Appendix 13-C

Murray River Project: Wildlife Habitat Ratings for Local Study Area

MURRAY RIVER PROJECT WILDLIFE HABITAT RATINGS FOR LOCAL STUDY AREA

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EDI ENVIRONMENTAL DYNAMICS INC.

EXECUTIVE SUMMARY

HD Mining International Ltd. (HDI) is conducting environmental baseline studies for the Murray River Project (MRP), which is a proposed underground coal mine located approximately 12.5 km southwest of Tumbler Ridge, British Columbia. HDI initiated Wildlife Habitat Ratings studies in summer 2010 with assessment of the MRP Regional Study Area, and continued the work in 2012 to assess the Local Study Area (LSA). This report provides results of Wildlife Habitat Ratings for the LSA.

The first version of this report[1] summarized Wildlife Habitat Ratings based on a LSA that was delineated for the Murray River Project in early 2012. The LSA was subsequently expanded to include additional mine infrastructure and a revised Terrestrial Ecosystem Map was completed by March 2013. The Wildlife Habitat Ratings were then expanded and revised to match the current LSA of the Murray River Project based on that mapping product. In addition to encompassing the revised LSA, this version of the report addresses comments provided on Version 1 of the LSA report by the BC Ministry of Forests, Lands and Natural Resource Operations, and addresses review of Version 2 and Version 3 by the HDI Environmental Assessment team lead by ERM (formerly Rescan Environmental Services). Review was solicited from First Nations during this process.

Seven terrestrial wildlife species were selected for habitat rating: woodland caribou (*Rangifer tarandus caribou*), Black-throated Green Warbler (*Dendroica virens*), mountain goat (*Oreamnos americanus*), moose (*Alces alces*), grizzly bear (*Ursus arctos*), fisher (*Martes pennanti*) and elk (*Cervus elaphus*). Selection of key wildlife species and life requisites was based upon a number of social, economic, ecological and regulatory considerations. Species selection considered social values as determined from meetings with stakeholders and First Nations.

The methodology followed Resources Inventory Standards Committee (RISC) Wildlife Habitat Ratings standards. The RISC standards apply an expert-based model for life requisites and seasonal use of selected species and are based on a four or six class system relative to provincial benchmarks that provide optimal habitat condition. A Bayesian Belief Network tool was used to define decision models that describe the "ecological causal web" for each species' selected life requisite. The software program, Netica® (version 5.12, Norsys Systems Corporation, Vancouver, B.C.) served as the framework for processing the decision models. A single decision model was created for each life requisite of the seven selected species for a total of 18 models.

This final report summarizes the methods and resulting decision models used to develop Wildlife Habitat Suitability Ratings for the Murray River Project LSA. Models are presented using an approach that is transparent and repeatable, and one that reviewers from a wide background can evaluate. The methods are consistent with expectations for baseline studies within a B.C. Environmental Assessment. The purpose of this study's results is to inform wildlife habitat effects assessment and mitigation planning as HDI prepares an application for an environmental assessment certificate pursuant to the BC *Environmental Assessment Act*.

[1] Murray River Project – Wildlife Habitat Ratings for Local Study Area. Prepared for HD Mining International Ltd. Prepared by EDI Environmental Dynamics Inc. December 21, 2012.

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- Model review: Maureen Ketcheson (Ecologist, MSc, RPBio), Anne MacLeod (Wildlife Biologist, RPBio)
- Netica technical advice: Anne-Marie Roberts, RPBio
- Data management: Dennis Thideman
- GIS: Debbi Weber, RPF, Darren Wiens, MSc
- Species experts who provided species account review are as follows:
  - Woodland Caribou – Dale Seip, PhD, Wildlife Ecologist, Ministry of Environment
  - Black-throated Green Warbler – Mark Phinney, RPF, RPBio, District Biologist, Louisiana-Pacific Canada Ltd.
  - Mountain Goat, Moose and Fisher – R. Scott McNay, PhD, RPF, RPBio, Project Manager/Ecologist, Wildlife Infometrics Inc.
  - Grizzly Bear – Lana Ciarniello, PhD, RPBio, Aklak Wildlife Consulting
  - Elk – Andy Smith, MSc, EDI Environmental Dynamics Inc.
- Information requests: Mark Phinney (RPF, RPBio, District Biologist, Louisiana-Pacific Canada Ltd.), Bruce Rogers (MSc, RPBio, PAg, Ecologist, B.C. MFLNRO), British Columbia Breeding Bird Atlas[2]
- ERM (formerly Rescan Environmental Services) reviewed and provided feedback on this study as the prime consultant leading the Environmental Assessment Application.

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[2] We thank the British Columbia Breeding Bird Atlas for supplying data. We would also like to thank the following partners in the Breeding Bird Atlas: Canadian Wildlife Service, British Columbia Ministry of Environment, BC Nature, BC Field Ornithologists, Biodiversity Centre for Wildlife Studies, Louisiana Pacific, and the Pacific Wildlife Foundation, as well as all of the volunteer participants who gathered data for that project.

Acronym List

BEC	Biogeoclimatic Ecosystem Classification
EA	Environmental Assessment
GIS	Geographical Information System
LSA	Local Study Area
MFLNRO	Ministry of Forests, Lands, and Natural Resource Operations
MRP	Murray River Project
RSA	Regional Study Area
TRIM	Terrain Resource Inventory Mapping
TEM	Terrestrial Ecosystem Mapping
PEM	Predictive Ecosystem Mapping

Glossary of Terms

Data inputs	Raw data that is mapped and used as inputs to habitat models using GIS.
Ecosystem unit	A mapped unit that describes a similar ecosystem, such as a vegetation type.
Habitat capability	The ability of an ecosystem in its optimal natural conditions for a species to provide its life requisites, irrespective of the current condition of the habitat.
Habitat suitability	The ability of the habitat in its current condition to provide the life requisites of a species.
Habitat predictors	Variables that can be used to predict the suitability of habitat for a species.
Life requisite	Necessities for life such as food and shelter. The general combination of these activities is called "living."
Species account	A written description of an animal species' life requisites and seasonal habitat requirements that are relevant to the project area. It documents the ecosystem attributes that provide these requirements. Species accounts provide the reasoning behind the wildlife habitat ratings for a species.
Species-habitat model	The combination of a species account and wildlife habitat ratings for a species.
Wildlife Habitat Rating	A rating is the value assigned to a habitat for its potential to support a particular species for a specified season and activity compared to the best habitat in the province used by that species for the same season and activity. It is expressed as a percentage of the best habitat in the province (the provincial benchmark) and it reflects the expected use of a habitat by the species. Ratings in this study are presented in a four or six categorical system where 1 is the best habitat.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

HD Mining International Ltd. (HDI) is conducting environmental baseline studies for the Murray River Project (MRP), a proposed underground coal mine located approximately 12.5 km southwest of Tumbler Ridge, British Columbia. HDI's Murray River Coal Exploration license area is 16,024 hectares and includes a total of 57 coal licenses within the Peace River Coalfield (PRC) (Rescan 2013). At the time of writing, the MRP Potential Mine Surface Development Areas are expected to encompass approximately 312 ha of the Murray River Coal Exploration area, including 78 ha for the recently sited (June 2012) portions east of the Murray River for the Proposed Coarse Coal Reject Area and Coal Preparation Plant.

