	Annual	Winter (aerial surveys, ground transects), year-round (IR cameras)	Change in mortality or mortality risk relative to Project disturbance
Construction	Sensory disturbance monitoring	Presence / absence in N1 LSA	N1, Pen Islands, Cape Churchill populations	2 years	Annual	Winter	Proximity relative to construction

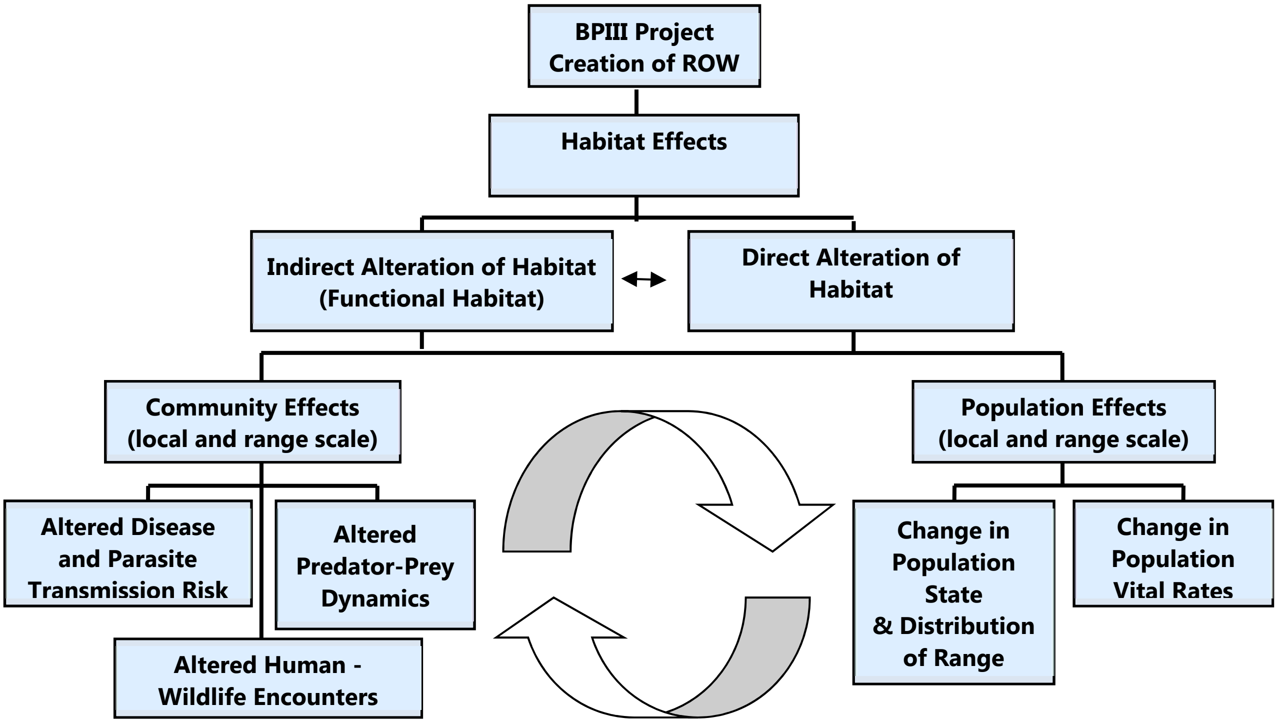

Figure 2-3-1: Monitoring Design Conceptual Overview of Effects Pathways

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LEGEND

- Ecozones
- Ecoregions

BPIII Transmission Line Route

By Section

- N1
- N2
- N3
- N4
- C1
- C2
- S1
- S2

- AC Collector Lines

0 70 140 210 280 350 Kilometres

NOTES:
- Background topographic map extracted from ESRI online basemap services
-

Datum: NAD83
Projection: UTM Zone 14N

Manitoba Hydro

wood.

MANITOBA HYDRO BIPOLE III TRANSMISSION PROJECT

Bipole III Transmission Project Overview

PROJECT N°: WX17393

FIGURE: **2-3-2**

SCALE: 1:2,300,000

DATE: December 2019

3.0 Monitoring Activities

Pre-monitoring (2013/14) – Pre-monitoring activities conducted by MB Hydro in 2013/14 are presented in AMEC (2014). These activities included acquisition and review of existing information and baseline data for the Bipole III Project, including the Project's EIS, regulatory review documents and associated technical reports and included compilation of Project commitments. This informed the planning and development of a comprehensive and rigorous mammals monitoring plan scope, which is a component of the Bipole III Transmission Project Biophysical Monitoring Plan (Manitoba Hydro 2015).

Year 1 (2014/15) Monitoring - The mammals monitoring plan is presented in AMEC's Year 1 monitoring workplan and was presented at a meeting (September 17, 2014) with Manitoba Conservation and Water Stewardship (Arsenault & Hazell 2014a and b). Mammals monitoring results for Year 1 were presented in Amec Foster Wheeler 2016.

Year 2 (2015/16) Monitoring – a summary of activities and results for Year 2 are provided in Amec Foster Wheeler 2017.

Year 3 (2016/17) Monitoring – a summary of activities and results for Year 3 are provided in Wood 2018.

Year 4 (2017/18) Monitoring – a summary of activities and results for Year 4 are presented in this report.

Year 5 (2018/19) Monitoring – a summary of activities and results for Year 5 are presented in Part A and Part B of the Year 5 Mammals Monitoring Technical Reports.

3.1 Data Acquisition – Year 5 (2018/19)

Data obtained from sources outside of that collected by Wood Environment & Infrastructure Solutions include the following:

1. MB Hydro - Boreal woodland caribou GPS satellite telemetry data collected by MB Hydro from 2010 to 2019 were acquired for each monitored boreal woodland caribou population (P-Bog, N-Reed, Wabowden) for analysis of baseline movement behaviors in ranges directly intersected and adjacent to the Project, as well as for a reference population (Charron Lake).

2. Other data obtained and used in the report *Mammals Monitoring Program Technical Report Year 5 (2018/19) – Part A* (hereafter "Part A") was from MB Gov (Provincial moose population survey results for populations in proximity to the Project, annual furbearer harvest statistics for 42 registered traplines) as well as MB Hydro for the Multi-species Aerial Survey.

