

**IDENTIFYING FOREST ROADWAYS FOR  
REHABILITATION WITHIN THE CHASE CARIBOU HERD  
RANGE BOUNDARY  
PEA-F19-W-2650**



PREPARED FOR: FISH AND WILDLIFE COMPENSATION PROGRAM  
PREPARED BY: CHU CHO ENVIRONMENTAL LLP  
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Tsay Keh Dene, BC, V0J 3N0

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**PREPARED FOR:**

THE FISH AND WILDLIFE COMPENSATION PROGRAM

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THIS REPORT WAS PREPARED WITH ADDITIONAL FINANCIAL SUPPORT FROM TSAY KEH DENE NATION, THE SOCIETY FOR ECOSYSTEM RESTORATION IN NORTHERN BRITISH COLUMBIA, ENVIRONMENT AND CLIMATE CHANGE CANADA, CONIFEX TIMBER INC. AND DUNKLEY LUMBER LTD.

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## Executive Summary:

The southern mountain population of woodland caribou (*Rangifer tarandus caribou*) is listed on Schedule 1 of the Federal *Species at Risk Act* (SARA) as ‘Threatened.’ As stated in the *Recovery Strategy for the Woodland Caribou, Southern Mountain Population in Canada*, “the range of the southern mountain population has shrunk by up to 40% and 13 of 19 herds are declining.” These herds are “threatened by decreasing habitat quantity and quality, harassment, and predation.”

The recovery strategy for the southern mountain population of woodland caribou identifies forest roadways as a factor contributing to habitat loss and population declines. The recovery plan states the following habitat management action should be taken: “Undertake coordinated actions to reclaim southern mountain caribou habitat in all currently utilized seasonal ranges through restoration efforts (e.g., restore industrial landscape features such as roads, old seismic lines, pipelines, cut-lines, temporary roads, cleared areas; reconnect fragmented annual ranges) to make it less suitable for other prey species.” This project aligns with the Fish and Wildlife Species of Interest Action Plan. Specifically, Action 1b-2: Implement projects identified through approved recovery strategies, action plans and management plans.

The Chase herd of southern mountain caribou (considered northern mountain by the province of British Columbia) appears to have declined in population from 1993 – 2019. The herd is still viable, however, and so it is important that we take a proactive approach to habitat management by restoring forest roadways at strategic locations to help prevent and arrest potential population declines.

The long-term objective of this project is to restore forest roadways at strategic locations within the herd boundary of the Chase caribou, and within Tsay Keh Dene Nation Territory. We are seeking to restore these roadways to benefit the Chase caribou by employing both functional and ecological restoration techniques to make the roadways less suitable for other prey species and predators, and ultimately return the roadways to a mature forest environment. In 2018, our project team worked to identify priority roadways for restoration based on an approach that balances ecological, cultural and logistical considerations.

Our team employed a previously developed GIS algorithm to identify reforestation opportunities on unused forest roads across the project area while ensuring minimal impacts to other users on the land base. The algorithm was applied to produce a list of candidate roads selected for rehabilitation, which was further refined through engagement with licensees operating on the land base that could be affected by these decisions. The final results from the road rehabilitation analysis identified 1,942.8 km of road with potential for rehabilitation and/or reforestation activities across the entire Chase caribou herd boundary. Assuming an average road width of 5 m, this results in 971.5 ha of area potentially available for reforestation. This list of candidate roads is a suitable starting point for road rehabilitation planning projects, large scale cumulative effects analyses, and access management planning.

Ecological considerations for road rehabilitation primarily focused around current and historic information on caribou and their distribution and use across the landscape. Data included caribou locations from 1999-2010 and 2018-2019, designated Ungulate Winter Ranges, caribou migration corridors, and local expert knowledge (from wildlife biologists that have studied the Chase herd for over 30 years combined). A total of

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21 polygons were identified around sections of road for prioritization of road rehabilitation. Prioritized high elevation areas included areas around the Swannell and Chase Mountains, and low elevation included the Ingenika River and south and east of Tutizzi Lake. Being cognizant of the potential conflict between moose and caribou, we also modeled and mapped moose habitat quality to help inform future restoration activities. These data could be used if a high priority road is directly adjacent to or connects moose and caribou habitat. Reforestation techniques may try to use species that are unpalatable to moose to limit or reduce that potential for conflict.

Our project team then worked closely with Tsay Keh Dene Nation Lands, Resources and Treaty Operations Department and Tsay Keh Dene membership to identify areas of seasonal use and archaeological history that may be relevant to our project goals. Priority areas for road restoration and habitat protection were identified based on the Lands Department's experience, incoming referrals, and knowledge of land use by membership. Engagement sessions were also carried out in Tsay Keh Dene Nation with elders and knowledge holders to identify the priority areas for restoration within the Chase caribou herd range boundary, but also areas where continued access by membership was desired.

Following field assessments to verify the list of roads for rehabilitation that was produced through these steps, a list of roadways and areas for restoration within the Chase caribou herd range boundary was produced. Priority areas and roads for restoration activities were identified near Johanson Lake and at various points along the Tenakihi Forest Service Road, Tutizzi Lake, the Swannell River drainage, the Ravenal and Flood Creek area to the south of the Ingenika River. Now that the priority areas for restoration within the chase caribou herd range boundary have been identified, the next step is to develop and implement treatment prescriptions to restore and decommission these sites to benefit the Chase caribou.

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## 1.0 INTRODUCTION

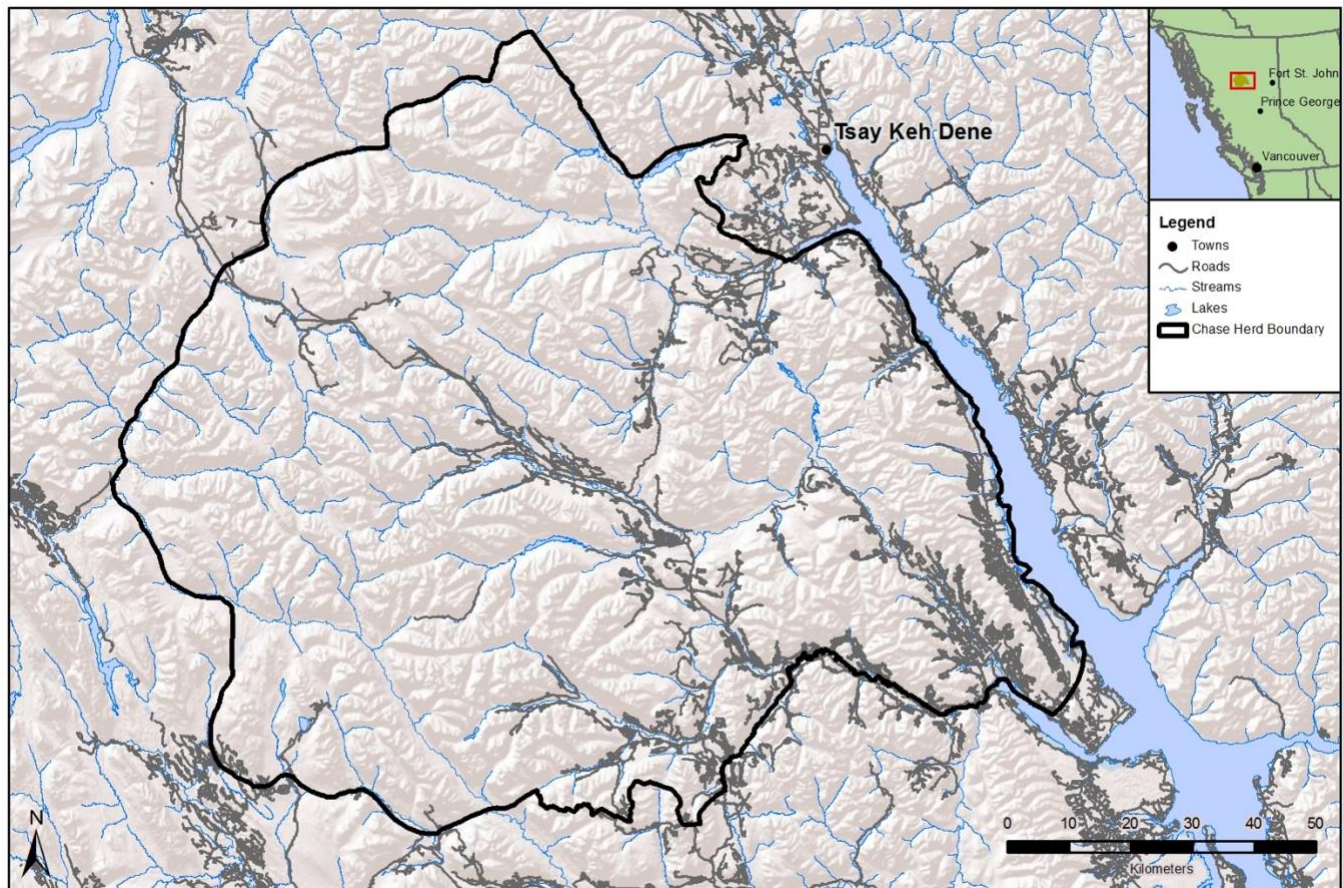
The southern mountain ecotype of caribou (*Rangifer tarandus caribou*) is listed on Schedule 1 of the Federal *Species at Risk Act* as Threatened. As stated in the *Recovery Strategy for the Woodland Caribou, Southern Mountain Population in Canada*, “the range of the southern mountain population has shrunk by up to 40% and 13 of 19 herds are declining (Environment Canada, 2014).” These herds are “threatened by decreasing habitat quantity and quality, harassment, and predation (Environment Canada, 2014).” If steps are not taken to address the factors threatening this species, it is likely to become endangered.

The Chase caribou herd is considered part of the blue-listed northern mountain population of caribou in British Columbia (B.C. Conservation Data Centre, 2019), and federally as part of the southern mountain population of caribou (Environment Canada, 2014). The caribou herd range boundary is 12,465 km<sup>2</sup>, and includes four major watersheds: the Ingenika, Mesilinka, Osilinka and Omineca Rivers (Figure 1). The herd is found on the west side of the Williston Reservoir, within the Mackenzie and Stuart Nechako Natural Resource Districts. Like many other herds of southern mountain caribou, the Chase caribou population appears to have declined in population from 1993 – 2017 (Environment Canada, 2014; Anderson and Heard, 2017). The most recent population estimate was collected in March 2019, and is the Chase caribou population is estimated at ~501 animals (Pers. Comm. Morgan Anderson, BC Ministry of FLNRORD, March 25 2019).

This project has been initiated in response to the massive habitat alteration that has occurred within the Chase caribou herd range. In 1968, the W.A.C. Bennett Dam flooded over 1,773 km<sup>2</sup> of valley bottom within the Rocky Mountain Trench. The resulting Williston Reservoir has irrevocably altered the capacity of the 1,773 km<sup>2</sup> area to provide habitat to mountain caribou. More recently, the mountain pine beetle (*Dendroctonus ponderosae*) infestation has impacted approximately 75% of the mature lodgepole pine (*Pinus contorta*) within the Timber Supply Area (TSA; FLNRO, 2013). The Mackenzie TSA covers 6.41 million hectares (ha), of which, 1.5 million ha is considered suitable for timber harvesting. In 2014, the annual allowable cut within the Mackenzie TSA was increased by 47.5% (from 3.05 million cubic meters to 4.5 million cubic meters) in response to the pine beetle infestation. The resulting salvage timber harvesting fragmented habitat, but also resulted in the creation of new forest roadways within the TSA. Tsay Keh Dene Lands Resources and Treaty Operations Department estimates that as of 2016 there are more than 2,094 ha of forest roadways within the Chase herd range boundary (assuming a 5 m road right of way). In addition to these disturbances, wildfires have burned a total 101,285 ha within the Chase herd since 2000.

The cumulative impacts of hydro- and non-hydro-related disturbances such as wildfire, coupled with industrial pressures, pine beetle kill, changes in stand dynamics resulting from the pine beetle kill (Cichowski et. al., 2017), and salvage harvest has reduced the available habitat for the Chase caribou. While disturbances such as wildfire and pine beetle kill may occur naturally in low elevation pine forests in central and northern British Columbia, when combined with anthropogenic disturbances, this could have negative consequences for caribou. The Federal Recovery Strategy for the southern mountain population of caribou cites that “habitat alteration (i.e., habitat loss, degradation, and fragmentation) from both human-caused and natural sources, and increased predation as a result of habitat alteration, have led to declining numbers throughout their

distribution (Environment Canada, 2014).” The province of British Columbia cites predation as the greatest threat to northern mountain caribou, in addition to access, industrial development and natural disturbances (B.C. Conservation Data Centre, 2018).