As a component of the MRP environmental baseline studies for wildlife, EDI Environmental Dynamics Inc. (EDI) completed a Wildlife Habitat Rating (WHR) study resulting in habitat suitability ratings. Habitat suitability ratings measure the current ability of an ecosystem to provide the conditions necessary to meet the various life requisites for a given wildlife species. The purpose of this study is to quantify the amount of wildlife habitat available in the baseline condition, so that effects prediction and mitigation planning can take place and potential effects to wildlife habitat can be monitored during and following development.

Two study areas were delineated around the MRP general proposed development area for environmental baseline studies: the Local Study Area (LSA) is 12,436 ha and the Regional Study Area (RSA) is 230,000 ha (Map 1, Appendix A). The RSA was created to cover a broad area where there may be potential for environmental effects directly or indirectly due to the project and to incorporate the home ranges of wildlife species of the area. The LSA was developed to capture the area where potential direct and sensory effects on wildlife are most likely to occur due to the Project activities (Rescan 2013). Wildlife Habitat Ratings for both the RSA and the LSA are a component of baseline data information requirements.

The WHR study was initiated in late summer 2010. Field sessions were completed in each summer/fall of 2010, 2011, and 2012. An interim report was completed following the first session of field work. Three final technical reports were completed to date: one for WHRs in the RSA, one for WHRs in the original layout of the LSA, and the current report that provides WHRs in the revised LSA. A brief timeline of the study is summarized below.

- March 2011: Interim Report, titled "Murray River Project Wildlife Habitat Ratings: Field Program 2010 Interim Report"
    - WHRs were completed for the western area of the RSA using an existing Predictive Ecosystem Mapping (PEM) product as base data. Capability and suitability ratings were generated for each mapped ecosystem unit within the PEM. The study was initiated in 2010.
- April 2012: Final Report, titled "Murray River Project Wildlife Habitat Ratings Study Final Report"
    - WHRs were refined and applied to the entire RSA. A PEM developed specifically for the MRP by Rescan was used as a base layer, in addition to slope and aspect data that was developed from existing terrain data (TRIM). New information resulting from July 2011 field work and expert review of the species accounts was incorporated into the ratings. The

final report presented the species-habitat models including wildlife habitat ratings and species accounts, a summary of 2010 and 2011 field work, and final habitat suitability mapping. Report was referred to and feedback was received from First Nations and MFLRNO representatives.

- December 2012: Report titled "Murray River Project Wildlife Habitat Ratings for Local Study Area: Version 1"
  - The objective of this study was to develop a finer scale of wildlife habitat suitability ratings for the smaller LSA. A Terrestrial Ecosystem Mapping (TEM) product was produced by Rescan for the LSA which provided more precise ecological information than the PEM product at the site level of the project. Report was referred to First Nations and MFLRNO representatives; feedback was received from MFLNRO representatives.
- October 2013: Report titled "Murray River Project Wildlife Habitat Ratings for Local Study Area: Version 2"
  - Changes to the mine plan included additional areas where potential development of mine facilities could occur. LSA Report Version 2 was an amended version of the December 2012 LSA Report updated to include wildlife habitat ratings for the revised LSA area. The new LSA comprised additional ecosystem units and additional data was extrapolated from regional vegetation field guides in order to rate these new habitats. The report addressed review comments received to date on the study.
- January 2014: Report titled "Murray River Project Wildlife Habitat Ratings for Local Study Area: Version 3"
  - The report was a revised version of the October 2013 LSA Report. It included revisions to report structure and the species-habitat models according to input and review provided by Rescan/ERM.
- April 2014: Report titled "Murray River Project Wildlife Habitat Ratings for Local Study Area: Version 4"
  - This current report is a minor revision of Version 3. It includes an additional set of caribou models to represent generalized woodland caribou winter and growing season living requirements in addition to the herd-specific models that were created in previous versions. The rationale for these additions is to present a more comprehensive EA package to both First Nations and reviewers with multiple caribou mapping products that can be simplified to generic models if need be or expanded to specifics, for example for effects and mitigation planning. The generalized caribou models may coordinate well with emerging recovery plans from First Nations and the federal recovery strategy.

The objective of the current study was to model wildlife habitat suitability for seven species (i.e. woodland caribou, Black-throated Green Warbler, mountain goat, moose, grizzly bear, fisher and elk) in the LSA. The LSA extends 3 km north and 4 km southeast of the project site within the boundaries of the License Area.

The Murray River flows south to north roughly in the center of the study area (Map 1). Using Terrestrial Ecosystem Mapping for the LSA and refining species models initiated at the RSA resulted in finer scale habitat suitability ratings appropriate to the scale of the site level for this project.

The objective of this report was to summarize the approach and results of habitat suitability ratings in the LSA. This is a technical baseline study; however, the report is presented with the non-technical audience in mind. The reader is referred to additional sources for background information: i) information on wildlife habitat ratings were introduced and discussed further in the previous WHR report for this project "Murray River Project Wildlife Habitat Ratings Study Final Report" (April 2012), and ii) background technical information on the project area setting, the regulatory context of wildlife in the study area, and wildlife habitat modeling methodologies is provided in Appendix B.