3.2 Field Activities – Year 5 (2018/19)

Most of the field surveys and data analysis pertain to monitoring components presented in *Mammals Monitoring Program Technical Report Year 5 (2018/19) – Part A* (see Section 4.0 for details of survey design). For this Part B report, the satellite telemetry monitoring component, the following primary data collection methods were undertaken in Year 5:

1. **Woodland Caribou Recruitment Surveys** assisted by GPS telemetry relocations in all woodland caribou study areas.

2. **Caribou Fecal Pellet Sampling** - Non-invasive Genetic sampling (NGS) for Capture-Mark-Recapture (CMR) population estimation in all woodland caribou study areas.

3. **Woodland Caribou Telemetry Study** – ongoing monitoring of caribou occurrence and movement dynamics in each woodland caribou study area using GPS satellite telemetry data obtained from MB Hydro. Fresh collars were deployed (February 16 to 20, 2019) in Charron Lake (n = 19; 2 failed), Wabowden (n = 21) and P-Bog (n = 18) caribou ranges.

4. Boreal woodland caribou **Telemetry collar Mortality investigations.**

5. **Winter Track Transects and Camera Trap Studies** to collect incidental local scale occurrence of caribou relative to the ROW.

4.0 Methods

This report focuses on quantifying and comparing results from the Pre-construction phase (2010 to November 2014) to the Construction phase (December 2014 to August 2018) to the first year of operations (September 2018 to July 2019). The following section provides summaries of field and analytical methods.

4.1 Boreal Woodland Caribou

Three woodland caribou ranges (P-Bog, N-Reed and Wabowden) interact with the Bipole III Project (Figure 4-1-1). In addition, Charron Lake is used as a reference woodland caribou range for population demographic and telemetry analytical comparisons.

4.1.1 GPS Satellite Telemetry Studies

GPS satellite collar telemetry studies were initiated for the Project in 2010 and are currently underway in four woodland caribou ranges. Two of the woodland caribou ranges (P-Bog, Wabowden) interact with the Project and have been included in the monitoring program to assess the extent (if any) that the Project alters movement dynamics of woodland caribou within each of these ranges. Caribou within the N-Reed range have not demonstrated frequent interaction with the Project footprint since the monitoring program was initiated in 2014. Charron Lake is included in the monitoring program as a reference range that is isolated from the Project, as well as other forms of cumulative disturbance (e.g., mining and forestry). These ranges were all delineated through long term monitoring data of satellite collared caribou and defined by MB Gov (Government of Manitoba 2014). Telemetry was continued in Year 5 of this monitoring program, including deployment of additional collars in three caribou ranges (Charron Lake n = 19; 2 failed; Wabowden n = 21 and P-Bog n = 18 caribou ranges).

A Before-After-Control-Impact (BACI) study design has been implemented to assess for potential shifts in behaviour relative to baseline conditions observed during the Pre-construction period and/or the reference location, as well as across all phases of the Project including; 1) Pre-construction; 2) during Construction; and; 3) Post-construction. Specifically, monitoring objectives for the woodland caribou satellite telemetry program are to:

1. Quantify whether there are any shifts in annual or seasonal range use through Project phases. Shifts in range use can indicate responses to disturbance or suggest adaptation to variation in local abiotic or biotic factors.

2. Quantify whether there are any shifts in levels of site fidelity to annual and/or seasonal ranges areas through different phases of the Project. Abandonment of traditionally used areas can indicate responses to disturbance.

3. Quantify resource selection functions and use RSF models to control for habitat related variation in ZOI.

4. Determine whether there is a detectable ZOI around the Project demarcating the change in behaviour of caribou relative to the Project location.

5. Determine whether the Project has caused a barrier to movement on the landscape.

6. Quantify the extent to which caribou are using or benefitting from mitigative tools installed on the landscape such as vegetation leave areas.

Annual and seasonal range use and site fidelity analyses were completed for all ranges. Analysis of the ZOI around the Project was completed for the Wabowden and the P-Bog ranges for both the Pre-construction, Construction phases and the first year of Operation. Too few animals in the N-Reed range have spent enough time in proximity to the Project to quantify the ZOI for this range. ZOI analysis will not be undertaken for the Charron Lake range as it is not impacted by the Project and is a reference range.

In the Wabowden range, the Project widened an already pre-existing linear corridor providing the unique opportunity to examine the response of caribou to the widening of an existing linear disturbance. A ZOI around this linear feature could have been in the Pre-construction period, prior to the Project widening it. Subsequently it was decided that the analysis would; 1) assess whether there was a ZOI associated with the pre-existing linear feature during the Pre-construction phase and then 2) assess the extent to which the ZOI changed as a result of the Project installation during the Construction and Operation phases.

In the P-Bog range, aside from some limited areas adjacent to Highway 10, the Project created a largely new corridor on the landscape allowing for the assessment of the response of caribou to the creation of a new corridor. Accordingly, the analysis assessed whether there was a ZOI around the Project during the construction phase.

4.1.1.1 Range Use

Kernel analysis was undertaken to ascertain the annual home range for each GPS collared animal and the relative probabilities of use within that home range (Worton 1989) using ArcGIS 10.1 Spatial Analyst Extension and Home Range Extension v9. Kernels are used as one of the bases in the resource selection, zone of influence and site fidelity analysis.

Kernel volume contours are generated by connecting areas of equal probability of animal occurrence based on the utilization distribution, a measure of the geographic spread of observation points, and the defined smoothing factor (h). For example, a 90% kernel contour represents the region within which (during a given monitoring period), there is a 90% chance of finding the animal during the monitoring period.

The smoothing (h) factor defines the spread of the probability kernel generated over each observation point. The probability kernels are combined into a probability surface called the utilization distribution. The adaptive kernel method allows the kernel (smoothing factor) to vary slightly from the defined smoothing factor based on the density of observation points. This method is used to minimize both over and under estimation of the home range.

To ensure direct comparisons with baseline information and analysis (2010 – 2014), home ranges per collared animal were generated using a 90% volume adaptive kernels (h=0.4). Seasonal range areas such as overwintering and calving areas were generated per animal using 70% volume adaptive kernels (h = 0.4). Core over-wintering areas included data from December 1 to February 28 and core calving areas included data from May 1 to June 30. Core overwintering areas are also used to inform the genetic CMR and calf recruitment surveys in January and February and based on the success of locating animals were accurate delineations of where high concentrations of caribou spend the winter months.