**Figure 1.** Chase caribou herd boundary (black) and roads (gray) located west of Tsay Keh Dene, and the Williston Reservoir.

The Recovery Strategy for the southern mountain population of caribou (*Rangifer tarandus caribou*) in Canada provides the following recommendation: “Undertake coordinated actions to reclaim southern mountain caribou habitat in all currently utilized seasonal ranges through restoration efforts (e.g. restore industrial landscape features such as roads, old seismic lines, pipelines, cut-lines, temporary roads, cleared areas; reconnect fragmented annual ranges) to make it less suitable for other prey species (Environment Canada, 2014).”

This project seeks to address this recommendation from the *Recovery Plan* (Environment Canada, 2014), by identifying opportunities for road restoration within the Chase caribou herd range boundary. This project is funded and directed under the Fish and Wildlife Compensation Program (FWCP). This project aligns with the Species of Interest Action Plan. Specifically, Action 1b-2: Implement projects identified through approved recovery strategies, action plans and management plans.

Roadways fragment habitat and typically act as barriers to movement for wildlife species, thereby reducing habitat quality and connectivity. Roadways have negative impacts on many species, including: woodland

caribou (James and Stuart-Smith, 2000; Festa-Bianchet et al., 2011; Pigeon et al., 2016), black bears (*Ursus americanus*; Switalski and Nelson, 2011; Tigner et al., 2014), grizzly bears (*Ursus arctos* ssp.; Roever et al., 2008a; Roever et al., 2008b) and wolverines (*Gulo gulo*; Bowman et al., 2010).

Human alteration of the landscape can, however, make the habitat more suitable for moose by increasing the abundance of early seral forest and forage that is palatable to moose (Serrouya et al., 2011). As moose populations increase, so do predator (i.e., wolf (*Canis lupus*)) populations. In disturbed habitat, wolf predation can eliminate caribou because the predator population is sustained by an alternative prey species (i.e., moose), and typical predator-prey dynamics, consequently, do not apply (Holt, 1977; Seip, 1992). Thus, roadways negatively impact woodland caribou by reducing effective habitat through habitat fragmentation, and by facilitating predator movement and access to caribou range (James and Stuart-Smith, 2000; Festa-Bianchet et al., 2011; Environment Canada, 2014; Pigeon et al., 2016; Dickie et al., 2017).

The long-term objective of this project is to restore forest roadways at strategic locations within the herd boundary of the Chase caribou, and within Tsay Keh Dene Nation Territory. We are seeking to restore these roadways to benefit the Chase caribou by employing both functional and ecological restoration techniques to make the roadways less suitable for other prey species and predators, and ultimately return the roadways to a mature forest environment. Returning a road or other linear feature to its pre-disturbance structural state is referred to as *Ecological restoration* (DeMars & Benesh 2016, SER 2019), whereas in *Functional restoration* refers to recovering a chosen indicators of ecosystem health such as predator prey relationships (Crow. 2014)

The negative impacts of forest roadways and habitat fragmentation on caribou are well known, and this project seeks to take a proactive approach to habitat management for the Chase caribou to help arrest current, and prevent future, population declines.

### 1.1 PROJECT OBJECTIVES

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In 2018, our project team worked to identify priority roadways for restoration based on an approach that attempts to balance ecological, cultural and logistical considerations. The 2018 project had several short-term objectives that include:

- 1) Compile landscape, linear feature and Tsay Keh Dene Nation cultural use data for the project area.
- 2) Work closely with the licensees to identify candidate roadways for restoration, and those considered temporary, lacking obligations, and not accessing future timber supply.
- 3) Carry out caribou habitat mapping to identify important corridors and habitat based on historical and current collar data for the Chase caribou.
- 4) Inventory vegetation and soil characteristics, and assess impediments to wildlife travel on candidate roadways within the Chase herd boundary.
- 5) Consolidate the field data, habitat features and available caribou data to recommend priority roadways for rehabilitation based on both logistical, ecological and Tsay Keh Dene Nation cultural considerations.

- 6) Provide preliminary treatment recommendations for identified roads.

## 2.0 METHODS

We carried out the project in three phases:

*Phase 1:* Desktop study compiling landscape, ecological, forest road and Tsay Keh Dene cultural use data for the project area.

*Phase 2:* Inventory vegetation and soil characteristics, and assess impediments to predator travel on forest roadways within the Chase herd boundary.

*Phase 3:* Consolidate the field data, habitat features and available caribou data to recommend priority roadways for restoration based on logistical, ecological, and cultural considerations.

### 2.1 LOGISTICAL CONSIDERATIONS

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Our project team collaborated with Foresite Consultants Ltd. on this component of the project. We utilized the Road Rehabilitation Algorithm that was developed by Chartwell Consultants and Steve Thompson, with contributions from Foresite Consultants Ltd., John Degagne and Bill Chapman. The algorithm was initially implemented as a component of a larger, multi-phase process developed by the Society for Ecosystem Restoration in Northern British Columbia (SERNBC) to identify and reforest unused forest roads in the Francois Lake area in a collaboration with West Fraser Ltd. The algorithm has undergone multiple iterations to improve its accuracy, with the intention that it can be employed on any land base in the province. This project represented an opportunity to test this algorithm in a new area with different objectives (i.e. wildlife focus), with subsequent validation through field data collection.

We employed the road algorithm and identified candidate forest roadways for restoration within the project area. The key factors driving the algorithm were:

- 1) Access to future harvesting opportunities.
- 2) The geographic location of roads relative to the opportunity.
- 3) Free growing status of a cutblock.
- 4) Constraints limiting road construction and harvesting.

This project focused on working with the forest licensees, as forestry has the largest industrial disturbance footprint within the project area. While other resource development and disturbance, such as mine exploration and the Williston Reservoir, is found within the project area, we determined the best approach is to work with the non-forestry based tenure holders once candidate roads have been identified through the application of the roads algorithm.

The datasets assembled for the algorithm included: Integrated Road Database, FTEN Roads, VRI, VRI Cutblocks, RESULTS Openings, Forest Cover Reserves, FTEN Cutblocks, OGMA, Integrated Cadastral Fabric (Private Land), FTEN Recreation Polygons, Provincial Parks, Ecological Reserves, Protected Areas, National Parks, FWA Lakes, FWA Rivers, FWA Streams (major), FWA Streams (minor), Wetlands and Slopes greater than 80%. Roadways were then classified based on these logistical considerations as Restoration

Opportunity (ROP) or No Opportunity Expected (NOE).

We made additional considerations for supplementary caribou habitat data provided by the Ministry of Forests, Lands, Natural Resource Operations and Rural Development for calving and post-rut areas, as well as migration corridors. This data was used to further refine road classifications to rehabilitate as much road area as possible within these habitat types, while maintaining access for forestry activities. In addition, roads that travelled from low elevation to high elevation areas (relative to road elevations in the project area and within known caribou habitats), as well as by biogeoclassification (BEC) zone were identified as primary candidates for this project. These roads were manually identified using elevation and contour data and classified as a rehabilitation opportunity specifically to mitigate movement of predators from lower elevations into high elevation caribou habitat.

The algorithm produced a list of candidate roads selected for rehabilitation, which were further refined through engagement with forest licensees (Conifex Timber Inc. and Dunkley Lumber Ltd.) operating on the land base that could be affected by these decisions. Harvest opportunity for these licensees was considered based on three attributes: merchantable volume, patch size, and distance between Vegetation Resource Inventory (VRI) polygons combined into larger opportunity polygons. In order to accommodate silvicultural activities within an area, a requirement of the algorithm was to maintain access to all non-free growing cutblocks and safe walking distance (< 800 m) for silviculture crews.

We then completed a manual review of the algorithm results and the results modified based on forest licensee consultation. We sent a list of candidate roads to the licensees for revision and consideration surrounding plans for future development and outstanding obligations. We asked licensees to identify roads classified by the algorithm as rehabilitation opportunities but were required for future access, as well as key areas or roads that would be suitable for inclusion in this project. This engagement allowed for integration of licensee plans and resulted in roads identified for rehabilitation that better reflect operational realities.

## 2.2 ECOLOGICAL CONSIDERATIONS

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Our project team collaborated with Wildlife Infometrics Inc. on this component of the project. This desktop study work was completed in two phases:

- 1) A geographic information systems (GIS) component focusing on identifying road densities, high use caribou areas, caribou Ungulate Winter Ranges (UWRs) and migration corridors within the Chase herd range.
- 2) A mapping exercise using local expert caribou biologist knowledge that have over 30 years combined experience studying this herd.

The goal of this exercise was to prioritize forest roadways at the landscape level for field assessments where restoration activities have the highest potential to benefit caribou.

Our team focused on identifying large, intact habitat areas for the Chase caribou. To do this we collated a

## Identifying Forest Roadways For Rehabilitation Within The Chase Caribou Herd Range Boundary

suite of GIS layers (Table 1) to assess priorities for road rehabilitation that will benefit caribou. An additional analysis for grizzly bear is included in Appendix 1. This was included to highlight the potential co-benefits of strategically restoring forest roadways on the landscape.

**Table 1.** Description and source of GIS layers used to assess priorities for road rehabilitation that will benefit the Chase caribou herd.

Project Data	Input Used	Source
<i>Raw Data</i>		
Wildfire	BC Wildfire layers	<a href="https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-historical">https://catalogue.data.gov.bc.ca/dataset/fire-perimeters-historical</a>
Chase caribou herd boundary	Caribou Herd Locations for BC	<a href="https://catalogue.data.gov.bc.ca/dataset/caribou-herd-locations-for-bc">https://catalogue.data.gov.bc.ca/dataset/caribou-herd-locations-for-bc</a>
Caribou Locations	ONCP Caribou Locations	Wildlife Infometrics Inc.
Roads	Digital Road Atlas	<a href="https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads">https://catalogue.data.gov.bc.ca/dataset/digital-road-atlas-dra-master-partially-attributed-roads</a>
Forsite roads - Prioritized for reforestation	Integrated Road Database	Forsite Consultants Ltd.
Pine Lichen Winter Range (PLWR)	PLWR preference 2007	Wildlife Infometrics Inc.
Core Caribou UWRs	Approved BC UWR layer	<a href="https://catalogue.data.gov.bc.ca/dataset/ungulate-winter-range-approved">https://catalogue.data.gov.bc.ca/dataset/ungulate-winter-range-approved</a>
Caribou Post-Rut WHAs	Caribou Post-Rut WHAs	B.C. Ministry of Forests, Lands and Natural Resource Operations and Rural Development
Caribou Migration Corridor WHAs	Caribou Migration Corridor WHAs	B.C. Ministry of Forests, Lands and Natural Resource Operations and Rural Development
Caribou Calving Range WHAs	Caribou Calving Range WHAs	B.C. Ministry of Forests, Lands and Natural Resource Operations and Rural Development
Caribou High-Elevation Winter Range	HEWR Modeling	B.C. Ministry of Forests, Lands and Natural Resource Operations and Rural Development
Elevation	Digital Elevation Model	<a href="http://ftp.geogratis.gc.ca/pub/nrcan_rncan/archive/elevation/geobase_cded_dnc/50k_dem">BC Gov't Source or: ftp://ftp.geogratis.gc.ca/pub/nrcan_rncan/archive/elevation/geobase_cded_dnc/50k_dem</a>
Grizzly Habitat Value	DMK Grizzly Value Layer	B.C. Ministry of Forests, Lands and Natural Resource Operations and Rural Development
<i>Output layers</i>		
Road Density	Digital Road Atlas	A raster layer generated to measure road density (km/km <sup>2</sup> )
Grizzly Habitat/Road Density	DMK Grizzly Value Layer and Road Density Layer	

We used roads from the province's Digital Road Atlas<sup>1</sup> to estimate road density within the Chase herd boundary. We clipped the roads to a modified version of the study area (Chase herd area) that was buffered by 1 km to ensure that the effect of roads adjacent to the study area would be included in the density estimate. We calculated density using a 'moving window' approach where local road density was determined for each 100 m cell (1 ha) of the study area by summing the total length of roads within a 1km<sup>2</sup> circular neighborhood around the cell being evaluated. We clipped the results down the extent of the unbuffered study area and classified the results as ROP or NOE.