2 METHODS

2.1 SPECIES SELECTION

Selection of key wildlife species and life requisites for this study took a number of regulatory, ecological, social, economic, and regional considerations into account. These criteria were as follows:

- Species identified by legislation under the following acts or regulations:
  - *Species at Risk Act* (*SARA*): Endangered, Threatened and Special Concern species
  - *Forest and Range Practices Act* (*FRPA*): Identified Wildlife, Ungulate Winter Ranges (UWR), Wildlife Habitat Areas (WHA). *FRPA* does not explicitly apply to the mining industry; however, UWR and WHAs are applied under other guidelines and can inform conditions in *Mines Act* permitting. There is no overlap of the Project's footprint with UWR or WHA. Map 2 shows the proximity of UWRs and WHAs to the project.
  - *Wildlife Act*: Red and blue-listed species
- Umbrella species representing habitat requirements for a group of animals
- Socioeconomic, subsistence hunting, and regional importance
- Species that have the potential for impacts with respect to the location of the proposed development
- Consistency with the goals of the B.C. Conservation Framework

Species were initially selected if they were identified as at risk or considered umbrella species representing a group of animals anticipated being important. An important component in species selection is to consider inputs from stakeholders and First Nations and to consider species of regional importance. Input was received during several meetings as follows:

i. Following Rescan's review of the RSA final report for Wildlife Habitat Ratings, species selection for the LSA was considered and evaluated at a meeting with the proponent represented by Jody Shimkus on August 9, 2012.

ii. Comments were voiced at a meeting with Rescan, the proponent, and local First Nations on September 6, 2012 after West Moberly, Salteau, and McLeod Lake representatives were provided the final report on RSA Wildlife Habitat Ratings.

iii. A working group meeting occurred in Tumbler Ridge on October 2, 2012 and representatives provided input that informed species selection.

Discussions with external reviewers and stakeholders provided valuable input to species selection. For example, the importance of modeling fisher habitat was heard during the working group meeting occurring in Tumbler Ridge, October 2, 2012. Rescan's "Review of Murray River Habitat Suitability Mapping Report" (July 2012) suggested that species including elk, marten, and mule deer should be modeled or a rationale provided explaining why they were not. Elk was added for analysis within the LSA due to its regional socioeconomic importance and expected frequent occurrence within the LSA. Marten and mule deer were not selected as other furbearers and ungulates of similar socioeconomic value and higher legislative concern were selected for rating. The rationale for all species selection is presented in Table 1.

The life requisites for each species were similar to those previously selected for rating within the RSA. One difference was that three rather than four life requisites were mapped for grizzly bear in the LSA. The primary habitat of the fourth life requisite for grizzly bear, hibernating, is in alpine and subalpine areas which do not significantly occur in the LSA. The intent of species selection in this study is congruent with the purpose of the B.C. Ministry of Environment's Conservation Framework to prioritize species for conservation or study. Species and their life requisites chosen for this study are outlined in Table 2. A total of 18 species-life requisites combinations have been rated in this study.

Table 1. Summary of rationale for species selection within the revised Local Study Area.

Species	*SARA* Schedule 1	B.C. Blue List	Identified Wildlife	Ungulate Winter Range within RSA	Socioeconomically Important	Umbrella species	Habitat Location
Woodland Caribou	✓	✓	✓	✓	✓		
Black-throated Green Warbler		✓	✓				✓
Mountain Goat				✓	✓		
Moose					✓		✓
Grizzly Bear		✓	✓		✓		✓
Fisher		✓	✓		✓	✓	✓
Elk					✓		✓

Table 2. Species and life requisites selected for the Wildlife Habitat Ratings study of the revised Local Study Area.

Species	Code	Life Requisites	Code
Woodland Caribou • Quintette herd • Bearhole/Redwillow herd • Generalized model	RATA	Living in the growing season; Living in the winter season (both herds)	LI-G; LI-W
Black-throated Green Warbler	BTNW	Reproducing	RE
Mountain Goat	ORAM	Living in the growing season; Living in the winter season	LI-G; LI-W
Moose	ALAL	Living in the growing season; Living in the winter season	LI-G; LI-W
Grizzly Bear	URAR	Living in the spring season; Living in the summer season; Living in the fall season	LI-P; LI-S; LI-F
Fisher	MAPE	Living in all seasons; Birthing	LI-A; BI
Elk	CEEL	Living in the growing season; Living in the winter season	LI-G; LI-W

2.2 MODEL DEVELOPMENT

The development of Wildlife Habitat Ratings for the LSA involved several steps including the creation of species accounts, the collection of field data to assist in model development, and the creation, review and revision of the various models. Note that the Wildlife Habitat Ratings in this study describe habitat suitability (the current capacity of habitat to support a particular species' life requisite) as opposed to habitat capability (the ability for habitat to support a species life requisite in its optimal seral condition), which was modeled in some of the earlier studies.

2.2.1 Species Accounts

A species account summarizes information on a species, its life requisites, and habitat use specific to the project area. It is produced with information derived from a literature search and consultation with species experts and provides those details that are used to rate habitat suitability/capability within the project area for the species (MELP 1999).

The species accounts for most of the species and life requisites of interest were created in earlier phases of this study. These accounts were reviewed during pre-field planning and preliminary model development for the LSA. A species account for a new species to the LSA study, elk, was developed and subject to a review and revision process similar to that used for the other species.

Each of the species accounts were submitted to an external species expert for their review. Comments for consideration and suggested edits were provided by each of the reviewers. Revisions to the accounts were made accordingly. Additional information suggested by reviewers or found through continual literature and data search over the course of the study was also incorporated.

Species accounts in this version of the LSA report were revised very slightly from the previous study (EDI 2012), and from the previous version of this report (Version 2). For example, descriptions of life requisites rated in the RSA but not within this LSA study were removed. Species accounts are presented in this report as part of the wildlife habitat suitability models (Section 3) as they are inherently part of the process and result of model development for the seven wildlife species of this study.

2.2.2 Field Work

Fieldwork occurred from September 19th to 24th, 2012 with the purpose of collecting data that could help predict wildlife habitat value in association with available GIS data for the LSA. EDI completed 147 plots of a total 467 ecology and wildlife plots completed within the LSA to date (Map 3). A few relationships were found among GIS data and collected habitat variables; these results were incorporated into the species-habitat models. Details on the methods and results of fieldwork are provided in Appendix C.

2.2.3 Analysis and Revisions

The goal of modeling habitat in the Local Study Area was to apply a model that was comparable to that of the RSA, but at a finer level of detail. This was achieved in part through the use of TEM as base data for the LSA, which provided more precise ecological information than the PEM. Additionally, we refined each species model and we used Bayesian Belief Networks (BBN) as a tool to arrive at habitat ratings. Because habitat suitability is dependent on the combination of habitat predictors, using a belief network to model these relationships provides added transparency and repeatability to the study. BBNs are being used increasingly within ecological modeling for the evaluation of wildlife habitat (e.g. see references for McNay et al. 2006, Marcot et al. 2006, Wilson and Hamilton 2007).