4.1.1.2 Site Fidelity

Fidelity is the tendency of animals to remain in, or return to, a particular location at different times of the year (Switzer 1993) and is believed to increase an individual's knowledge of the local environment by increasing their ability to find resources while reducing predation risk (Schaefer et al. 2000). Disturbance within home range or local core use areas can cause species to abandon those areas or shift their distribution (Dyer et al. 2001, Antoniuk 2007). Therefore, demonstrating site fidelity to an area suggests that Project activities have not disturbed these individuals to the extent that they are avoiding or abandoning traditionally used areas; or, that they are not sensitive to this type of disturbance.

Studies of site fidelity have been hampered by arbitrary designations of spatial scale and the lack of null models for comparison, however Schaefer et al. (2000) developed a method to deal with both issues using empirical data to define null expectations. Following Schaefer et al. (2000), fidelity was defined as the propensity for consecutive year locations of an individual to be closer together than random pairs of locations from satellite collared caribou bounded by their distribution over a specified time. We defined the total population range as the space denoted by locations of all satellite collared animals within each respective range (i.e., Wabowden, P-Bog, N-Reed and Charron Lake) during all portions of the annual cycle. We defined the seasonal range as the space denoted by the locations of all satellite collared caribou within each respective range (i.e., Wabowden, P–Bog, N-Reed and Charron Lake) during a specific month of the annual cycle.

Null expectations of fidelity were generated at different scales and then compared to empirically based distances between consecutive year locations for each caribou. Null expectations define what we would expect to see if caribou were behaving randomly and no particular behaviour or site selection was being demonstrated. This analysis used an informed "null" such that random expectations are still derived from the empirical caribou telemetry locations themselves so are not completely random. Null expectations were generated at both a large population range scale and local seasonal range scale. The population range null was defined by computing distances between random pairs of locations during any period of the annual cycle from any year of monitoring within each range (i.e., Wabowden, P-Bog, N-Reed and Charron Lake). A bootstrapping method was used to generate the null expectation, whereby a random subsample of 100 locations was repeatedly generated to calculate the mean distance of all possible pairs and the repeated until the estimate of the mean stabilized. Therefore, the null model is consistent across all months, representing the entire extent available for the year (Schaefer et al. 2000). The seasonal range was defined as the locations of all collared caribou within each range within each month. The null expectations were derived by calculating distances between all possible pairs of locations within each month within each range for any location at least one year apart. The null model was generated separately per month and could therefore vary from month to month.

For the observed pattern, distances between consecutive year "locations" were calculated using harmonic means of monthly range use for each collared caribou. Harmonic means are a measure of the centroid of use for a given period of time; they are an average "location" per sample period (in this case, per month). Ranges may still overlap from year to year but the centre of activity within a given range can change, making harmonic means an appropriate indicator of disturbance. Harmonic means were calculated for each month for each year for each collared caribou for both the Pre-construction (2010 to 2014), Construction (2014 to 2018) and the first year of Operation (2018/19). Larger distances between monthly harmonic means from year to year indicate weaker fidelity, smaller distances between harmonic means indicates stronger fidelity.

Site fidelity was denoted as occurring when the null value was outside the confidence interval for that month. Analysis was undertaken for both the Pre-construction and Construction phases to assess whether any changes had occurred as a result of the Project. All statistical analyses were performed using R (The R Foundation for Statistical Computing).

4.1.1.3 Resource Selection models and Zone of Influence

Resource selection function (RSF) models were used to quantify selection and disturbance responses through ZOI analysis of monitored caribou during each season using recent methods developed in detail for caribou effects assessments (Johnson et al. 2005, Boulanger et al. 2012 and Johnson & Russell 2014). The base RSF models were developed and used to facilitate intra year comparisons of ZOI. The RSF model acts to control for habitat differences when quantifying the ZOI around the Project. Details on the development of the RSF are in previous years monitoring reports (Amec Foster Wheeler 2016, Amec Foster Wheeler 2017).

Zone of Influence (ZOI)

The distance at which caribou change their behaviour, habitat selection and distribution relative to disturbance has been labelled the ZOI (Johnson et al. 2005, Johnson and St. Laurent 2011, Boulanger et al. 2012) and has implications for measuring cumulative effects on wildlife (Johnson & Russell 2014, Dyer et al. 2001, Vors et al. 2007, Quinonez-Pinon et al. 2007, Leblond et al. 2011, Polfus et al. 2011 and Dussault et al. 2012). It is a measurement of reduced occurrence of caribou around a given disturbance and controls for habitat quality at a given location.

Project ZOI within Wabowden and P-Bog ranges was quantified during the Construction phase; both ranges have an accumulation of caribou telemetry locations within 10 km of the Project from 2015 to 2018. The ZOI analysis in the Wabowden range quantifies the behavioral response of caribou to widening of an existing corridor. Whereas the ZOI analysis in the P-Bog range quantifies the behavioral response of woodland caribou to a newly created linear corridor. The N-Reed range will continue to be considered for inclusion in this assessment in following years, however, currently does not have a large enough sample size of caribou location points near the Project for this analysis. In this 2019 report, the telemetry locations from September 30, 2018 to July 30, 2019 were used to assess any changes in ZOI during the first year of operations.

The base habitat model was used to iteratively estimate the Project ZOI through a piecewise conditional regression approach with distance to the Project as an additional predictor variable (Boulanger et al. 2012). As a linear corridor was present in the Wabowden prior to the initiation of the Project, a ZOI in both the Pre-disturbance and Construction phase was quantified. Whereas in the P-Bog range, the Project created a new linear corridor on the landscape, therefore ZOI was solely quantified for the Construction phase.