We developed a working map that overlaid the following layers within the Chase herd boundary: roads layer, historic and current caribou locations from GPS collared caribou, caribou UWRs, and caribou migration

<sup>1</sup> <https://www2.gov.bc.ca/gov/content/data/geographic-data-services/topographic-data/roads>

corridors for discussions with expert caribou biologists. Line Giguere (owner of Wildlife Infometrics Inc.), and Dr. Scott McNay (Senior Wildlife Biologist, Wildlife Infometrics Inc.) both have extensive knowledge from over 14 years each of studying the Chase, Wolverine and Finlay caribou herds from 1998 to 2012. They were interviewed by Krista Sittler (Wildlife Biologist, Wildlife Infometrics, Inc), who has currently reinitiated monitoring of the Chase caribou herd and understands their current distribution (Sittler, 2018). The group identified sections of roads that if restored, would provide the most benefit to caribou. Due to the sensitive nature of the caribou data, current and historic caribou locations have been removed from the final recommendation map.

Being cognizant of the potential conflict between moose and caribou, we also modeled and mapped moose habitat quality to help inform future restoration activities. These data could be used if a high priority road is directly adjacent to or connects moose and caribou habitat. Specifically, the priority of a roadway for restoration will be reduced if a significant portion of the roadway is within S1 moose habitat. Reforestation techniques may try to use species that are unpalatable to moose to limit or reduce that potential for conflict. To better inform restoration prescription development (i.e., type and distribution of species planted) we have examined habitat preference by moose by modeling moose habitat suitability across the Chase range using three basic sample strata. Our approach is similar to the stratification adopted by the provincial government during moose census (Heard et al. 1999a; Heard et al. 1999b; Demarchi 2000; Walker et al. 2006; Walker et al. 2007). Habitat of relatively “high” value to moose forms stratum S1, S2 consisted of relatively “moderate” value to moose, and S3 is considered to have “little to no value for moose.” The S1 stratum is any area <1,600 m that is also young forests between the age of 5 and 40 years old (irrespective of the nature of disturbance - human or “natural”), or alternatively, any shrub dominated<sup>2</sup> sites and deciduous leading forests on relatively warm slopes<sup>3</sup>. All class 5 rivers are buffered by 250 m and the resulting polygons are also added to S1. S2 is defined by any area <1,600 m asl that is also forested and < 5 years old or > 40 years old. All other area falling outside the data queries for S1 and S2 are considered of relatively little or no value to moose (i.e. S3). Vegetation and geographic data to assist the stratification have been collected from the VRI and a 25 m Digital Elevation Model<sup>4</sup>.

### 2.3 CULTURAL CONSIDERATIONS

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This component of the project has factored in the proximity of roadways to recreational areas and towns, and the estimated use of the existing roadways by humans. This component focused on conversations with Tsay Keh Dene (TKD) Nation membership and Tsay Keh Dene Nation Lands, Resources and Treaty Operations Department (LRTO) to identify areas of seasonal use, and archaeological history that may be relevant to our project goals.

We worked closely with TKD Nation LRTO to compile an accurate roads data layer that could be used in all algorithm analysis for this project. Furthermore, we collaborated with TKD Nation LRTO to identify priority

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<sup>2</sup> VRI codes indicating a shrub-dominated condition will be considered to be: M (meadow), OR (open range), NPBR (non-productive brush), NCBR (non-commercial brush), and NSR (not sufficiently restocked).

<sup>3</sup> Relatively warm slopes will be determined using the Solar Radiation Toolbox (ESRI, Redlands CA)

<sup>4</sup> It is expected that the current version of this dataset may be provided by FLNRO. Otherwise an older version of the dataset will be collected by the proponent from public sources (<http://www.geobase.ca/geobase/en/find.do?produit=cded>)

areas for road restoration and habitat protection based on their experience, incoming referrals, and knowledge of land use by membership. Engagement sessions were carried out in Tsay Keh Dene Nation with elders and knowledge holders on February 25 and 26<sup>th</sup>, 2019. Formal interviews were carried out each day, and an informal dinner and discussion was hosted in the Tsay Keh Dene Learning Centre on the evening of February 25<sup>th</sup>. These engagement sessions provided an opportunity for membership to identify the priority areas for restoration within the Chase caribou herd range boundary, but also areas where continued access by membership was desired.

Chu Cho Environmental LLP and TKD Nation LRTO are also collaborating on the project ‘Tsay Keh Dene Nation Southern Mountain Caribou Response to Habitat Alteration: A Traditional Knowledge Study’ with financial support from TKD Nation and the Aboriginal Fund for Species at Risk. As a component of this study, traditional knowledge interviews were conducted in Tsay Keh Dene Nation in January 2019. These interviews have informed this project, and other caribou stewardship initiatives currently being led by TKD Nation. These interviews have provided information on areas of current and historical importance for the Chase caribou, their distribution, and how the caribou have responded to anthropogenic and natural habitat disturbance.

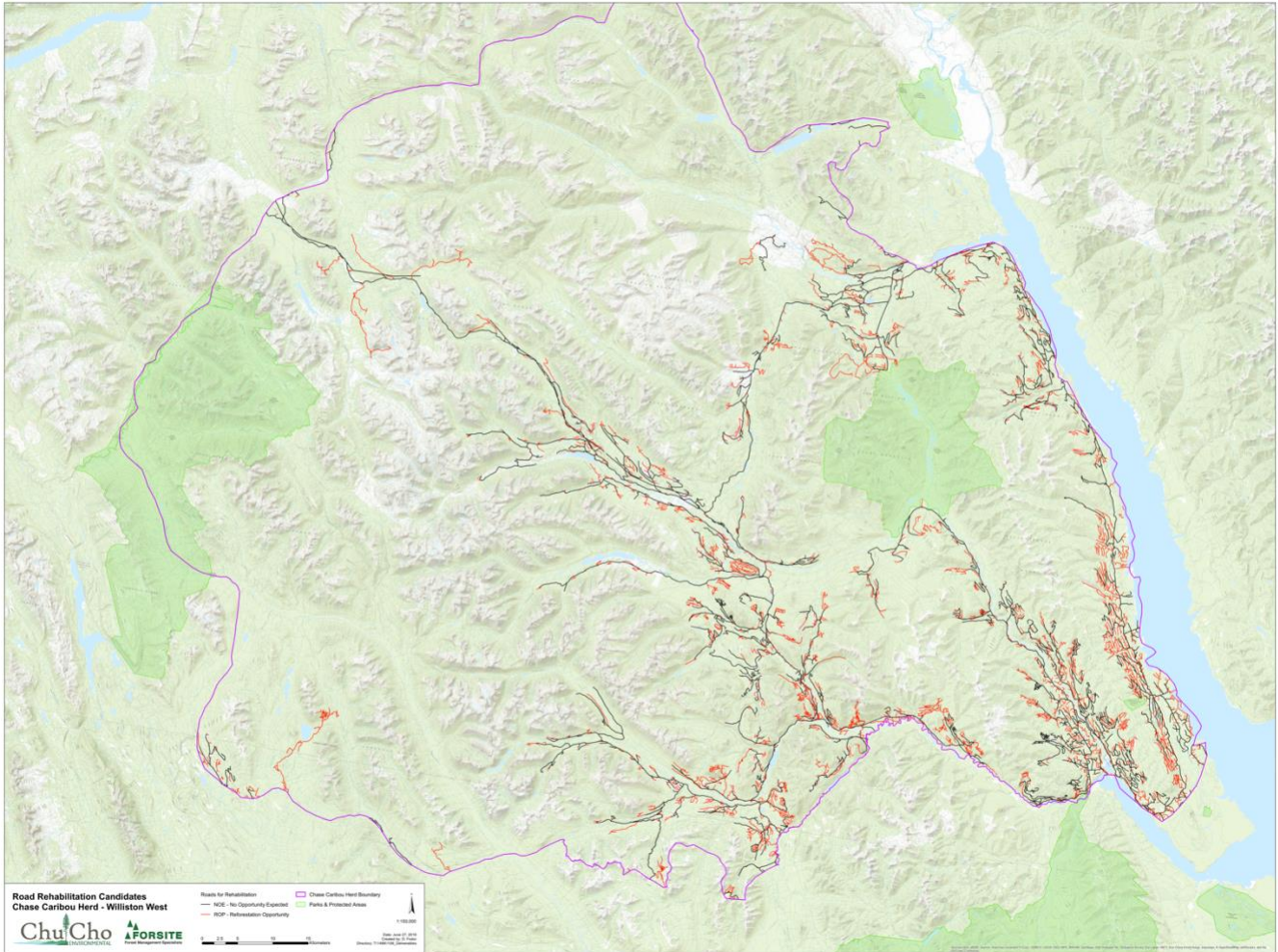
Furthermore, these interviews have helped to identify management tools that membership would like to see employed to stop the decline of caribou populations within Tsay Keh Dene Nation Territory. The data collected during these interviews and throughout the collaboration with TKD Nation LRTO is sensitive, and is not shared in this report. However, this phase of the project has confirmed that road restoration and access management can play a role in meeting TKD Nation LRTO’s land management goals, and additionally, has worked to identify priority roadways and techniques for restoration within the Chase caribou herd range boundary. The resulting recommendations for road restoration provided in this document are a result of the conversations and interviews with TKD Nation LRTO and membership.

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### 2.4 FIELD DATA COLLECTION

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Chu Cho Environmental LLP field crews visited the roads identified during the logistical and ecological components of this project as opportunities for rehabilitation to evaluate their suitability for rehabilitation. Two field crews (crews of two technicians) visited the candidate roadways over a total of 14 field days between September 6 and 15, 2018. If access control structures preventing access were encountered, this was noted on the base map in Avenza Maps (Figure 2) with a picture, and description of the access control. If the roads being assessed were overgrown and not navigable, crews would then walk along these roads for up to 2 km to collect the data used to determine suitability for rehabilitation. Recreational and wildlife use was noted during the site visit. However, further site visits will be required during the development of the restoration prescription to ensure that the seasonal use of the roadway by both wildlife and recreational vehicles is better understood.



**Figure 2.** Roads identified through the algorithm, as rehabilitation opportunities (red) within the Chase caribou herd boundary (purple).

#### 2.4.1 DETERMINING SUITABILITY OF A ROAD FOR RESTORATION

Studies have highlighted a suite of key site limiting factors that influence the recovery of vegetation along linear features (Pyper et al. 2014):

- 1) Human access (ATVs and other vehicles).
- 2) Too much or too little moisture.
- 3) Microsite availability.
- 4) Soil compaction as factors that can severely limit restoration success.

Based on the findings of Pyper et al. (2014) and a similar project carried out by the Society for Ecosystem Restoration in Northern British Columbia (SERN, ND), field crews determined a roadway as suitable for restoration if it met the following criteria:

1. Natural regeneration on the road <1.5 m tall.

2. Existing regeneration on the road <700 stems/hectare (SPH).
3. Sight lines along the road >50 m.
4. Width of the road >1.5 m.

The long-term objective of this project is to restore forest roadways at strategic locations within the herd boundary of the Chase caribou, and within Tsay Keh Dene Nation Territory. While working towards this objective, our project team does not intend to disturb succession processes on roads that are re-vegetating naturally (eg. Road width < 1.5 m and existing regeneration > 700 stems/hectare).

### 2.4.2 DATA COLLECTION

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If a road meets our suitability criteria, then field crews collected the following information along with a GPS track of the road.

1. **Roadway width:** The running surface (i.e. flat surface compacted by vehicles, animals and horses) is measured at multiple locations and an average road width is recorded. The narrowest width is also noted.
2. **Road grade:** Field crews measured the average road grade with a clinometer or using the Theodolite app on the iPad. If the road grade varies significantly then a grade range is noted.
3. **Soil:** Soil texture (fine, moderate, coarse) is determined using soil cards (Appendix 2). It is also noted whether the soil is compacted (no compaction test performed; the soil on most roads being considered for rehab is compacted). The coarse fragment content is estimated using soil cards and the presence or absence of organic material or topsoil is noted.
4. **Plant species present:** Plant species, percent composition and canopy closure of the adjacent stand is recorded, as is whether the adjacent stand is a plantation. The species and percent composition of herbaceous plants along the side of the road is also noted. If there is regeneration on the roadway, the species, percent cover, height and stems per hectare is noted. If invasive species are identified, then a subsequent invasive plant species survey form is also completed.
5. **Wildlife signs:** When wildlife sign is encountered, the type (i.e. scat, droppings, prints, browse) and number is recorded.
6. **Hydrology:** Slope angle is measured using a clinometer or Theodolite and recorded. If classifiable streams are present along the roadway then average width, gradient and suspected classification is noted (see Appendix 1). The presence of culverts, water bars, cross ditches and adjacent riparian areas is noted. Pictures of existing culverts and their condition (i.e. working as intended, blocked) are also recorded.
7. **Photos and video:** Photographs and videos of the road and adjacent area are taken.
8. **Recreational use signs:** Signs of recreational use (i.e. tire tracks, used shotgun shells, evidence of campfires, horse tracks and droppings etc.) are also recorded.