In the Resources Inventory Standards Committee (RISC) standard wildlife habitat ratings approach, wildlife biologists make expert-based decisions on the suitability of each unique ecosystem unit to provide habitat that is suitable for each life requirement of a species and season of interest (MELP 1999). Wildlife biologists make expert-based decisions based on what is known about each ecosystem unit such as what forage plants are present, the amount of canopy closure that occurs, or the elevation range at which that unit occurs. Using BBNs within the WHR approach, wildlife biologists select multiple habitat predictors that are known to influence habitat suitability for each species. A decision model is then created to describe habitat suitability depending on the combination of habitat predictors. For example, if canopy closure is one predictor for fisher habitat suitability, but it only plays a role in areas susceptible to high snowfall, the decision model is structured to assign suitability dependent on those specific combinations of habitat predictors. Netica® (version 5.12, Norsys Systems Corporation, Vancouver, B.C.) software provided a visual framework to draw decision models using box/linkage diagrams and provided an interface to run the BBN models using GIS.

The wildlife species-habitat models were developed through a process of review and revision. Species experts reviewed each species account to ensure known information was complete and accurate. At multiple stages the models including species accounts and resulting maps were submitted to external reviewers for comment. The models were revised taking reviewer comments into account and incorporating any additional information that may have been acquired during the reviewing timeframe. Prior to the second version of this report, ecologist Maureen Ketcheson (Ecologist, MSc, RPBio) provided review on the species-habitat models to assess if the models performed according to the intended species account assumptions. In the process of writing the current version of this report, the models underwent internal review for overall accuracy and were revised accordingly (Anne MacLeod, Wildlife Biologist, RPBio).

2.3 DATA INPUTS

The development of species-habitat models used GIS spatial data inputs as predictors of habitat suitability. Available data was investigated, compiled and used in models as follows.

- Base layers available through national and provincial databases:
  - National Topographic Database (NTDB) shapefiles
  - 1:20,000 TRIM shapefiles
  - Google Earth imagery
  - ESRI base maps
  - Parks and Protected Areas shapefile

Spatial data created specifically for the Murray River Project that was used for Wildlife Habitat Ratings in the LSA were as follows.

- Terrestrial Ecosystem Mapping (TEM) produced by Rescan, version 1 received August 27, 2012 (dated August 1, 2012); Version 2 received March 4, 2013.
  - Created from 1:30,000 scale air photos of the study area taken in 2005 (B.C. Government colour photos, roll # 15BCC05122). The effective mapping scale at which polygons were produced was 1:10,000.
  - The TEM dataset was polygon-based and complex in nature since it had up to three deciles per polygon. This meant that within each polygon every variable could have up to three values. Decile 1 indicated the percentage of area within the polygon that is the primary site series/modifier/structural stage ecosystem map unit. Decile 2 indicated the second most common ecosystem map unit and decile 3 indicated the third most common ecosystem map unit that occurs within the TEM polygon.
  - Available information in the TEM included: Biogeoclimatic Ecosystem Classification subzone; general ecosystem type; and map unit, stand structure modifier, structural stage, forest type and provincial status for each decile.
  - The Map Unit field in the TEM provided the site series code or the restricted use code of the BEC subzone for each decile. Restricted use codes indicated either natural features (e.g. rivers, lakes or ponds) or disturbed habitats such as gravel pits, reclaimed mines or tailings, road or railway surfaces or urban/suburban areas.
- Generalized Stand Structure Mapping, created from Murray River TEM by Maureen Ketcheson
  - In order to assist development of models for prediction of wildlife habitat suitability, and to simplify complex TEM polygon structural stage data, the TEM mapping area was re-delineated and attributed to reflect a generalized stand structure legend and generate a set of

simple (non-deciled) polygons for use in the models. Complex TEM polygons have up to three differing stand structures represented as three deciles that occur at unspecified locations within each polygon boundary. If the structures differ significantly in their value to wildlife habitat it is very difficult to produce a spatially accurate habitat map.

  - The original TEM polygons (Rescan) were superimposed on georectified digital imagery and were subdivided and reclassified into homogeneous polygons with outer boundaries contiguous to the original TEM mapping using ArcMap 10.1 software. These polygons were visually interpreted and classified using stand structure definitions. This classification was based on stand elements that are considered important to habitat interpretations by the wildlife species specialists developing the models.

  - The spatial integrity of the original TEM polygon's outer boundaries was retained thus avoiding the production of slivers. The generalized stand structure layer had a separate role in the models and did not replace original TEM site series or structural stage data. Both datasets (i.e. Generalized Stand Mapping and TEM) were used extensively in the development of the models.

- A triangulated irregular network (TIN) was created from TRIM data using ET GeoWizard. This produced a dataset of elevation, slope and aspect for the entire LSA.

3 WILDLIFE HABITAT SUITABILITY MODELS

The species-habitat models for each species and their selected life requisites including the species account and the model are presented in this section. Models have been simplified for display purposes. For example, the habitat predictor, Arboreal Lichen Potential, has been simplified to a single variable although in the functional model it relies on Forest Type, Structural Stage and BEC Subzone. All habitat predictors, including those that have been simplified, are described in Appendix D. Maps of the habitat suitability ratings generated by these models are found in Appendix E.

3.1 WOODLAND CARIBOU

3.1.1 Distribution

Caribou in the Regional Study Area are members of the Quintette and Bearhole/Redwillow herds which are populations[3] of the northern ecotype[4] of the woodland caribou subspecies (*Rangifer tarandus caribou*) (Jones 2009, WCCC 2007a, Jones *et al.* 2004a). The northern ecotype (a.k.a. northern caribou) of woodland caribou reside in the mountainous and associated plateau sections of the west-central, east-central and northern interior of British Columbia where snowfall accumulations are low in comparison to other areas of the province (MWLAP 2004a). Northern caribou most commonly inhabit low elevation pine or black spruce forests in the winter and alpine/subalpine areas during calving and in the growing season (Jones 2009). Some northern ecotype herds, including the Quintette herd, reside in the alpine year-round. This herd is found southwest of Tumbler Ridge, generally bounded by the divide to the Parsnip watershed to the west, Kinuseo and Thunder Creeks in the south and Bullmoose Creek in the north (WCCC 2007a). However, some overlap with the Parsnip herd to the southwest beyond Kinuseo Creek has been documented (Jones *et al.* 2007). Within the Project area, the Quintette herd is generally found in the western portion of the RSA while the Bearhole/Redwillow[5] herd is found in the eastern portion; there is some movement between herds (Seip and Jones 2011). The Bearhole/Redwillow herd winters in the areas near Bearhole Lake and Redwillow River (Seip and Jones 2011).