The habitat model accounted for caribou distribution due to habitat selection with ZOI predictor variable and associated regression coefficient. A procedure analogous to a piece-wise regression was undertaken to determine an optimal cut-point (Boulanger et al. 2012). The influence of increased distance was assessed for each category by setting all distances greater than the current distance category to that categories cut value. For example, when a 1 km distance was tested, all locations >1 km were set to 1 km regardless of how far out they were. By doing this, the odds ratio of selection relative to the Project was able to change linearly up to the hypothesized ZOI at which point it would asymptote and remain constant for distances >ZOI. Thus, the odds ratio was allowed to vary up to a maximum at the ZOI. The model fit (log-likelihood) should increase to a maximum at the ZOI, before decreasing. If there is no ZOI there would be no pattern in the log likelihood or it would remain constant across the range of distances. The distance at which the log likelihood is maximized is the estimate for the ZOI; the maximum distance where an influence of the Project can be detected.

4.1.1.4 Crossing Analysis

In the P-Bog range, the Project created a new linear corridor on the landscape in most areas. The current accumulation of monitoring data allows for the quantification of movements across the landscape prior to the Project being installed and then any changes in movement behavior in areas where the Project was constructed. Whereas in the Wabowden range, the Project follows an existing linear corridor which was subsequently widened to accommodate the Project. Therefore, the current accumulation of data allows for the quantification of any barrier effects from the pre-existing linear corridor during the Pre-construction phase, as well as widening of the ROW through the Project Construction phase.

We calculated the degree of avoidance for each individual by comparing the actual number of crossings made by individual caribou, to the number of crossings that would have made by a randomly moving caribou on the landscape (Row et al. 2007). The number of crossings made by a randomly moving caribou was generated from 100 random walk (Turchin 1998) movement paths for each individual in R (package "adehabitatLT"). Each random movement path started at the same location as its paired caribou movement path and had the same chronological series of distances moved. A randomly determined bearing was used between each move.

For this most recent report, we compared the difference between actual and random crossings during the first year of operations. Crossing analysis for earlier Project phases (Construction and Pre-construction) is found in previous reports (Amec Foster Wheeler 2016, Amec Foster Wheeler 2017). In both ranges, individuals tracked across both phases were considered independent within each time period. We also confirmed the results by comparing the observed average random crossings within an individual using a linear model.

We subsequently tested for avoidance of crossing by comparing the overall difference between observed and random crossings against 0 using a mixed model. We confirmed the overall avoidance of crossing using a t-test of the mean difference against 0 for the average random crossings.

4.1.1.5 High Use Areas - Brownian Bridge Movement Models

Movement paths were quantified using Brownian Bridge Movement Models (BBMM's) were used to identify population level movement paths during each Project phase and then be mapped in relation to the ROW.

The package BBMM in R (R Core Team 2016) was used to develop BBMM's that probabilistically identify movement paths for satellite collared individual. The model result is a spatial utilization distribution (UD) that represents the probability (between 0 and 1) that an individual enters a raster cell. The size and extent of the total raster grid was defined as the total extent of all the movement paths set to a resolution of 200 x 200 m (4 ha).

The selected cell size was a tradeoff between providing high-resolution mapping while maintaining reasonable computer processing time. The BBMM model estimates the probability density function by discretizing time into small units that can be defined in the models. Population level UD were used to identify high, medium and low use areas used by caribou in each range where each cell was categorized into low (<10% of individuals), moderate (10 to 20% of individuals) and high (>20% of individuals) use areas. These areas were then mapped to ascertain the extent to which high use movement areas occur across the ROW for each Project phase. Further analysis could be undertaken during the operations phase to drill down to the next level of detail relative to seasonal movements across the ROW by each population.

4.1.1.6 Effectiveness of Vegetation Mitigation Analysis

There are two types of vegetation clearing undertaken within caribou ranges:

1. **Full ROW Clearing** - is the entire ROW to a width of 50 m. Full ROW clearing was applied in areas that were not designated as sensitive for caribou.

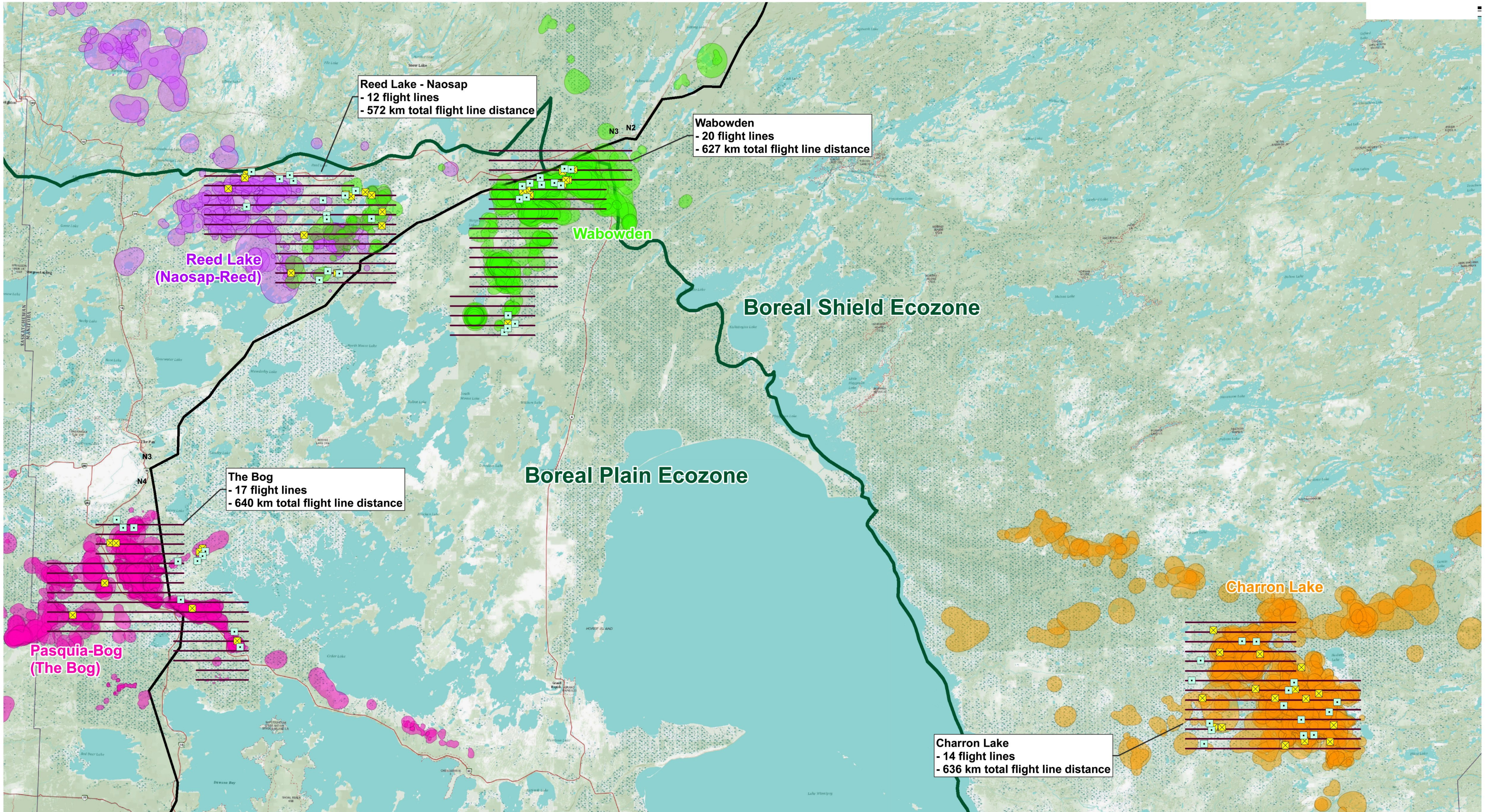
2. **Centerline Clearing** - are areas where vegetation mitigation has been applied. In these areas, the centerline of the ROW has been cleared, as well as any trees taller than the 40% line of sight (LOS) angle to the edge of the ROW and beyond. As a result, there are more trees and shrubs that are left standing as only the danger trees are removed.