### 3.0 RESULTS AND OUTCOMES

Based on the results of the GIS analysis, field crews collected data on the identified candidate roadways in order to assess rehabilitation opportunities. Not all the roadways identified in the GIS stage met the criteria for rehabilitation.

#### 3.1 LOGISTICAL CONSIDERATIONS

The results of the road algorithm are provided in Table 2. The spatial location of these roads is provided in Figure 2. The project area has 4,249 km of road network. Of this, a total of 1,361.1 km of road was classified by the algorithm as having a reforestation opportunity (ROP). However, upon further review of the algorithm results and inclusion of additional data sources, particularly with regard to caribou habitat data, an additional 718.9 km of road was identified as an ROP. This list of 2,080 km of candidate roads was provided to licensees for their in-depth review. Incorporation of their feedback resulted in 1,942.8 km of road identified for rehabilitation and/or reforestation activities across the entire Chase caribou herd range boundary. Assuming an average road width of 5 m, this results in 971.5 ha of area potentially available for reforestation.

**Table 2.** Results of the road rehabilitation analysis, including results from the initial Road Rehabilitation Algorithm, manual review, and final results following licensee review.

Road Classification	Algorithm Results	Total Road Length (km)	
		Manual Review	Licensee Review - Final
ROP – Reforestation Opportunity	1,361.1	2,080.0	1,942.8
NOE – No Opportunity Expected	2,887.9	2,169.0	2,306.2
<b>TOTAL</b>	<b>4,249.0</b>	<b>4,249.0</b>	<b>4,249.0</b>

Through the manual review and licensee feedback, an additional 581.7 km of road was identified as a ROP from the algorithm results. In general, these roads were misclassified by the algorithm for the following reasons:

- Roads maintained for access to future harvest opportunities based on the model assumptions of an opportunity. However, upon closer review many of these areas have no future developmental plans as provided by the licensees, or based on knowledge of the area it was unlikely these areas would be harvested due to concerns over caribou populations or because of their remote location.
- Not all roads identified for access to non- free growing (NFG) cutblocks are necessary. In some instances, access is maintained by roads travelling through the block, therefore additional roads into the block (less than 800 m) were not required.
- Some roads identified by the algorithm and desktop review as a ROP were not approved by licensees as they were required for access into those areas.

- Inaccuracy in the source roads dataset (IRDB) lead to some misclassification. There is some residual error in the IRDB in that it is not a networked dataset, rather roads are often represented by short, sometimes duplicated, segments. This limitation was addressed to some degree within the algorithm by removing duplicated records, merging short segments to create longer segments of roads extending between road junctions, and defining a core network of NOE roads using Forest Service Roads and FTEN roads longer than 5 km. However, this approach has not resolved all of the issues related to the source IRDB, which resulted in misclassification of roads as an opportunity or not.
- Additional roads were classified as a ROP as a result of including the additional caribou habitat data and considerations for roads travelling from low to high elevations.

### 3.2 ECOLOGICAL CONSIDERATIONS

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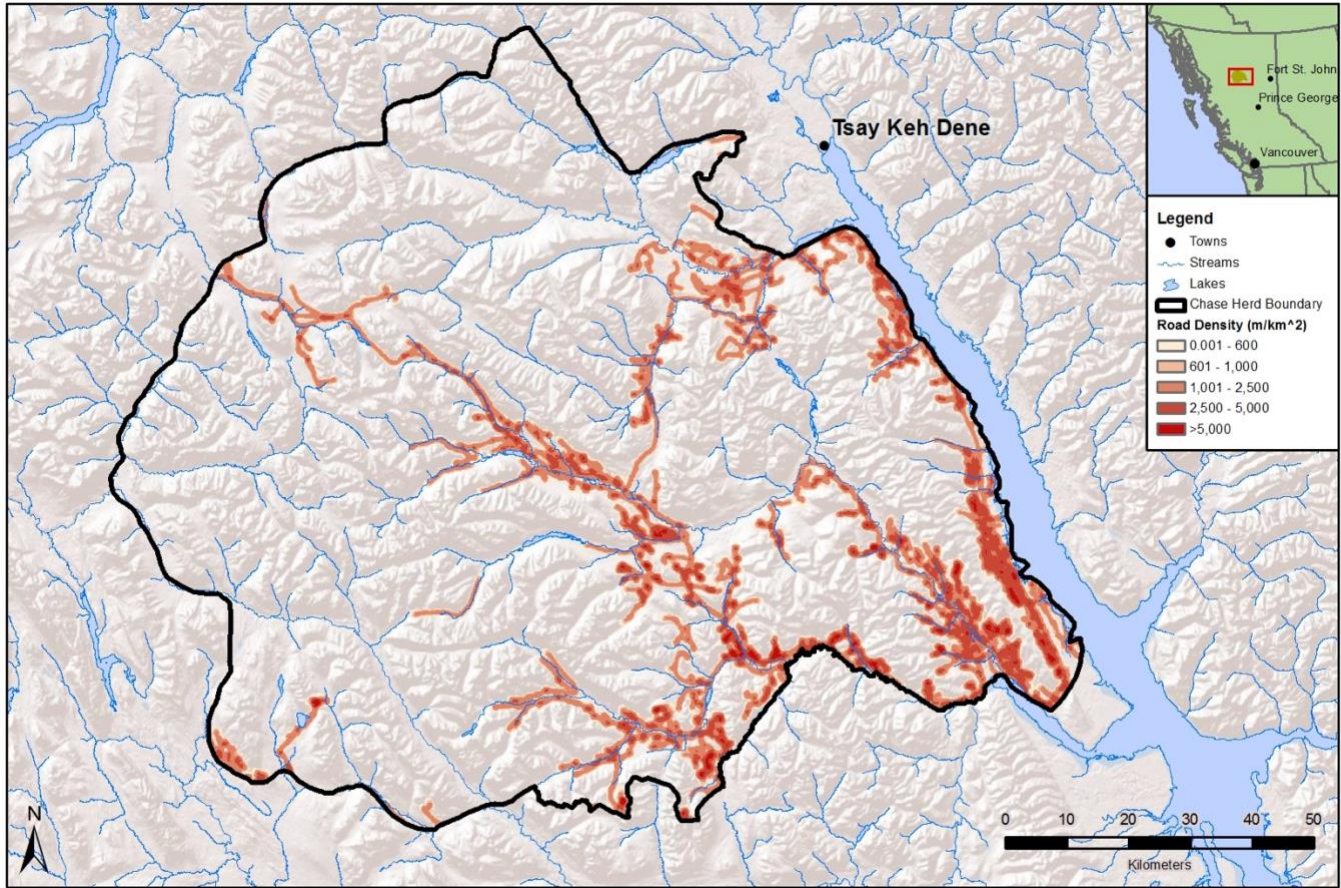
Road density varies across the Chase herd area (Figure 3), with the highest densities occurring within the major drainages (Osilinka, Mesilinka, and Ingenika), and on major destination roads (e.g., the route to Tsay Keh Dene, and the route to Black Pine and the Kemess Mine). The total area impacted by roads using this method is 240,466 ha, with 78% of this area over the 0.06 km/km<sup>2</sup> threshold (Table 3). In addition, of the 1,174,700 ha Chase caribou herd range, 20% is directly impacted by roads.

Based on proximity to historic and recent caribou locations, high value UWR, and migration corridors a total of 21 polygons have been identified around sections of road for prioritization of road rehabilitation (Figure 4).

The long-term objective of this project is to restore forest roadways at strategic locations within the herd boundary of the Chase caribou, and within Tsay Keh Dene Nation Territory. We are seeking to restore these roadways to benefit the Chase caribou by employing both functional and ecological restoration techniques to make the roadways less suitable for other prey species and predators, and ultimately return the roadways to a mature forest environment.

The goal is to select roads that provide alternative prey and predators access to core caribou areas. The Swannell Mountains and Chase Mountain Ranges are excellent high elevation habitat and caribou would likely benefit from reduced road access in these areas. Currently, the area along the Ingenika River has the highest use of low elevation pine-lichen habitat. The 2014 Mesilinka wildfire burnt a large portion of the pine-lichen winter and spring range for the Chase caribou, and appears to have displaced some caribou into other parts of the range, including the area to the east and south of Tutizzi Lake.

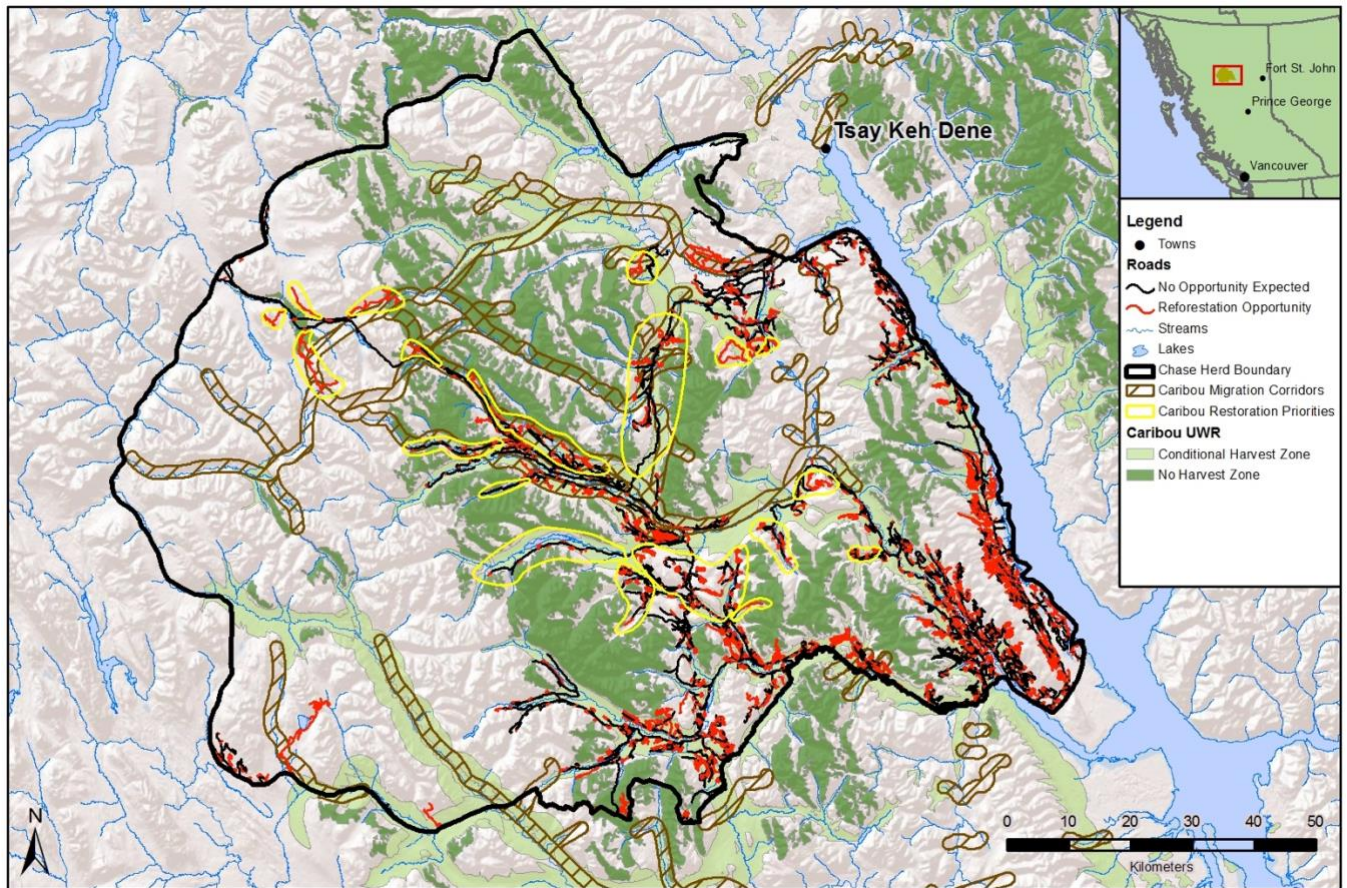
Not surprising, moose habitat is ubiquitous throughout low elevations within the Chase caribou herd range boundary (Figure 5), with S1 (high quality habitat) representing 202,017 ha and S2 (moderate quality habitat) representing 628,160 ha. Being cognizant of the potential overlap with caribou and moose, and to reduce this conflict when possible, when roads are selected for restoration and enhancement, this mapping will be used to inform the restoration techniques applied. For example, if the road is directly adjacent to or connects moose and caribou habitat, reforestation techniques may try to incorporate species that are unpalatable to moose in an attempt to limit or reduce that potential for conflict.