Estimated Quintette and Bearhole/Redwillow herd ranges in the vicinity of the RSA are presented in Maps 4 and 5. These ranges were estimated since provincial herd ranges displayed by iMapBC within the RSA do not specifically delineate the Bearhole/Redwillow herd (instead the larger Narraway herd is presented) and herd ranges presented in literature were often varied depending on the radiotelemetry data being used. Rather than attempting to recreate range boundaries from the literature, the range of each herd was estimated using Quintette and Bearhole/Redwillow telemetry data (2002-2011 and 2006-2010 respectively, South Peace Caribou Research Program) provided by the Ministry of Environment. Minimum convex polygons were created using ET GeoWizards (Build Convex Hull tool), a third party GIS extension for

[3] Note that it is uncertain that these groups are distinct biological populations or if they are part of larger metapopulations.
[4] Ecotype: a grouping based on a similar pattern of habitat use, seasonal movements and winter diet selection. Ecotypes are not formal taxonomic designations. There are three ecotypes of woodland caribou found within British Columbia: boreal, mountain and northern caribou.
[5] Provincially, this herd is part of the larger Narraway herd (D. Seip 2012 *pers. comm.*)

ArcGIS®. Polygons were generalized (smoothed) for presentation. Since a simple analysis of density using this data set was possible, density raster datasets were created using ArcGIS® extension, Spatial Analyst (Kernel Density Tool). The data was clipped by their respective minimum convex polygon. Note that this data is an estimate only and cannot be used to provide density estimates over the RSA as presented.

According to this herd range analysis, the Quintette herd range overlaps the LSA, but appears to be a low use area. The Bearhole/Redwillow herd does not overlap the LSA but occurs within approximately 1 km of the eastern boundary. Although this data shows that radio-collared individuals of the Bearhole/Redwillow herd were not located within the LSA for the years 2006 – 2010, the habitat suitability of the LSA was modelled for several reasons. First, due to the close proximity of the nearest radiotelemetry location point, the possibility of occurrence of individuals of this herd cannot be ignored. Second, as mentioned previously, there is potential for members of either herd to move between the herds (Seip and Jones 2011). Finally, as some members of the Quintette herd have been located within low elevation Boreal White and Black Spruce biogeoclimatic zone in winter (Williamson-Ehlers 2012b in Seip and Jones 2012), modelling habitat suitability over the LSA for the Bearhole/Redwillow could serve to adequately represent the value of this area to those individuals of the Quintette herd which utilize lower elevation habitats. Habitat suitability of the Bearhole/Redwillow herd was ranked one category down in consideration of the fact that no animals of the herd have been known to occupy the LSA.

3.1.2 Threats and Status

The Quintette and Bearhole/Redwillow herds are part of the Southern Mountain metapopulation within the Southern Mountains National Ecological Area, which is composed of several small, isolated herds. Many of these herds are subject to increased levels of harassment and predation, loss of critical habitat and displacement to sub-optimal habitat (COSEWIC 2002a, WCCC 2007a). Caribou are sensitive to forestry, mining and other developments, transportation corridors, hunting and other recreational activities. These types of land disturbances can cause them to move from preferred to suboptimal habitat.

There are various means by which anthropogenic activities can impact caribou and their habitat. There is some documentation that human activities or disturbance cause woodland caribou to move from or avoid once preferred habitats (e.g. Cumming and Hyer 1998 and Bradshaw *et al.* 1997 in MWLAP 2004a). Dryer and colleagues (2001) documented maximum avoidance distances of 250 m from roads and seismic lines and 1000 m from oil and gas wells for woodland caribou. Another study found woodland caribou avoided the area within 4 km of a 2 km^2 mine site during most seasons (Weir *et al.* 2007). Increased development and associated linear developments such as roads, transmission lines, oil/gas right-of-ways and seismic exploration line increases access for both predators and people to caribou habitat. Increased predation pressure appears to be a result of increased access and a complex predator-prey system where high predator numbers can be sustained by other ungulate populations and in turn support increased predation on caribou (MWLAP 2004a). Wolves have the potential to eradicate a small caribou population that has been weakened by other natural and anthropogenic factors. Hunting has been documented as a contributing factor in a number of caribou population declines (Kelsall 1968, Bergerud 1974, 1978 in COSEWIC 2002a). Direct loss, fragmentation and degradation of habitat occurs frequently through agricultural encroachment, timber harvesting, mining developments as well as through natural causes such as wildfire (COSEWIC 2002a).

Due to the declining population numbers and range of a number of caribou herds within the Southern Mountains National Ecological Area, the metapopulation including the Quintette and Bearhole/Redwillow herds, is considered threatened by the Committee on the Status of Endangered Wildlife in Canada and is legally designated as such on Schedule 1 of the *Species at Risk Act* (*SARA,* BC CDC 2011; Table 3). Listing on Schedule 1 of the *Species at Risk Act* requires that recovery planning be completed for these animals. Both herds within the RSA are the ecotype of woodland caribou that is blue-listed provincially. Most recent population status assessments conducted in 2013 have estimated 114 – 129 individuals within the Quintette herd (by population census) and 24 individuals within the Bearhole/Redwillow herd (Seip and Jones 2013).

Table 3. Status of woodland caribou (Rangifer tarandus caribou), northern ecotype (BC CDC 2011).

RISC Species Code	M-RATA
Provincial Status	S3 – special concern, vulnerable to extirpation or extinction
B.C. List	Blue
Identified Wildlife (Yes/No)	Yes
COSEWIC Status	T - Threatened
Global Status	G5T4Q - G5 = Secure—Common; widespread and abundant, T4Q = Apparently Secure—Uncommon but not rare; some cause for long-term concern due to declines or other factors.

The southern mountain population, including the Quintette and Bearhole/Redwillow herds, is provincially designated as "Identified Wildlife" under the Identified Wildlife Management Strategy. There are eight Wildlife Habitat Areas for northern caribou within or bordering the RSA (WHA 9-059 to 9-066) (Map 2). Approved orders and general wildlife measures are available to guide proponents undertaking activities within these Areas. Ungulate Winter Range #U-9-002 designated for caribou and mountain goats includes units SPC-009, 014, 015, 016, 017, 046, 047 that are within the RSA. A portion of UWR #U-9-002, SPC-047 (designated for caribou and mountain goats) is located above the 1300 m contour in the southwest corner of the newly revised LSA. However, none of the WHAs or UWRs lie within the proposed project footprint as identified in current mine planning.

3.1.3 Habitat Requirements

Caribou habitat use requirements for forage and security elements vary between the seasons and life stages. By definition, habitat use and selection differs between the three woodland caribou ecotypes, but it also differs between herds of the same ecotype. Our study and the following discussion focused on habitat use and selection by the Quintette herd and the Bearhole/Redwillow herd as documented by a number of studies undertaken within the RSA.