The locations of these vegetation mitigation areas were selected based on the movement behavior and distribution of caribou during the Pre-construction phase. Mitigation was applied in areas that had previously been used by caribou and was focused on providing as much cover as logistically possible and shortening the width of open area the caribou would have to cross to move across the ROW. Therefore, if the mitigation strategy was effective, we would expect to see caribou continue to use these areas to cross the Project more than at areas that had not been mitigated.

- In the P-Bog range, the site-specific locations of the vegetation mitigation prescriptions is known. Analysis was undertaken to assess the extent to which these mitigation areas effectively facilitated movement across the ROW (comparison of mitigated to unmitigated areas within the range)

- In the Wabowden range, mitigation was applied the entire length of the ROW within the range. Therefore, a comparison of mitigated versus unmitigated areas could not be undertaken as the mitigation was applied everywhere.

In the P-Bog range, we assessed the extent to which caribou used the vegetation mitigation areas (Full Centerline) versus the unmitigated (Full ROW) areas to cross the ROW. We tested this by comparing the proportion of mitigated crossings to unmitigated crossings from observed caribou and 100 random caribou (same starting locations and distances, random directions). If caribou were preferentially crossing at mitigated areas, we expected a higher proportion of mitigated crossings for observed caribou. Any sequential location that was greater than 6 hours was split into separate tracks (hereafter called bursts), because we had to assume that the crossing location on either side of the ROW corresponded to the straight-line path between the locations. Longer time periods between locations increases the likelihood that this assumption is not valid. Although 3 hours could also be used, this resulted in very short bursts for many individuals. We also removed any bursts that did not cross the ROW at least twice, because the goal was to determine "where", not "if" individuals were crossing and thus bursts with zero crossings did not assist with the analysis. We used a mixed model with a random effect for individuals and a t-test on individual means to determine if individuals had a significantly higher proportion of mitigated crossings than random. Because of the similar results for the different models only t-test results are shown.



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LEGEND

- Survey Area Flight Lines
- BPIII Transmission Line Route
- Ecozones

Caribou Pellet Sampling Locations (2019)

- Round 1 Pellet Collection Sites (capture/mark, CMR1)
- Round 2 Pellet Collection Sites (re-capture, CMR2)

Over-wintering kernels per Caribou Monitoring Range

- 70% Adaptive Kernel Contours for Pasquia-Bog Collars (darker pink areas indicate greater amount of Over-Wintering overlap)
- 70% Adaptive Kernel Contours for Reed Lake-Naosap Collars (darker purple areas indicate greater amount of Over-Wintering overlap)
- 70% Adaptive Kernel Contours for Wabowden Collars (darker green areas indicate greater amount of Over-Wintering overlap)
- 70% Adaptive Kernel Contours for Charron Lake Collars (darker orange areas indicate greater amount of Over-Wintering overlap)

NOTES:
- Background topographic map extracted from ESRI online basemap services
- Collars from 2010 to 2019 are shown on the map
- Over-wintering kernels are based on telemetry locations between December and end of February
- CMR1 survey conducted between Jan. 22, 2019 and Feb. 7, 2019
- CMR2 survey conducted between Feb. 20, 2019 and Feb. 26, 2019