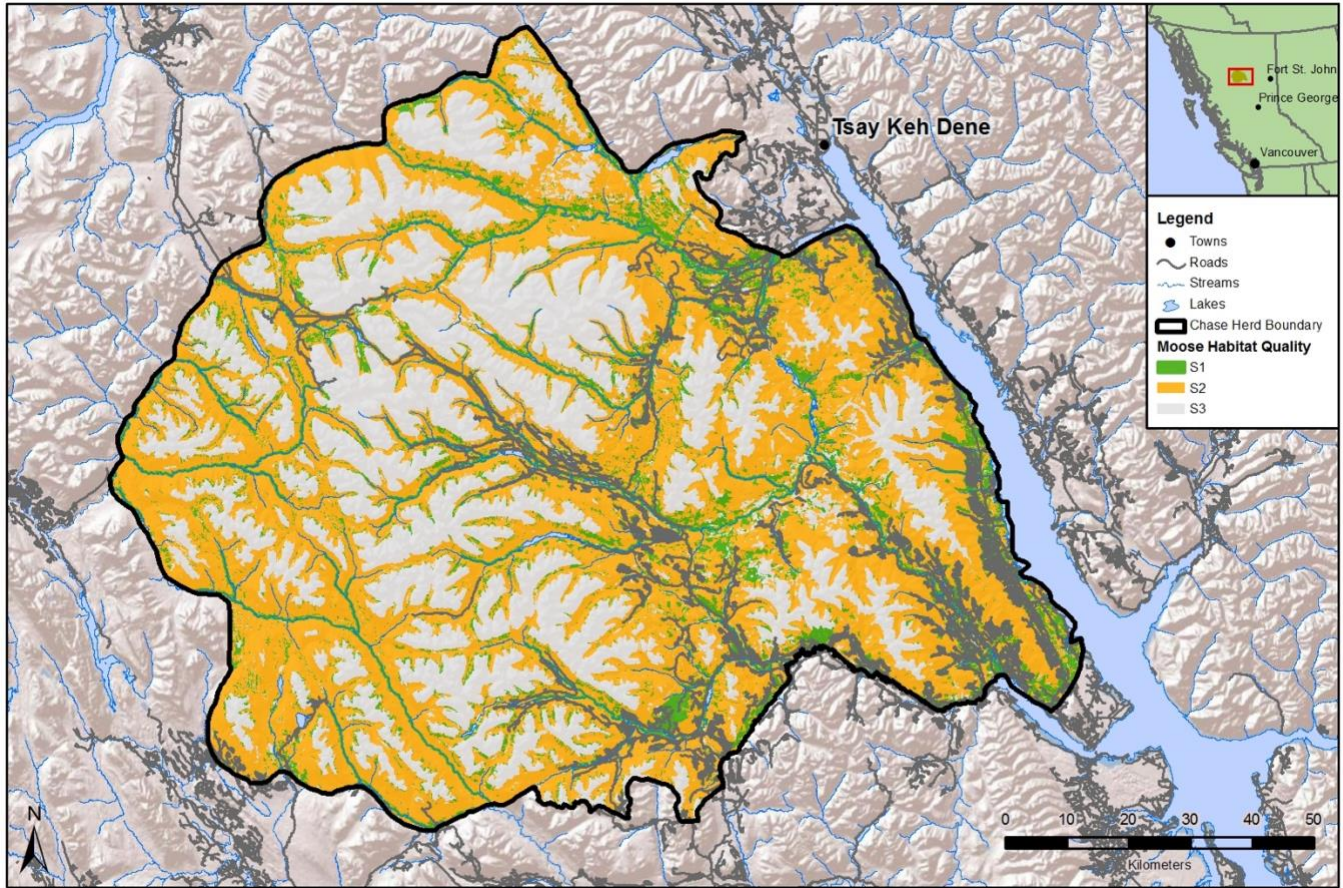
**Figure 3.** Road density within the Chase caribou herd using a moving window analysis. The threshold of .6 km/km<sup>2</sup> is considered detrimental to caribou.

**Table 3.** Summary of road density classes and area of each class within the Chase herd boundary as of Sept. 2018.

Density Class	Area (ha)
0 km/km <sup>2</sup>	1,005,900
.001 - .6 km/km <sup>2</sup>	51,912
.6 – 1 km/km <sup>2</sup>	26,983
1.001 – 2.5 km/km <sup>2</sup>	108,661
2.501-5 km/km <sup>2</sup>	49,552
>5 km/km <sup>2</sup>	3,358



**Figure 4.** Final recommendations for road restoration priorities based on considerations for caribou are highlighted in yellow circles. Roads shown in red were identified by licensees as roads available for reforestation.



**Figure 5.** Modeled moose habitat quality within the Chase herd. S1 = high quality (green); S2 = moderate quality (yellow); S3 = no value (grey). All roads are shown in dark grey.

### 3.3 FIELD DATA RESULTS

During the field reconnaissance portion of this project a total of 46 roads were visited, 21 of which were shortlisted as suitable roads for rehabilitation and surveyed further ([Appendix 3](#)).

Some of the roads identified as reforestation opportunities in the GIS exercise were found to have fresh ribbon in the field, indicating future development by the licensee. Some of these roads met the criteria for reforestation, while others did not. Further consultation with licensees at a future date is required to remove these roads from the total reforestation opportunity.

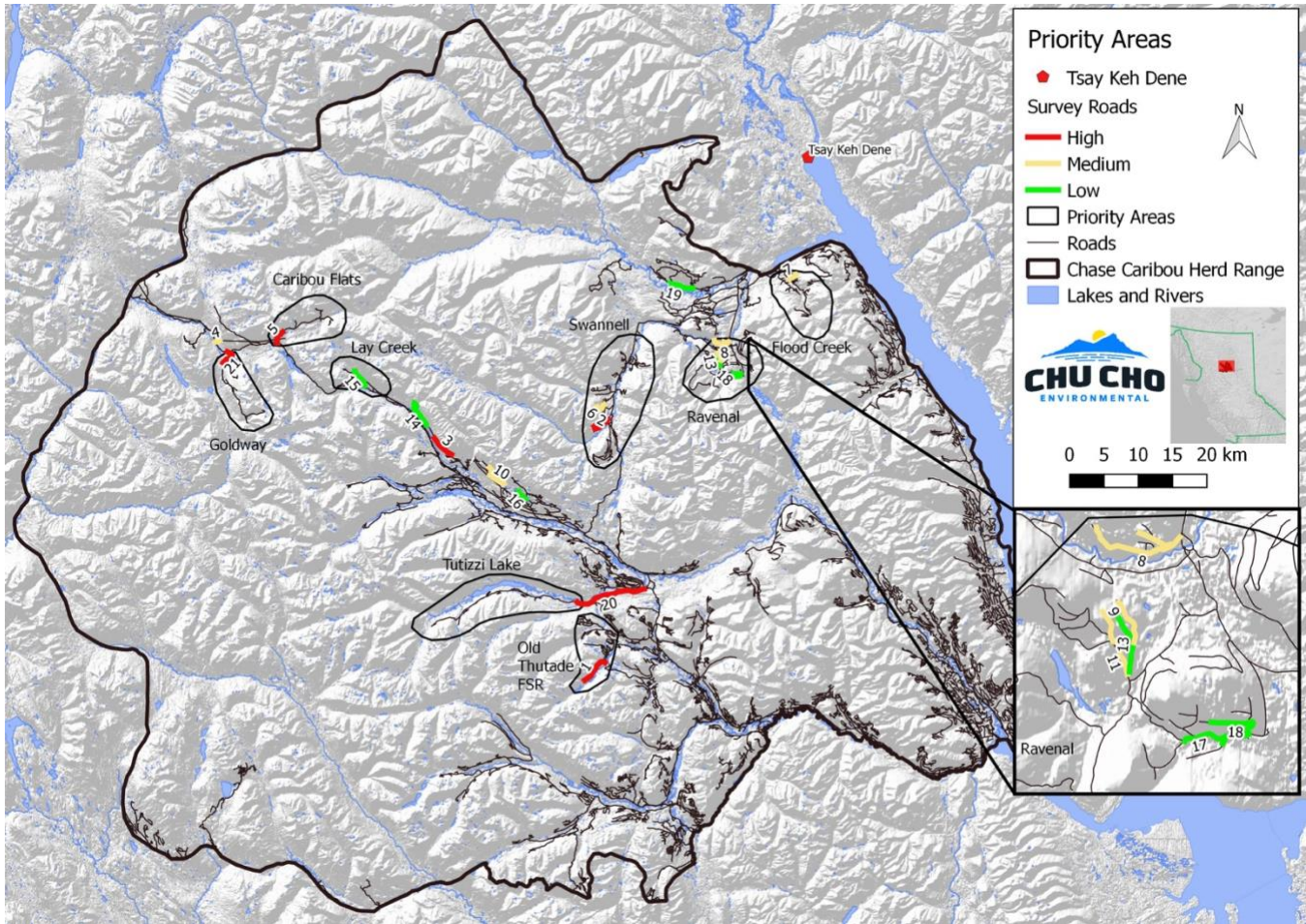
A road was considered high priority if it met the criteria for rehabilitation, and was located within the high priority areas (Figure 4) identified using caribou collar data. Roads which met the criteria but were shorter than 200m, were located outside the high priority areas, or provided access to the Kemess powerline, were considered medium priority roads for rehabilitation purposes. Finally, roads which met the criteria for rehabilitation but did not provide access to sensitive caribou habitat were considered low priority. Of the 21

roads surveyed, 7 were considered high and medium priorities for rehabilitation and are summarized in Table 4.

**Table 4.** Summary of priority roads for rehabilitation.

Road ID	Rehabilitation criteria met?	Within caribou high priority area?	Accesses higher elevation?	Over 200 m in length?	Rehabilitation priority
Road 1	Yes	Yes	Yes	Yes	High
Road 2	Yes	Yes	Yes	Yes	High
Road 3	Yes	Yes	Yes	Yes	High
Road 4	Yes	Yes	Yes	No	Medium
Road 5	Yes	Yes	Yes	Yes	High
Road 20	Yes	Yes	Yes	Yes	High
Road 21	Yes	Yes	Yes	Yes	High

summarizes the roads and areas considered to be the priorities for rehabilitation categorized into high, medium, and low treatment priority. [Appendix 4](#) provides a description of these roadways and areas. The circled areas summarize the road networks considered by TKD LRTO Department and TKD membership to be high priority for rehabilitation.



**Figure 6.** Summary of priority roads and areas for rehabilitation. Roads considered to the priorities for rehabilitation are categorized into high, medium, and low treatment priority. The circled areas summarize the road networks considered by Tsay Keh Dene Nation’s Lands, Resources and Treaty Operations Department to be high priority areas for rehabilitation.

## 4.0 DISCUSSION

This project is expected to have several short and long-term benefits. These include the restoration of habitat for the Chase caribou, a species listed on Schedule 1 of the Federal *Species at Risk Act*, but also providing a methodology for identifying candidate roadways for restoration based around an approach that balances logistical, ecological and cultural consideration that can be applied to other caribou herd ranges, and more broadly to other wildlife species and their habitats.