3.1.3.1 Introduction

Habitat selection by caribou in all seasons is a balance between forage availability, forage abundance, and forage quality with risk of predation (Jones *et al.* 2007). In the current version of this study, the life requisites that were rated for northern caribou were: LI-W (living in winter[6]) and LI-G (living in the growing season[7]). Living requisites (LI), incorporating both feeding and security requirements, were chosen for rating rather than rating habitats separately for these requirements as it is more likely that caribou habitat use is based on a favorable combination of features providing both forage and security from predation. No studies documenting unique habitat use for security, forage or thermal requirements alone were found. The objective of this study was to document any valuable habitat and its relative quality to any life requisite of the selected species; generalized life requisites such as living in the growing season were deemed sufficient to meet this objective given the level of information on the species requirements within the RSA while ensuring that important life stages with specific habitat requirements were rated (MELP 1999). Specific environments for thermal cover do not appear to be required due to the high cold tolerance of caribou and consequently thermal/shelter habitat suitability was not selected for rating (Edmonds and Bloomfield 1984 in Saxena and Bilyk 2000).

The Quintette herd is known to use the alpine and subalpine extensively year-round. A study by Jones and colleagues (2007) found that the Quintette herd selected for elevations greater than 1300 m and generally avoided pine- or spruce-leading forests as well as shrub, deciduous and young coniferous stands. They believed that predation risk from wolves might have been higher within these vegetation cover types. Selection for western and southern aspects and avoidance of steeper slopes and eastern and northern aspects was also documented in this study (Jones *et al.* 2007). Quantifiable ecosystem attributes for northern caribou, Quintette herd, used in this study are presented in Table 4.

The Bearhole/Redwillow herd generally restricts use of the alpine to the growing season and winters in low-elevation boreal forests near Bearhole Lake and Redwillow River (Seip and Jones 2011). Generally habitat use and requirements by this herd are not yet well studied and documented (FIA Project Completion Report 2007-2008). Quantifiable ecosystem attributes for northern caribou, Bearhole/Redwillow herd, used in this study are presented in Table 5.

3.1.3.2 Winter

The winter diet of northern caribou primarily consists of terrestrial lichen. During poor snow conditions, when the energetic costs of cratering through deep or crusted snow are too high, arboreal lichens may also be consumed. Secondary forage may also include dwarf shrubs. Wintering areas where lichens are available include alpine tundra, subalpine forest, mid-elevation pine stands and wetlands. Different ecotypes and

[6] The winter season includes the months of November to April as defined for the Subboreal Interior ecoprovince per the Chart of Seasons by Ecoprovince (MELP 1999).
[7] The growing season is a combination of spring, summer and fall seasons and includes the months of May to October as defined for the Subboreal Interior ecoprovince per the Chart of Seasons by Ecoprovince (MELP 1999).

herds within ecotypes make use of different areas and exhibit differing winter migration patterns in response to predation risk, snow depths and snow density.

In a study by Jones and colleagues (2007), caribou of the Quintette herd were found to primarily use alpine areas from early winter to spring. Concentration on windswept alpine ridges above 1700 m was typical (Jones *et al.* 2004b, Jones 2007). Within the RSA, Mount Spieker and Quintette/Babcock Mountains alpine complexes appear to be the most heavily used. Occasionally Mount Reesor and Fortress Mountain are also used (WCCC 2007a). Although most members of the Quintette herd remain in the alpine during the winter season, there have been a few documented cases of individual caribou moving to low elevation habitats (D. Seip, *pers. comm.*).

The Bearhole/Redwillow herd follows a different pattern of winter habitat use and diet selection. Lower elevation boreal forest with potential for terrestrial or arboreal lichen such as pine and spruce forests are used by wintering caribou. A study by Jones (2009) indicated that caribou selected for mature pine, pine-leading, black spruce-leading and tamarack-leading stands while deciduous, shrub and fir-leading forests were avoided. Non-vegetated areas and natural openings were also avoided. A 2007-2008 FIA Project, *Habitat Use of Woodland Caribou in the Peace Forest District*, documented use of spruce and spruce-pine forests and foraging on arboreal lichens during years of deep or dense snow. In more favorable snow years, Bearhole/Redwillow caribou fed on both terrestrial and arboreal lichens. In these years, the caribou were found in young pine forest, mature pine-spruce, mature spruce and mature tamarack forest; GPS collar locations have indicated these locations are often close to lakes, rivers or wetlands (FIA Project Completion Report 2007-2008). Use of these forest types, not typically used by other ungulates is believed to create separation between caribou and their predators (Bergerud *et al.* 1984 in Jones 2009).

3.1.3.3 Growing Season

In the growing season, woodland caribou eat willow and birch leaves, other shrubs (e.g. mountain ash), Labrador tea and Vaccinium species. These species are abundant in subalpine meadows and moist high-elevation forests. In the study by Jones and colleagues (2007), Quintette caribou again selected for alpine or parkland areas during calving and summer/fall seasons. Use of low elevation forests in spring was not documented and may demonstrate an exchange of higher quality green forage for a lower risk of predation in alpine areas. Lower elevation forests on the eastern side of the Rockies, including within the RSA, may not be as productive and may support a higher number of ungulates (and therefore predators) than the wetter western side of the Rockies (Jones *et al.* 2007). During the summer and calving periods, the use of subalpine, fir-leading, high elevation habitat by the Quintette herd increases (WCCC 2007a). Sopuck (1985, in WCCC 2007a) also found that Quintette caribou used high elevation alpine and open subalpine habitats exclusively in summer and fall (WCCC 2007a).

Members of the Bearhole/Redwillow herd may move to alpine and subalpine areas for the growing season or conversely remain in low elevation forests (FIA Project Completion Report 2007-2008, Jones 2009). Females calve in the alpine and subalpine and males may be more likely to remain at lower elevations year-round (Jones 2009). Migration to higher elevations is likely an anti-predator tactic during the calving season (Seip 1992 in Jones 2009).

Table 4. Quantifiable ecosystem attributes for northern caribou, Quintette herd (modified from Saxena and Bilyk 2000).

Season	Life Requisite	Ecosystem Attributes
Winter	LI	• alpine and ridges where terrestrial lichens are exposed • high use of windswept alpine ridges >1500 m • forage is primarily terrestrial lichen, but arboreal lichen and dwarf shrubs may also be used
Growing	LI	• alpine tundra and parkland that provide abundant terrestrial lichens • subalpine, fir-leading, high elevation forests may also be used but likely to a lesser degree • forage species include terrestrial lichen, willow, birch, other shrubs, Labrador tea, Vaccinium spp.