Datum: NAD83
Projection: UTM Zone 14N

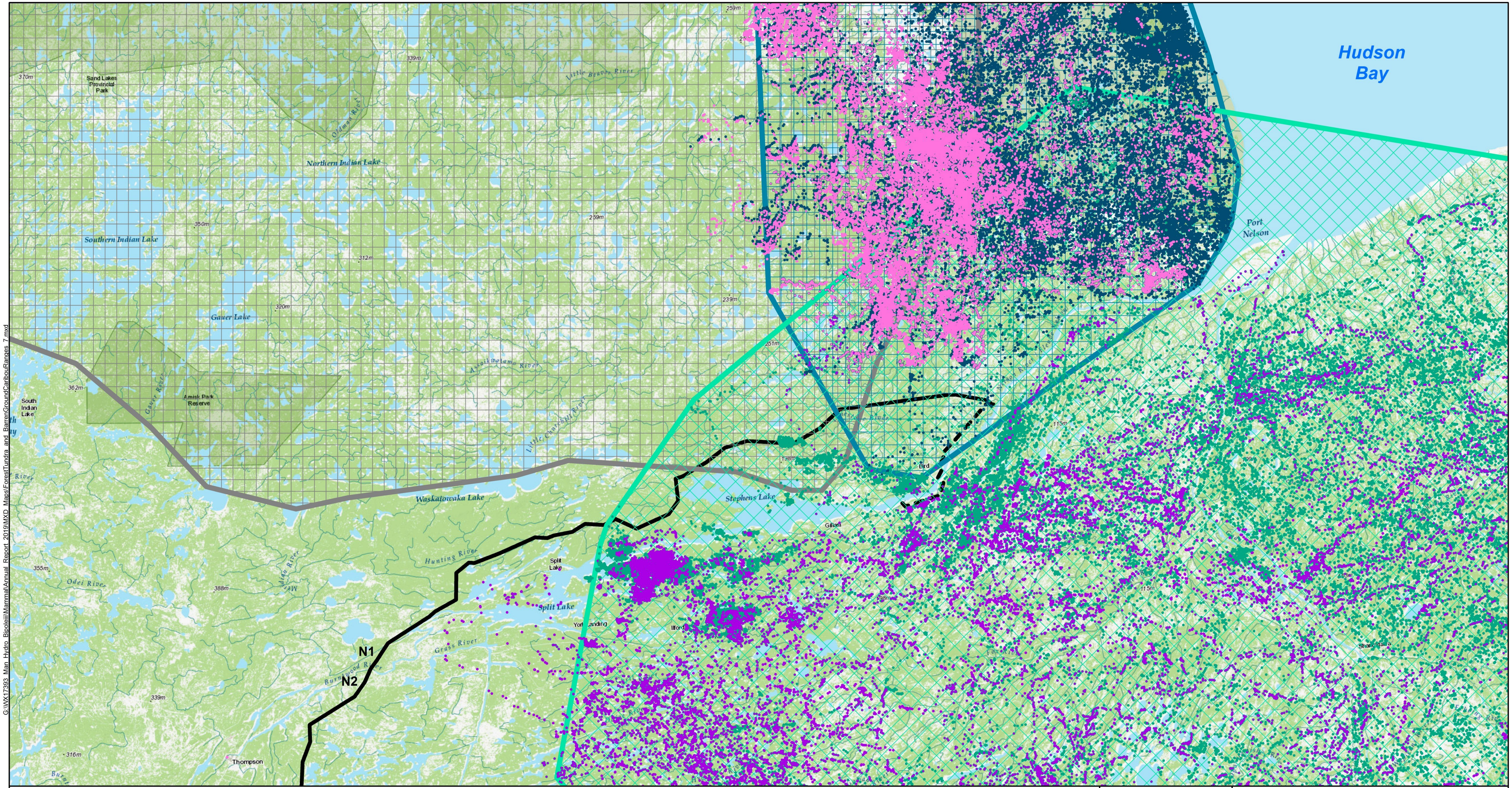
0 60 120 180 240 300 Kilometres

Manitoba Hydro | wood.

MANITOBA HYDRO BIPOLE III TRANSMISSION PROJECT

Boreal Woodland Caribou Survey Areas in Relation to Bipole III Transmission Project

PROJECT N°: WX17393	FIGURE: **4-1-1**
SCALE: 1:1,190,000	DATE: December 2019



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LEGEND

Caribou Coastal/Forest-tundra/Barren ground Ranges

- Cape Chruchill Range Boundary (2013)
- Pen Islands Range Boundary (2013)
- Beverly Qamanirjuaq Range Boundary (2010)
- AC Collector Lines
- BPIII Transmission Line Route

- Pen Islands Winter Telemetry Points (December 1st - March 31st)
- Cape Churchill Winter Telemetry Points (December 1st - March 31st)
- Pen Islands Telemetry Points (all season 2010 - Sept. 2018)
- Cape Churchill Telemetry Points (all season 2010 - January 2015)

NOTES:
- Background topographic map extracted from ESRI online basemap services
- Telemetry point for Cape range from 2010 to mid-January 2015.
- Telemetry point for Pen Is. range from 2010 to mid-September 2018.
- Winter telemetry selected as December-January-February-March

Datum: NAD83
Projection: UTM Zone 14N

0 60 120 180 240 300 Kilometres

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wood.

MANITOBA HYDRO BIPOLE III TRANSMISSION PROJECT

Forest-tundra Caribou and Barren Ground Ranges and Wintering Occurrences in Relation to Bipole III Transmission Project

PROJECT N°: WX17393	FIGURE: **4-2-1**
SCALE: 1:1,170,000	DATE: December 2019

5.0 Results and Discussion

5.1 Boreal Woodland Caribou

The monitoring program involves three boreal woodland caribou ranges (P-Bog, N-Reed, Wabowden) intersected by the Bipole III Transmission Project and one reference population (Charron Lake) (Figure 4-1-1). GPS satellite telemetry study is used for range scale and fine scale assessment of winter core use areas, habitat use patterns, movement, and mortality rates / sources (for collared adult female caribou).

5.1.1 GPS Satellite Telemetry Studies

5.1.1.1 Range Use

Distributions of annual and seasonal range areas for each monitored population have not shifted since the monitoring program was initiated and largely show similar patterns of distribution from year to year. The average home range and seasonal range use size for caribou varied across ranges in the as illustrated by the high variation around the average sizes for each range type (Table 5-1-3). The average annual and season ranges for caribou in Charron Lake caribou are significantly larger than those for any other ranges ($P<0.05$). Annual and seasonal range sizes between N-Reed, Wabowden and P-Bog caribou are not significantly different in most years.

Annual 90% kernel home ranges (Figures 5-1-3 to 5-1-6) and 70% overwintering ranges (Figures 5-1-7 to 5-1-10) for individual collared caribou overlap considerably in all four ranges. The 70% kernel calving ranges for individual collared have some level of overlap but are more spread out that than observed during the winter (Figures 5-1-11 to 5-1-14). From 2014 to 2019, the seasonal range use null models created for the site fidelity analysis corroborated this pattern, revealing that from May to September, collared cows are more spread out from each other than during the winter months as depicted in the higher null expectations for this period.

5.1.1.2 Site Fidelity

Significant philopatry is the tendency of individuals to stay in, or return to, their core use areas. It is present when null models are outside the 95% confidence intervals for empirical means per month (Figures 5-1-15 to 5-1-22).