### 4.1 SHORT TERM BENEFITS

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This project has had several specific short-term benefits:

1. Identified 1,942.8 km of road for rehabilitation and reforestation across the Chase caribou herd range boundary that are deemed not needed by Conifex Timber Inc. and Dunkley Lumber Ltd. Assuming an average width of 5m, this equals 971.5 ha identified for restoration and reforestation.
2. Provides a Summary of priority roads for rehabilitation (Figure 6).
3. Our project team effectively engaged with Tsay Keh Dene Nation through a direct collaboration with TKD Nation LRTO Department. Our project team effectively identified priority forest roadways within the Chase caribou herd range boundary that TKD Nation considers priorities for restoration. TKD Nation LRTO was integral to facilitating community engagement with TKD Nation membership throughout the delivery of this project.
4. Chu Cho Environmental LLP and TKD Nation LRTO collaborated on Science Week in TKD BC in September 2018. The event included field trips, presentations and discussions surrounding the variety of environmental monitoring and research projects that Chu Environmental and TKD Nation are collaborating on in the territory. During a dinner and open house hosted during Science Week, our project team presented on this project and had one-on-one discussions with interested community members regarding our approach to the project, data collection and field reconnaissance, while also providing the opportunity for community members to contribute their own knowledge of wildlife and places within the territory that are important to caribou.
5. Provided direct employment to a member of TKD Nation throughout the field component of this project. Additionally, the project has provided opportunity for capacity growth by Chu Cho Environmental LLP, and research and environmental services company that is wholly owned by TKD Nation.
6. Further Traditional Knowledge interviews were carried out in January 2019 in TKD, BC related to the 'Tsay Keh Dene Nation Southern Mountain Caribou Response to Habitat Alteration Traditional Knowledge Study'. The results of the interviews and discussion supported our work to identify priority areas for habitat restoration within the Chase caribou herd range boundary.
7. Engagement sessions were carried out with TKD Nation elders and knowledge holders on February 25<sup>th</sup> and 26<sup>th</sup>, 2019 in order to further clarify the priority roadways for restoration, along with the

techniques that may be employed in future restoration efforts. This process worked to identify priority roadways, but also clarified the areas and roads that membership intends to continue using for access and gatherings.

8. The application of the road algorithm has improved science and knowledge in the field of ecological restoration. As discussed, the road rehabilitation algorithm has undergone multiple iterations to increase the accuracy of the output. This project has presented the opportunity to employ the algorithm on a new land base in British Columbia, with validation of the results through field reconnaissance. Our project team has been able to provide direct feedback on the accuracy and results of the algorithm, bringing the algorithm one step closer to achieving the goal of being applied to any land base in the province.

### 4.2 LONG TERM BENEFITS

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The long-term goal of this project is to restore forest roadways under a timeline that is ecologically significant to the recovery of the Chase caribou. In practice, this means that we intend to apply ecological restoration treatments in order accelerate the return of these roadways to a mature forest environment, while also restoring biological processes to their pre-disturbance state (ie. Functional Restoration). In the case of the Chase caribou, the chosen functional indicator of ecosystem health is the historic caribou-predator encounter rates. Functional restoration treatments applied may include installing visual barriers every 200m and at corridor intersections (Golder Associates. 2015) capable of blocking 90% of a standing adult caribou from view at a distance of 60m (BC MFLNRO. 2016). These treatments may reduce the encounters between caribou and wolves, and potentially slow the population decline of southern mountain caribou.

The next step in this project is to restore and enhance habitat for the Chase caribou by applying ecological and functional restoration techniques to roads determined as suitable for restoration. Restoring these roadways is expected to:

1. Make the roadways less suitable for other prey species. This process will be informed by the moose model developed as a component of this project. Furthermore, our project team intends to incorporate plant species that are not palatable to moose into restoration prescriptions. The intention being that we do not want to create moose habitat while restoring these roadways.
2. Make the roadways less suitable for travel by predators and humans. In the short-term this will be accomplished through the application of functional restoration techniques such tree hinging and blocking site lines (Golder Associates. 2015), and over the long-term accomplished by applying ecological restoration techniques that accelerate the return of the roadway to a mature forest environment.
3. Reduce habitat fragmentation within the Chase caribou herd range. Our project team will focus resources on restoring large areas for the Chase caribou. In addition, our project team will first focus on areas that are in or run adjacent to migration corridors for the Chase caribou, as well as roadways that move from low to high elevation caribou winter habitat.

## 5.0 RECOMMENDATIONS

The next phase of this project is to restore the forest roadways within the Chase caribou herd range boundary that have been identified as priorities for restoration activities by TKD Nation, the forest licensees operating in the project area, and the caribou biologists most familiar with the Chase caribou. During this step, consultation will be carried out with other land users that include, but are not limited to, mineral tenure holders, guide outfitters and special use permit holders. These discussions were beyond the scope of this project to date, but will occur as the project progresses.

Our team will focus our efforts on restoring large areas of habitat for the Chase caribou. These activities will be focused on the roadways closest to areas of high ecological value to the Chase caribou () such as identified ungulate winter range, migration corridors and seasonal habitat. Our project team is also cognizant of the potential for conflict between moose and caribou. The moose habitat data presented in this report will work to inform future restoration activities. For instance, where a road is directly adjacent to or connects moose and caribou habitat, the reforestation techniques employed may focus on species that are unpalatable to moose in an attempt to limit or reduce the potential for conflict.

Our approach to road restoration will be one that employs both ecological and functional restoration techniques, and aligns with TKD Nations expectations for road restoration. Our team feels that an approach to restoration that incorporates both techniques will provide immediate benefits to caribou by working to restore the biological processes (predator – prey relationships) to their pre-disturbance level, while also working to accelerate the return of the roadway to a mature forest environment. While restoring a single forest roadway cannot be expected to halt the decline of the Chase caribou, restoring a series of roadways to create large areas of intact habitat would contribute to the recovery of the Chase caribou. Our team intends to continue working to restore habitat for the Chase caribou, while also implementing a monitoring plan to determine how vegetation, wildlife and recreational vehicle use respond to these treatments. It is our goal to benefit the Chase caribou, while also providing information to forest managers, biologists and practitioners of restoration ecology who are looking to become engaged in the recovery of caribou in Canada.

## ACKNOWLEDGEMENTS

Our project team gratefully acknowledges the financial support of the Fish and Wildlife Compensation Program ([www.fwcp.ca](http://www.fwcp.ca)) for its contribution for Identifying Forest Roads for Rehabilitation Within the Chase Caribou Herd Range Boundary. The FWCP is a partnership between BC Hydro, the Province of B.C., Fisheries and Oceans Canada, First Nations and public stakeholders to conserve and enhance fish and wildlife impacted by the construction of BC Hydro dams. Support from the FWCP also included a thorough review by Chelsea Coady, as well as an anonymous reviewer, whose comments strengthened this report and project as a whole.

We also gratefully acknowledge the financial support provided by the Society for Ecosystem Restoration in Northern British Columbia (SERNbc) for their support of the GIS and field work components of this project. Furthermore, we acknowledge the financial support our project team has received from Environment and Climate Change Canada for the engagement sessions in Tsay Keh Dene. These sessions proved invaluable for further identifying priority areas for restoration, but also refining the techniques that will be applied in future decommissioning and restoration programs in caribou habitat within Tsay Keh Dene Nation Territory. This project also received financial and in-kind support from Conifex Timber Inc. and Dunkley Lumber Ltd.

Our project team would like to thank Luke Gleeson, Sina Abad, and Nicole Wheelie of Tsay Keh Dene Nation Lands, Resources and Treaty Operations Department for their countless hours of in-kind support for this project. Without the in-kind support of Tsay Keh Dene Lands Resources and Treaty Operations Department this project would not have been possible.

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## APPENDICES

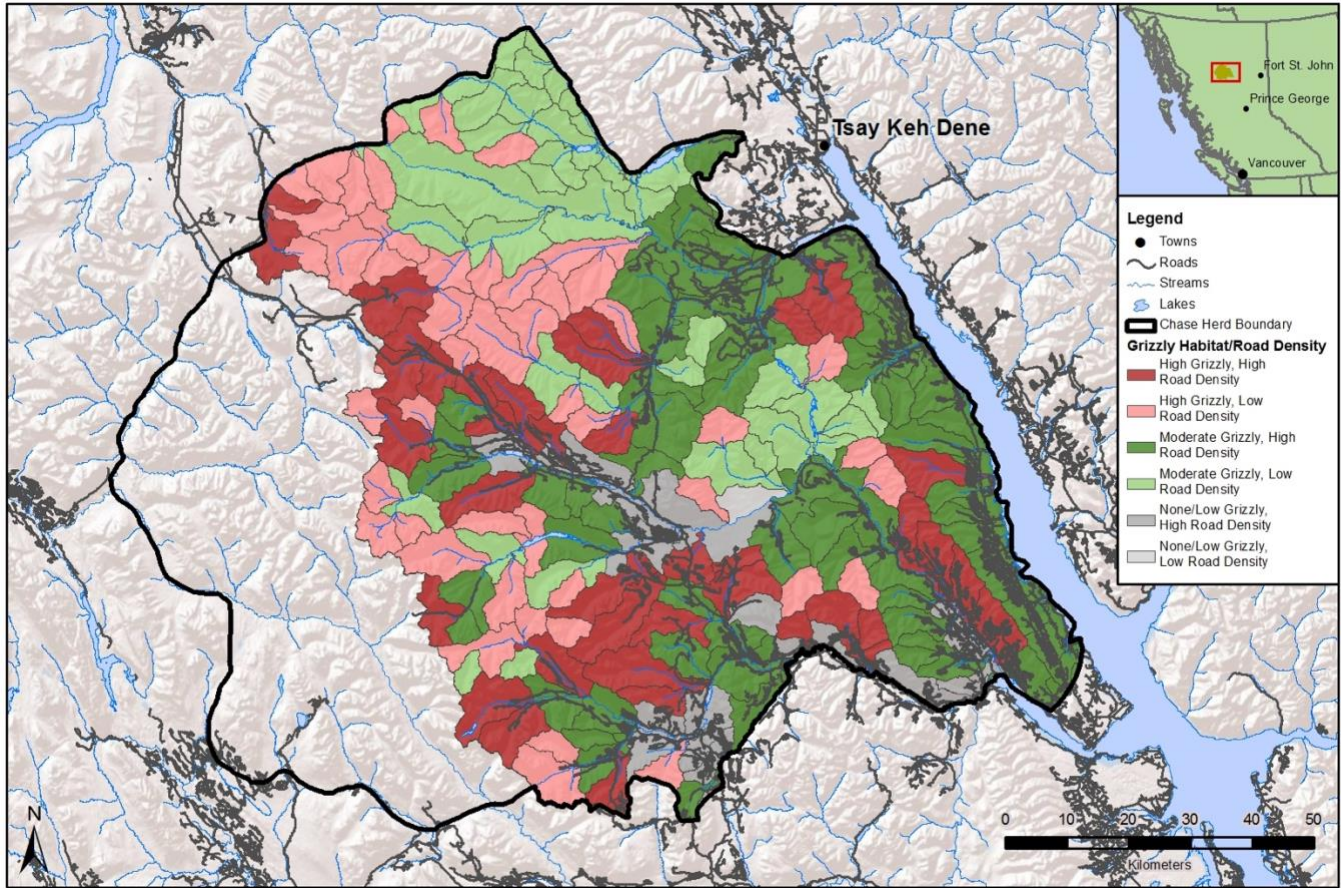
### APPENDIX 1

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We made additional considerations for grizzly bears in the areas, a wide-ranging species that is also sensitive to road densities. While not related to the objectives of this project, identifying areas of high quality habitat for grizzly bear can work to further clarify where limited resources for road restoration can be focused within the Chase caribou herd range boundary.

We overlaid road density onto the grizzly bear habitat management polygons. We have used a road density of  $>0.6$  km/km<sup>2</sup> as the threshold for “high density” road areas and polygons containing no roads or  $<0.6$  km/km<sup>2</sup> were deemed to be ‘low density’. The exception to this rule occurred when a polygon contained only a small number of roads that were confined to a small portion of the polygon, where we then deemed low density. Grizzly bear habitat data were only available in the Mackenzie TSA, so the western third of the Chase herd was not classified.

Grizzly bear habitat quality within the Chase herd is highly correlated with mountainous regions that provide high berry production, and many of these areas (shown in red in Figure 7) also overlap with core caribou areas. Of the areas where data is available, a total of 857,262 ha is considered high-moderate quality for grizzly bears and 58% of this area is within high road density areas.