Table 5. Quantifiable ecosystem attributes for northern caribou, Bearhole/Redwillow herd (modified from Saxena and Bilyk 2000).

Season	Life Requisite	Ecosystem Attributes
Winter	LI	MORE FAVORABLE SNOW CONDITIONS
		• young pine forest, mature pine-spruce, mature spruce and mature tamarack forest with terrestrial and/or arboreal lichen
		• terrestrial lichens are found and eaten by cratering in pine forests; both terrestrial and arboreal lichens may be foraged in mature pine-spruce forest and black spruce forest/bog[8]; arboreal lichens are used in mature spruce and tamarack forests
		LESS FAVORABLE[9] SNOW CONDITIONS
		• spruce and pine-spruce forests with arboreal lichens for easier foraging
Growing	LI	• alpine and subalpine areas • males may be more likely to remain at low elevations for the season (Jones 2009)

[8] FIA Year-end Report 2008-2009

[9] Less favorable snow conditions consist of higher snow depths and densities such that cratering through snow for terrestrial lichens is energetically inefficient.

3.1.4 Ratings

As there is a substantial level of knowledge on the habitat requirements of northern caribou in the RSA a 6-class rating scheme was used.

The winter season provincial benchmark for northern caribou is the undifferentiated Spruce-Willow-Birch/Alpine Tundra (SWBun/AT) biogeoclimatic zone, Lodgepole pine – Alpine Grassland of the Stikine Plateau (STP) ecosection within the Northern Boreal Mountains. The provincial benchmark represents the best habitat available provincially (e.g. rating of "1") and provides a comparison against which habitats within the study area are rated (MELP 1999).

The growing season provincial benchmark is the Alpine Tundra (AT), Alpine meadow of the Stikine Plateau (STP) ecosection within the Northern Boreal Mountains. The provincial benchmark possesses a rating of "1" and provides a comparison against which habitats within the study area are rated (MELP 1999).

3.1.5 Quintette Herd Winter Habitat Suitability

The following describes the Quintette herd winter habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 1) followed by assumptions used to create the model.

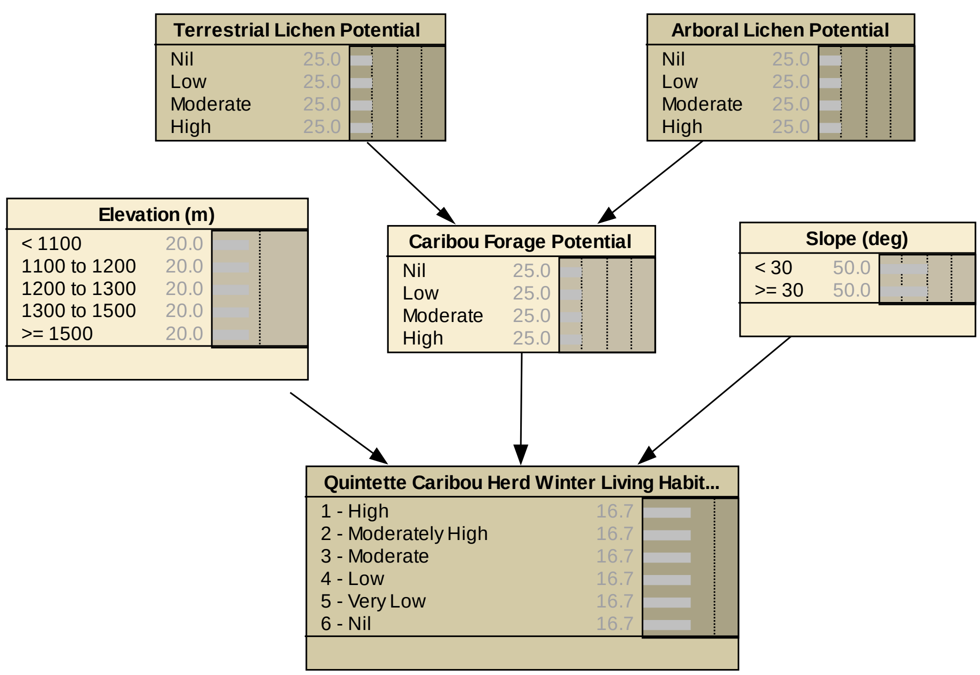

Figure 1. **Species model for Woodland Caribou, Quintette Herd, Winter Living Habitat Suitability.**

3.1.5.1 Model Assumptions

1. Habitats with a slope of greater than 30 degrees are restrictive.
2. All areas of structural stage 4 (i.e. Pole/Sapling) are avoided since this stage has the thickest canopy closure which is generally avoided by caribou.
3. Using the system of Jones *et al*. (2004) in Goddard 2005 this study defined the elevational range for subalpine forest as 1100 – 1550 m and low elevation forest as less than 1100 m.
4. Winter forage is primarily terrestrial lichen but arboreal lichen may also be used. There is limited use of subalpine ESSF habitats for arboreal lichen depending on snow conditions.
5. This herd demonstrates high use of windswept alpine and krummholz areas which was defined as all areas above 1500 m elevation. There is a gradual decrease in use between 1500 and 1100 m (i.e. between alpine and low elevation habitat). Elevations above 1300 m are selected for year-round.

3.1.5.2 Model Description

1. Caribou Forage Potential
   - Rankings of caribou forage potential were entirely weighted toward the terrestrial lichen rating of the area with the exception of when there was no terrestrial lichen, in which case, non-nil values of arboreal lichen produced low caribou forage potential.
2. Quintette Caribou Herd Winter Living Habitat Suitability
   - Habitat Suitability ratings increased with caribou forage potential. Highest ratings were above 1500 m elevation and ratings decreased gradually between 1500 m and 1100 m. All areas below 1100 m had Very Low ratings. Areas of slope greater than 30 degrees or of structural stage 4 also had Very Low ratings.

3.1.6 Quintette Herd Growing Season Habitat Suitability

The following describes the Quintette herd growing season habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 2) followed by assumptions used to create the model.