Collared female caribou displayed varying degrees of site fidelity within each range contingent on season and scale. The larger scale population null demonstrates an annual cycle in the empirical locations across all ranges. Distances between successive year activity centers are smaller during the calving period than other times of the year in all populations, where the majority of collared females within each range show strong fidelity to areas used from May to August, often using activity centers within 1 to 10 km of the previous year (Figures 5-1-5 to 5-1-22). At the population scale, caribou returned to the same calving areas within their larger population range from year to year.

In contrast, during the winter, a broader variation in space use is observed, with some collared females demonstrating weak fidelity, using areas up to 100 km apart from the previous year while others returning to within 10 km of the previous year (Figures 5-1-5 to 5-1-22). In spite of the greater variation observed during the winter, significant philopatry was still observed at the population scale for P-Bog, Charron Lake and Wabowden ranges indicating that animals returned to the same areas within their overall population range from year to year for overwintering. This behaviour was consistent whereby strong fidelity was displayed annually during both Pre-construction and Construction time periods. Fidelity in the N-Reed range was demonstrated during the calving period but then weakened during the fall and winter period during both the Pre-construction and Construction phases.

The smaller-scale seasonal null model implies that fidelity within winter range areas was absent for Wabowden and N-Reed ranges during some months in both the Pre-construction and Construction phases (Figures 5-1-14 and Figure 5-1-16). This suggests that patterns of fidelity to very local areas during the winter did not change as the Project was constructed. Conversely caribou within the P-Bog range demonstrated fidelity to all monthly wintering areas in the Pre-construction phase and a lack of fidelity during February and March in the Construction phase (Figures 5-1-18 and 5-1-20), suggesting that in P-Bog caribou may have altered the location of their local core activity areas during Construction. For all ranges, after May, females displayed attraction to sites occupied the previous year and local areas of concentrated use within monthly ranges remained similar from year to year (Figures 5-1-13 to 5-1-20). Charron Lake caribou are reference animals and did not show a change in levels of fidelity across years or seasons at this local scale.

This analysis at the more local seasonal scale also revealed that collared caribou are closer in proximity to each other than distances between animals observed during warmer months where females tended to spread out from each other. This pattern is reflected in the null model expectations which are derived using distances between collared caribou. The null expectations during winter are lower than those predicted for the summer. The null expectation was generated by calculating distances between all possible pairs of caribou locations within each month within each range. Larger distances between caribou in each month will generate larger null expectations for that month. Null expectations from May to September are increased by 15 km compared to that observed for the winter.

Overall, results suggest that winter range use is scale dependent for some caribou, where females are philopatric to general wintering areas within a larger population range but not necessarily to precise locations within these areas each month. Conversely, patterns observed after May persist across scales indicating consistent site fidelity from calving to breeding periods irrespective of the extent of observations, suggesting that female caribou are attracted to specific locations for the calving and post-calving period from year to year.

Fidelity to wintering areas in the P-Bog range became weaker during the Construction phase for both the population and seasonal scales. Looking at the distribution of wintering areas from 2015 to 2019 reveals that caribou have not dramatically shifted their distribution on the landscape away the Project, however these results indicate that their centers of activity within these wintering areas shifted from one year to the next and may have been a response to construction activities. This pattern in P-Bog should continue to be monitored through the operations phase to assess whether caribou strengthen fidelity to wintering areas again now that Construction is complete.

For caribou, minimization of predation risk to females and calves is regarded as the underlying drive for space use patterns (Ferguson et al. 1988). Assuming the scale invariant site fidelity by female caribou for the calving and post–calving period is a strategy to minimize predation risk, these monitoring results from 2015 to 2019 support previous studies that report the consistent and limiting effects of predation on the more sedentary forest-forest ecotype populations (Seip 1992, Bergerud 1996, Rettie & Messier 1998, Schaefer et al. 1999 and Schaefer et al. 2000). This hypothesis is also supported by the increased spacing out of female caribou from each other at the more local seasonal scale. Calving in isolation from other caribou is a predator avoidance strategy as detection becomes harder (Bergerud 1996, Leclerc et al. 2012). Caribou in Wabowden, P-Bog and Charron Lake demonstrated fidelity to wintering areas within the larger population range, suggesting they may move to areas that have lower predation risk on the landscape and aerial survey results to date suggest little overlap with wolf in these areas. However, at a smaller scale, fidelity is weaker during the winter and caribou may be decoupling themselves from this predation risk (Schaefer et al. 2000) and preferring sites with better forage access or more optimal snow cover.

5.1.1.3 Zone of Influence

Previous reports revealed that there was a short ZOI of approximately 1 to 2 km during the Construction phase in the P-Bog range (Wood 2019) and a short ZOI of approximately 1 to 2 m for the pre-existing linear corridor present during the Pre-construction phase in the Wabowden range, as well for the widened corridor created through Project Construction (Wood 2019).

This pattern has continued into the first year of operations across all seasons (Figures 5-23a-e and Figures 5-24a-e). As was the case in past years for both ranges, caribou locations were fewer near the Project than areas farther away peaking in abundance at distances 10 to 15 km from the Project. As sample sizes are low within 0 to 2 km of the Project, the level of confidence with which the ZOI can be drawn at 1 km versus 2 km is uncertain. Therefore, very small changes (<1 km) in ZOI may have occurred, however, there are not enough locations to detect these shifts. Patterns in operations phases should continue to be assessed as more data accumulates.

Woodland caribou are affected by cumulative disturbance within a range (Environment Canada 2012) and behavioral responses to the Project could be affected by other disturbances within the range. In 2015, AIC analysis revealed that models which included both the distance to other linear features such as highways and distance to the existing linear corridor fit the data better than when they were included separately (Amec Foster Wheeler 2016). These responses could be explored and quantified through a more complex RSF model that was not focused on defining the ZOI around the Project in future analysis.

5.1.1.4 Crossing Analysis

After the completion of the ZOI analysis, caribou behavior was further assessed on a more local scale by evaluating the extent to which the Project acted as a barrier to local movements. This crossing analysis differs from the ZOI analysis in that it evaluates individual local movement responses of individual caribou to the Project whereas the ZOI analysis quantifies the overall avoidance response by all collared caribou within a given range. The crossing analysis specifically assesses the extent to which the Project acts as a barrier to individual local movements by caribou whereas the ZOI analysis examines overall distribution of caribou on the landscape relative to the installation of the Project.