**Figure 7.** Grizzly bear habitat quality and road density. High grizzly bear habitat with high road density (dark red); high grizzly bear habitat with low road density (light red); moderate grizzly bear habitat with high road density (dark green); moderate grizzly bear habitat with low road density (light green). All roads shown in dark grey.

**Table 5.** Summary of Grizzly bear habitat quality and road density class within the Chase herd boundary. Grizzly bear data were only available within Mackenzie TSA.

Grizzly Bear Habitat Quality x Road Density Class	Area (ha)
High Grizzly Bear Density x High Road Density	201,707
High Grizzly Bear Density x Low Road Density	184,938
Moderate Grizzly Bear Density x High Road Density	295,452
Moderate Grizzly Bear Density x Low Road Density	175,165
None/Low Grizzly Bear Density x High Road Density	74,269
None/Low Grizzly Bear Density x Low Road Density	3,850
Outside of Grizzly Bear mapping	292,985

APPENDIX 2

The following flowchart was used to assess streams found along the roads being evaluated for rehabilitation potential, and soil card to assist in road assessments.

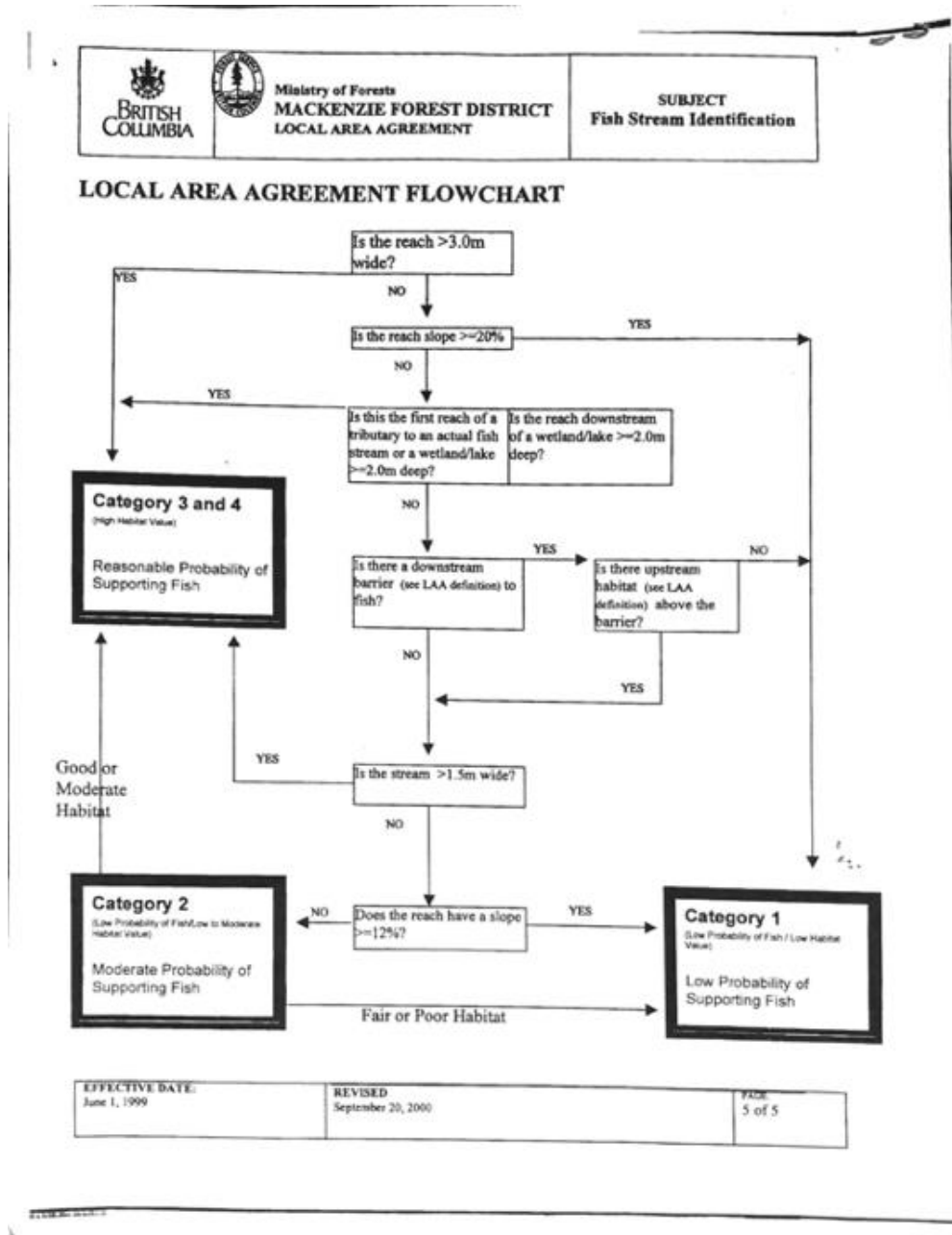


Figure 8. Mackenzie Forest District (now the Mackenzie Natural Resource District) local area agreement fish stream identification flow chart.

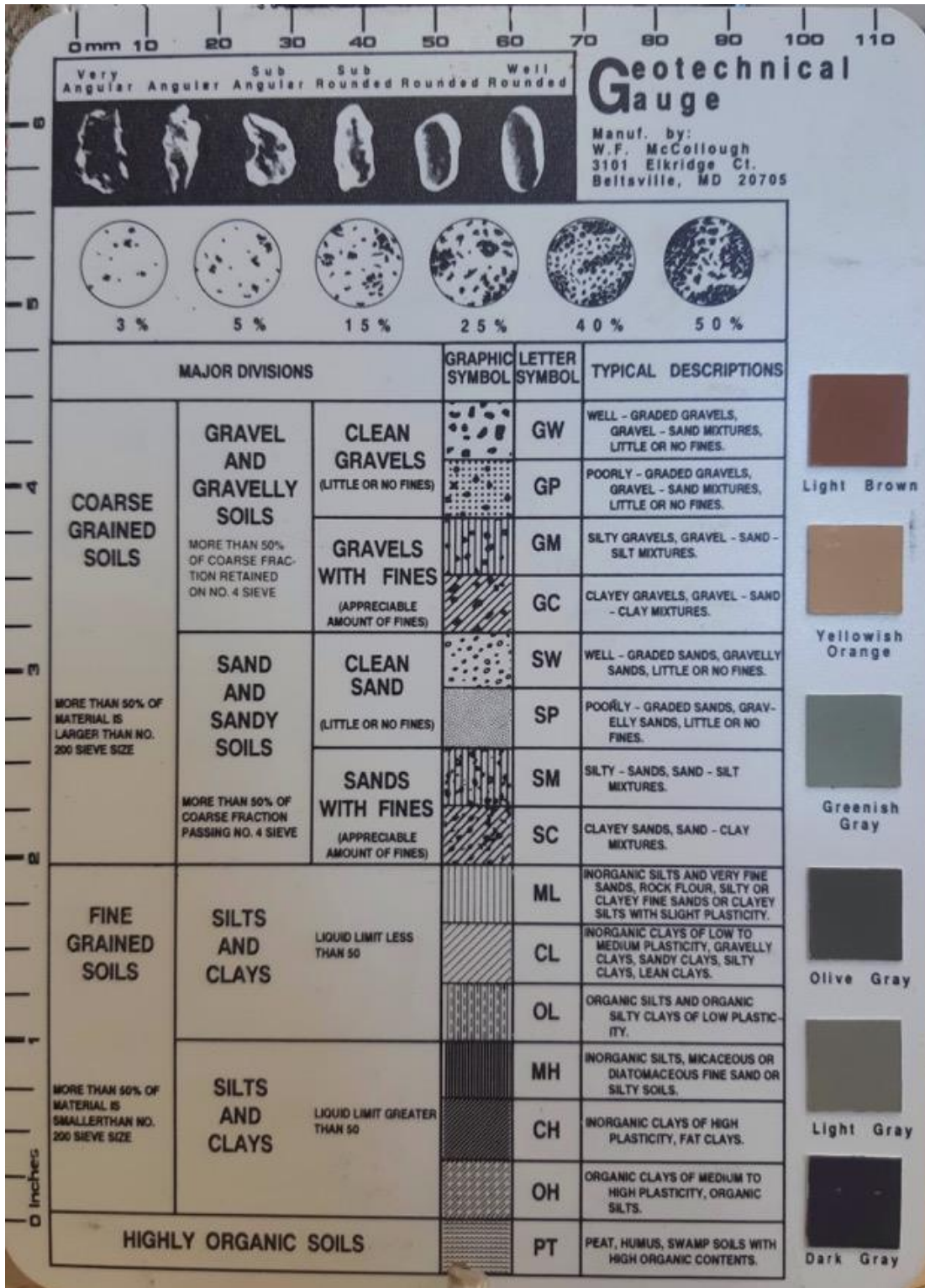


Figure 9. Soil card Side A used to assist road assessments.

CLAY				
CLAY CONSISTENCY	THUMB PENETRATION	SPT, N BLOWS/ FT.	Undrained Shear Strength (P.S.F.) TORVANE	Unconfined Compressive Strength $q_u$ Pressure Measurement
VERY SOFT	Easily penetrated several inches by thumb. Exudes between thumb and finger's when squeezed in hand.	< 2	250	500
SOFT	Easily penetrated one inch by thumb. Molded by light finger pressure.	2 - 4	250 - 500	500 - 1000
MEDIUM STIFF	Can be penetrated over 1/4" by thumb with moderate effort. Molded by strong finger pressure.	4 - 8	500 - 1000	1000 - 2000
STIFF	Indented about 1/4" by thumb but penetrated only with great effort.	8 - 15	1000 - 2000	2000 - 4000
VERY STIFF	Readily indented by thumbnail.	15 - 30	2000 - 4000	4000 - 8000
HARD	Indented with difficulty by thumbnail.	> 30	> 4000	> 8000

SAND			FIELD TEST
SOILTYPE	SPT, N Blows/ft. Density, %	Relative Density, %	
VERY LOOSE SAND	4	0 - 15	Easily penetrated with 1/2" reinforcing rod pushed by hand
LOOSE SAND	4 - 10	15 - 35	Easily penetrated with 1/2" reinforcing rod pushed by hand
MEDIUM DENSE SAND	10 - 30	35 - 65	Penetrated a foot with 1/2" reinforcing rod driven with 3-lb hammer
DENSE SAND	30 - 50	65 - 85	Penetrated a foot with 1/2" reinforcing rod driven with 3-lb hammer
VERY DENSE SAND	50	85 - 100	Penetrated only a few inches with 1/2" reinforcing rod driven with 3-lb hammer





Unified Soil Classification System (USCS)			
	MILLIMETERS	INCHES	SIEVE SIZES
BOULDERS	> 300	> 11.8	-
COBBLES	75 - 300	2.9 - 11.8	-
GRAVEL:			
COARSE	75 - 19	2.9 - .75	-
FINE	19 - 4.8	.75 - .19	3/4" - No. 4
SAND:			
COARSE	4.8 - 2.0	.19 - .08	No. 4 - No. 10 
MEDIUM	2.0 - .43	.08 - .02	No. 10 - No. 40 
FINE	.43 - .08	.02 - .003	No. 40 - No. 200 
FINES:			
SILTS	< .08	< .003	< No. 200
CLAYS	< .08	< .003	< No. 200 

Figure 10. Soil card Side B used to assist road assessments.

APPENDIX 3

**Table 6.** Summary of priority roadways for rehabilitation.

ID	Site ID	Zone	Location		Recommended Treatment Priority
			Easting	Northing	
1	Old Thutade FSR	10 V	348447	6230642	High
2	Swannell	10 V	349078	6266920	High
3		10 V	326527	6263903	High
4		9 V	662203	6277313	Medium
5	Caribou Flats	9 V	670811	6278223	High
6	Swannell	10 V	349862	6269391	Medium
7	Flood Creek	10 V	377325	6288346	Medium
8	Ravenal	10 V	368478	6279179	Medium
9	Ravenal	10 V	366914	6277568	Medium
10		10 V	335263	6258755	Medium
11	Ravenal	10 V	366769	6276991	Medium
12		10 V	333603	6260860	Medium
13	Ravenal	10 V	367298	6276616	Low
14		10 V	323645	6286090	Low
15	Lay Creek	9 V	682450	6274775	Low
16		10 V	338264	6256827	Low
17	Ravenal	10 V	369597	6274122	Low
18	Ravenal	10 V	369973	6274536	Low
19		10 V	364138	6286902	Low
20	Tutizzi Lake	10 V	353459	6242932	High
21	Goldway	9 V	663916	663916	High

APPENDIX 4

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The following are descriptions of each road and area considered to be a strong priority for restoration within the Chase caribou herd range boundary.