Both linear and mixed models were run for the crossing analysis in both the Wabowden and P-Bog ranges to control for individual level responses. Mixed models control for individual level effects without having to compare mean numbers of crossings. As both models provided comparable results, we only report the results for the linear model.

In the Wabowden range, there was no overall significant increase in the level of avoidance from the Pre-construction to Construction phase (df = 1, 76; p = 0.22) indicating that widening of the ROW through the installation of the Project did not significantly alter caribou crossing behavior after the initiation of Construction. Each year from 2015 through to 2018, collared caribou were found to cross the ROW less frequently than expectations generated through random movement trajectories suggesting that they avoid crossing the ROW frequently (df = 77, $p < 0.0001$) and this behavior has been consistent across Pre-construction and Construction phases (df = 18, $p < 0.001$). During the first year of operations this pattern continued, caribou significantly avoided the ROW (df = 24, $p < 0.0001$).

In the P-Bog range, there was no significant increase in the level of avoidance from the Pre-construction to Construction phase in the first two years of Construction (Amec Foster Wheeler 2017). However, caribou did start avoiding crossing the ROW in 2017 (df = 18, p = <0.03) and this continued in 2018 (df = 18, p = <0.02) which indicates a lag effect in avoidance behavior. In 2019, caribou also significantly avoided crossing the ROW (df = 23, $p = 0.006$).

5.1.1.5 Effectiveness of the Vegetation Mitigation Strategies

During the first year of operations, caribou did not use mitigated areas more frequently than expected (df = 17, $P = 0.3$, Figure 5-25).

However, from 2016 to 2018, individuals did choose to cross the Project in the P-Bog range at mitigated areas more frequently than expected (Figures 5-26 to 5-28, Wood 2018). This was confirmed by examining the movements of individuals (Wood 2018). Results suggest that mitigated areas were put in place where caribou would naturally cross the ROW and that these locations continued to be used through the construction phase.

This change in behaviour during the first year of operations can be observed through visual assessment of the movement trajectories (Figures 5-29 to 5-30). It could be that caribou do not prefer these mitigated areas as strongly once the sensory disturbance from construction activities ceases. However, this pattern may also change and should continue to be evaluated as more years of data accumulate.

In the Wabowden range mitigated areas were put in place through the entire length of the range (Figure 5-1-31). Caribou in this range, continued to cross the ROW on occasion after Construction widened the corridor, therefore overall it is likely that these mitigations aided in reducing barrier effects. However, it is not possible to assess effectiveness further (i.e., to the same extent it can be examined in the P-Bog range), through statistical comparison of mitigated versus non-mitigated locations in this range as all of the range is considered mitigated.

5.1.1.6 Summary of the ZOI verses Crossing Analysis Results

Barrier Effects and Crossing Analysis - After the completion of the ZOI analysis, caribou behavior was further assessed on a more local scale by evaluating the extent to which the Project acted as a barrier to local movements. This crossing analysis differs from the ZOI analysis in that it evaluates the local movement responses of individual caribou to Project construction; whereas, the ZOI analysis quantifies the overall avoidance response by all collared caribou in each range.

a) **Wabowden range** - Crossing analysis revealed that there was no significant increase in the level of avoidance from the Pre-construction to Construction phase to the first year of operations by individual caribou; suggesting that the installation of the Project did not significantly increase barriers to movement for caribou. This is likely due to the fact, that a linear corridor was already present on the landscape prior to the initiation of the Project and local caribou may have already exhibited a level of habituation to the corridor.

Results also revealed that collared caribou crossed the Project in the Wabowden range less frequently than expected. This result suggests that although caribou have not increased avoidance of the ROW during Construction, they are still significantly avoiding crossing the ROW.

Therefore, in the Wabowden range, boreal female woodland caribou do avoid the Project by a buffer of 1 to 2 km throughout the year, irrespective of Project phase. The Project is a semi-permeable barrier to movement, it does not completely prevent local movement on the landscape, however, it does reduce the frequency of caribou moving through the area directly across the ROW. Caribou do not cross the Project as frequently as would be expected by random, however, they still cross on occasion and the frequency of this behavior has not been altered by Construction or Operation to date.

b) **P-Bog range** – Crossing analysis revealed that during the initiation of Construction, individual collared caribou continued to move across the Project in similar locations to those used in the Pre-construction phase and no avoidance was detected. However, in 2017, caribou began to avoid crossing the ROW, suggesting there was lag effect in response to Construction and this avoidance continued in 2018 and in 2019.

The crossing analysis results do not contradict the ZOI results which indicated an overall avoidance buffer of approximately 1 to 2 km by caribou across seasons. Overall, collared caribou do not occur frequently within 1 to 2 km of the Project. However, caribou who decided to cross Project, are doing so less frequently than would be expected randomly. Results indicate that the Project has not been a complete barrier to local movements and may be the result of effective installation of vegetation mitigation areas.

5.1.1.7 Movement Paths and High Use Areas - Brownian Bridge Movement Models

Movement paths were quantified using Brownian Bridge Movement Models (BBMM's) were used to identify population level movement paths during each Project phase and then be mapped in relation to the ROW. These population level utilization distributions were used to identify high, medium and low use areas used by caribou within each range area (Figures 5-1-32 and 5-1-33). Charron Lake was also analyzed to assess the high use areas across years.

In both the Wabowden range (Figure 5-1-32) and the P-Bog range (Figure 5-1-33) the distribution of annual high use areas have not appreciably changed since the pre-construction period. Overlap of high use areas was 3.8%, 4% and 5.5% in the pre-construction, construction and operations in the Wabowden range. In the P-Bog range, overlap with high use areas was 5.5%, 5.1% and 6.5% in the pre-construction, construction and operations phases.

The distributions associated with the first year of operations are smaller but that is reflecting the smaller sample size of locations as only one year of data has accumulated. These results suggest that overall caribou have not abandoned preferred high use areas as a result of the Project. These distributions are supported by the site fidelity analysis which has not detected significant changes in levels of fidelity at local or population scales to range areas in most instances. The exception being the late winter period in the P-Bog range (Section 5.1.1.2).