6.1.1 ROAD 1

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Road 1 is accessible via the Tenakihi Forest Service Road (FSR) on the Old Thutade FSR. The lower section of the road is brushed in with willow (*Salix* spp.) and alder (*Alnus* spp.), before opening up and providing access to high elevation (Figure 11; Figure 12). Adjacent stands are spruce (*Picea* spp.) dominant, with a smaller pine (*Pinus* spp.) and subalpine fir (*Abies* spp.) component. There are plantations along one side of the road, interspersed with standing timber. The cut side of the road consists of standing timber and some riparian areas with no foreseeable timber harvest possibility.

The road surface is well compacted and is a mixture of gravel, moss and grasses with some natural regeneration of grass and red clover (*Trifolium* spp.; Figure 13). Natural regeneration of the alder and willow saplings is less than 1.5 m in height and less than 700 stems per hectare (sph). Average road width is 3.5 m and average road grade is < 5 %. There is more than 200 m of eligible road, over 4 m wide and not restocked, available for rehabilitation. The cut blocks have been replanted and are at the 'free-to-grow' stage. The road is located on a slope with a + 10 % and - 5 % grade. The average road grade is 2 % while the stream crossings are approximately -3 %, most flowing through a culvert. The streams have an average width of 0.86 m and the largest culvert is 0.9 m in diameter. There are no classifiable streams crossing the road. Several existing culverts have been left in place, providing drainage. Horse droppings and hoof prints were visible along the road indicating potential use of this road by Guide Outfitters. Bear, wolf, and moose scat were also observed.

This road is located in a high elevation (1300 m) area, is isolated from other road networks, and leads to alpine areas. Access management is recommended along with culvert removal and planting. A large portion of the road is maintained by repeated truck access, and so it will require appropriate mechanical site preparation before planting. There is an opportunity to remove a bridge over a large creek approximately 2.5 km before the road, which could accelerate revegetation on the entire 3-4 km road segment.



**Figure 11.** Road 1 brushed in with willow and alder.



Figure 12. Landing near the end of Road 1.



**Figure 13.** Compaction preventing natural regeneration on Road 1.

#### 6.1.2 ROAD 2

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Road 2 is accessed via the Swannell FSR, is located within a caribou migration corridor, and leads toward high elevation. There are pine flats with abundant lichen at the base of the slopes. There is evidence of moose browse along the road and evidence of recreation use by hunters and or Guide Outfitters, as horse droppings and the evidence of old camps are present (Figure 14). Adjacent stands are mixed young plantations of 60 %

pine and 40 % spruce (Figure 15). The adjacent stands appear to be healthy and the plantations are at the ‘free-to-grow’ stage. Fresh road ribbon is present indicating future development plans by the licensee.

The average road width is 4 m, and there is an average road grade of < 10 %. There is more than 200 m of eligible road over 4 m wide and not restocked, available for rehabilitation. As Figure 16 shows, the road is compacted and surfaced with coarse fragments with no organic material. There are a few grasses, willow, buffaloberry (*Shepherdia canadensis*), and poplar (*Populus balsamifera*) naturally regenerating along the road side. The ditch has a grade of + 11 % and – 23 %, while the road has a grade of – 17 %. Given the grade, there is potential for erosion along the steep slopes. The road has cross ditches rather than culverts to deal with water flow.

The road surface is well compacted and will require appropriate site preparation before planting. Discouraging access to the road within the first 200 m would help prevent the further compaction of the road base.



Figure 14. Evidence of recreational use on Road 2.



**Figure 15.** Mixed pine and spruce plantation adjacent to Road 2.



**Figure 16.** Heavy recreational use maintains the compacted road, slowing natural regeneration on Road 2.

### 6.1.3 ROAD 3

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Road 3 runs parallel to the Tenakihi FSR, on the slopes of the mountains to the north-east. The road is located within a caribou migration corridor. The road gradually gains elevation, passing two plantations along the way, and ending in a third. These plantations are composed of 65 % pine and 35 % spruce (Figure 17). The mature adjacent stands are pine leading with a component of spruce (Figure 18).

The average road width is > 4 m and over 200 m is eligible for rehabilitation. The compacted road is not surfaced, but has coarse texture and no organic matter. Willow, alder, fir, pine, and spruce are naturally regenerating with fir, pine and spruce greater than 700 sph. The road is also regenerating grasses, moss and clover. The slopes are gentle at - 4 % and + 6 %, with a road grade of - 3 %. The road does not cross a classifiable stream and has no erosion issues. Bear and moose scat were observed on the road during surveys. There is also evidence of recreational activity up to the first ditch. The road surface is well compacted and will require appropriate mechanical site preparation before planting the area that is not regenerating.



**Figure 17.** Road 3 showing adjacent plantations.



**Figure 18.** Road 3 showing adjacent timber stands.

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#### 6.1.4 ROAD 4

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Road 4 is located north of Goldway to the east of the Tenakihi FSR, located in a no harvest zone. The road leads from the FSR to the powerlines where it used by horses and ATVs. The adjacent stand is a mature stand of 50 % pine, 45 % spruce and 5% fir (Figure 19).

The road surface is composed of a fine texture and is not compacted (Figure 20). The road has an average width of 3.5 m and has less than 200 m of eligible length. The road has a grade of – 4 % with a ditch slope of – 10 % and – 7 %. The road goes through a wetland, but not a classifiable stream, and neither culverts or cross ditching is present. Grasses, willow and fireweed (*Chamaenerion angustifolium*) make up the bulk of the natural regeneration on the road (Figure 21).

Horse droppings indicate potential use of the road by Guide Outfitters. There is evidence of moose droppings and possible caribou tracks along the road. While raw planting could be sufficient, mechanical site preparation

before planting is the recommended treatment to ensure tree establishment and growth. Given the recent tracks, it would be advantageous to restrict access of ATVs using a barrier.



**Figure 19.** Road 4 showing adjacent timber stands.



**Figure 20.** Less compaction on the running surface of Road 4.



**Figure 21.** Natural regeneration of grasses, willow and fireweed on Road 4.

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#### 6.1.5 ROAD 5

Road 5 is located in Caribou Flats off the Tenakihi FSR with the upper reaches of the road leading into a caribou migration corridor. The adjacent timber stand is 50 % subalpine fir with 25 % of each pine and spruce (Figure 22). This road does not have plantations along it, however, the Kemess mine powerline crosses close to the Tenakihi FSR.

The road is compacted and has a coarse soil texture. The road has an average grade of – 11 % with a ditch slope of – 18 % and + 8 %. The road crosses a 3 m wide creek with a rocky creek bed and no culverts or cross ditching are present (Figure 23). Along the uncompacted areas of the road, lichen, moss and grasses are naturally regenerating. Ungulate tracks are evident along the road, possibly from a caribou.

This road provides access to high elevation caribou winter range, and to the powerline (Figure 24). There is the possibility of winter recreational use of this roadway and powerline. The road surface is well compacted and will require appropriate site preparation before planting. Access should be restricted to prevent access into the alpine, a caribou migration corridor and high elevation caribou winter range.



Figure 22. Road 5 showing adjacent stands.



Figure 23. Stream crossing on Road 5.



**Figure 24.** Road 5 leading into alpine.

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#### 6.1.6 ROAD 20

The road to Tutizzi Lake is accessed via the Tenakihi FSR, south of the Mesilinka River. Between two and three kilometers from the start of the road, access control is present in the form of bridge removal at a creek crossing. This deactivation prevents pickup truck access but all-terrain vehicles (ATVs) and horses can travel past this deactivation (Figure 25; Figure 26). The adjacent stand comprises of healthy standing timber of 80 % pine, 10 % poplar, and 5 % willow between recently planted blocks (Figure 27).

The road is, on average 7 m wide, has a + 2 % grade, and a compacted surface of coarse crushed gravel with no organic material. Along the edges of the road, the natural regeneration is comprised of grasses and clover. The road has a slope of 17 %, and the ditch is – 19 % for 5 m and then – 5 %. The streams crossing the road have an average width of 2 m with a gradient of – 4 %. There are several 1.2 m wide culverts in place along the road that require removal. Several creeks have culverts removed and the road ditched, as well as some

functioning culverts left in place for drainage. There is evidence of recreation along the road, along with indications of wildlife usage, with bear and canid scat present. Crews found one invasive species, a single plant of scentless chamomile (*Tripleurospermum inodorum*), and removed it.

Since this road already has creek crossings removed, it is recommended that the remainder of the road is ripped and planted. The road is compacted and surfaced, and will require a ripper to facilitate new seeds and plant establishment and growth. It is also recommended that culverts be removed and barrier puts in place at the beginning of the road to prevent road access. This road has not been identified by the licensees for rehabilitation, perhaps due to the several newly harvested cut blocks that have likely not met silvicultural obligations yet.



**Figure 25.** Access control on Tutizzi Lake road (bridge removed).



**Figure 26.** Road to Tutizzi Lake ditched to prevent pickup truck access.



**Figure 27.** The road to Tutizzi Lake west of the deactivation.

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#### 6.1.7 ROAD 21

Road 21 leads to Goldway Mountain, and is accessed from the Tenakihi FSR. The road leads to no harvest zones and a caribou migration corridor. The adjacent stand is equally composed of mature stands of pine and spruce (Figure 28). The average width of the road is 2 m and it is compacted with coarse soils. Willow and grasses are naturally regenerating on the road where it is not compacted.

There is a creek crossing at the beginning of the road that is crossable by ATV's (Figure 29). Access control measures are recommended to prevent the continue access and crossing of the stream by ATV's.



Figure 28. Adjacent stand of spruce and pine on Road 21.



Figure 29. Stream crossing at the beginning of Road 21.

### 6.1.8 CARIBOU FLATS

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The Caribou Flats area is north-east of the Tenakihi FSR, extending from the valley into high elevation. The road runs adjacent to a caribou migration corridor, and high elevation caribou winter range. There is one priority road within this area (Road 5), and it is high priority.

### 6.1.9 GOLDWAY

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Goldway is south of the Tenakihi FSR and wraps around the mountain and provides access to the alpine. The caribou migration corridor follows the mountain side and into the alpine. There is one road in the area (Road 21) that is high priority for rehabilitation.

### 6.1.10 LAY CREEK

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Lay Creek is located north of the Tenakihi FSR. Lay Creek proper feeds into the Mesilinka River, and a valley with two intersecting caribou migration corridors. There is one priority road (Road 15) that is low priority for rehabilitation. To the south of the area there is a high priority road (Road 3) along the same migratory corridor.

### 6.1.11 TUTIZZI LAKE

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The Tutizzi Lake area includes a 40 km road along the Tutizzi Lake. Much of the valley bottom is riparian and classified as ‘conditional harvest zone’ and the steep mountains are ‘no harvest zone’. Road 20 is located at the beginning of this area.

### 6.1.12 OLD THUTADE FSR

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Old Thutade FSR is off the Tenakihi FSR and most of the area follows roads that access high elevation. Much of the area is either ‘conditional harvest zone’ or ‘no harvest zone’ due to the elevation and riparian areas in the valley. There is one road (Road 1) that is high priority.

### 6.1.13 FLOOD CREEK

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Flood Creek is off the Swannell FSR and the caribou migration corridor extends down the creek, nearly to the FSR. There is a road network on either side of the creek, mainly consisting of in block roads. There is one priority road (Road 7) that is medium priority.

### 6.1.14 RAVENAL

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Ravenal is accessed off of the Swannell FSR and is comprised of riparian valley bottoms and roads leading into the alpine. Most of the area is classified as ‘conditional harvest zone’. There are 6 priority roads (Roads 8,9,11,13,17, and 18), 3 of each low and medium priority.

6.1.15 SWANNELL

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The Swannell area is located at the end of the Swannell FSR and serves as a caribou migration corridor through the valley and into the alpine. The Swannell River originates from this area, resulting in riparian areas. The valley is classified as 'conditional harvest zone' and the higher elevation is 'no harvest zone'. There are 2 roads in this area, one high priority (Road 2) and one medium priority (Road 6).