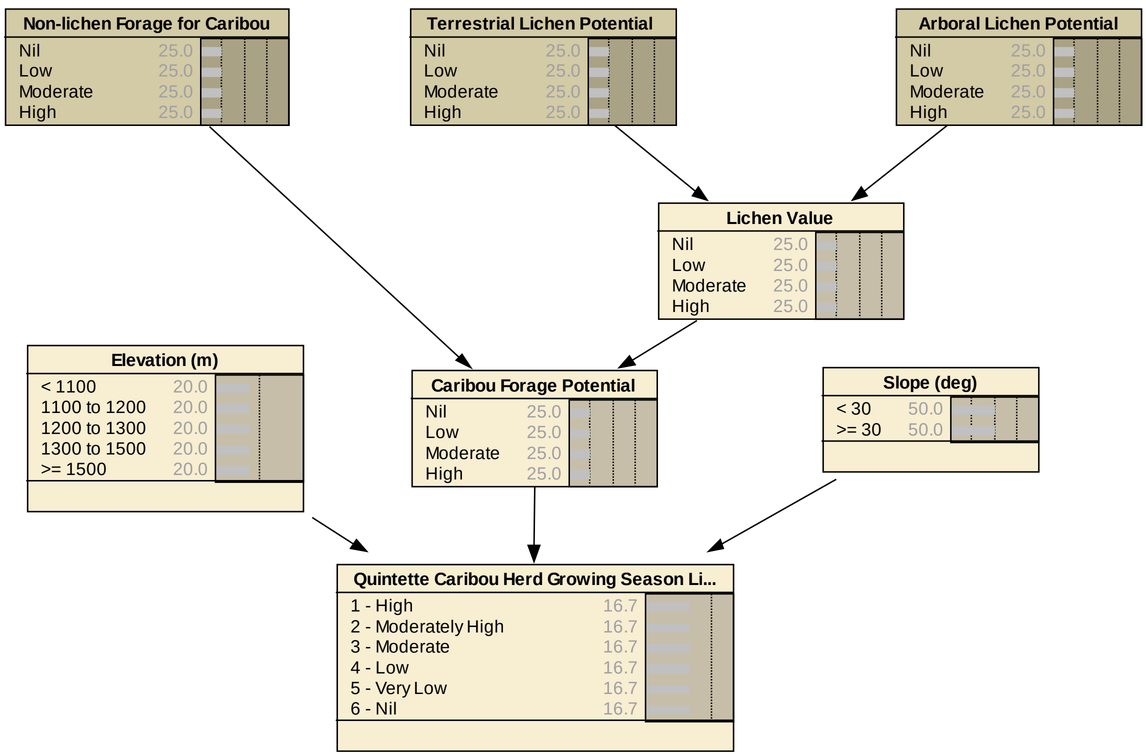

Figure 2. **Species model for Woodland Caribou, Quintette Herd, Growing Season Living Habitat Suitability.**

3.1.6.1 Model Assumptions

1. Habitats with a slope of greater than 30 degrees are restrictive.

2. All areas of structural stage 4 (i.e. Pole/Sapling) are avoided since this stage has the thickest canopy closure and is generally avoided by caribou.

3. Alpine and parkland areas are selected for by caribou. There is also an increased use of subalpine, fir-leading, high-elevation habitat (WCCC 2007a).

4. In the growing season non-lichen forage is preferred over lichen. However, caribou forage potential was weighted toward lichen value (specifically terrestrial lichen over arboreal lichen) rather than non-lichen forage due to the association of terrestrial lichen with habitat types that caribou prefer.

3.1.6.2 Model Description

1. Lichen Value

   - Rankings of lichen value were entirely weighted toward the terrestrial lichen rating of the area with the exception of when there was no terrestrial lichen, in which case, non-nil values of arboreal lichen produced low caribou forage potential.

2. Caribou Forage Potential

   - Rankings of forage potential were entirely weighted toward the lichen value (rather than non-lichen forage). Non-lichen forage was used only to upgrade habitats with no lichen value to low forage potential if they had some non-lichen forage.

3. Quintette Caribou Herd Growing Season Habitat Suitability

   - Habitat Suitability ratings increased with caribou forage potential. Highest ratings were above 1500 m elevation and ratings decreased gradually between 1500 m and 1100 m. All areas below 1100 m had Very Low ratings. Areas of slope greater than 30 degrees or of structural stage 4 also had Very Low ratings.

   - Habitat Suitability ratings were higher in the 1200-1300 m range in the growing season model than the winter model (Section 3.1.5) due to increased use of the subalpine in this season.

3.1.7 Bearhole/Redwillow Herd Winter Habitat Suitability

The following describes the Bearhole/Redwillow herd winter habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 3) followed by assumptions used to create the model.

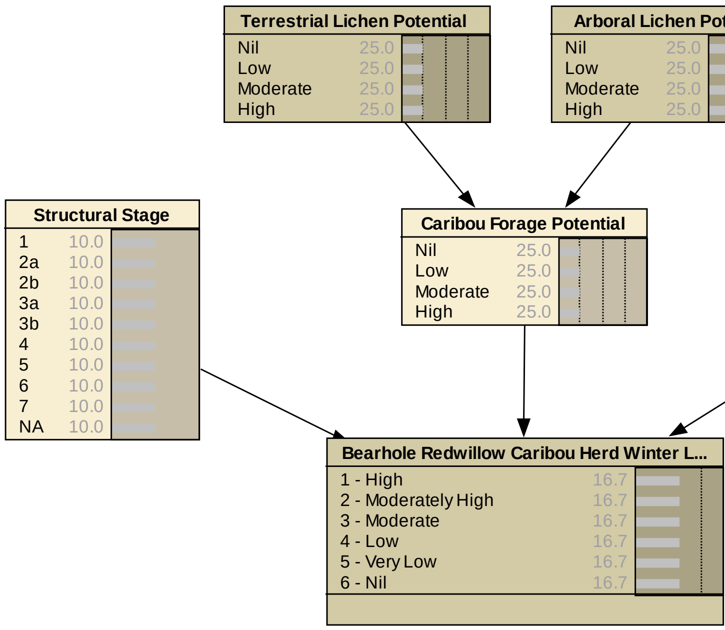

Figure 3. **Species model for Woodland Caribou, Bearhole/Redwillow Herd, Winter Living Habitat Suitability.**

3.1.7.1 Model Assumptions

1. Habitats with a slope of greater than 30 degrees are restrictive.
2. All areas of structural stage 4 (i.e. Pole/Sapling) are avoided as this stage has the thickest canopy closure which is generally avoided by caribou.
3. All areas of structural stage 1 (i.e. sparse/cryptogam) are avoided as this herd prefers to forage in forested environments.
4. We assumed the "Low Elevation Quintette" herd described in Goddard 2005 was equivalent to the Bearhole/Redwillow herd. The Bearhole/Redwillow is a low elevation herd that primarily uses 600 – 1200 m elevational range (Goddard 2005).
5. Winter forage is primarily terrestrial lichens, but feeding on arboreal lichens is important when snow conditions become unfavourable. Arboreal lichen feeding is also opportunistic.

3.1.7.2 Model Description

1. Caribou Forage Potential

   - Ratings of caribou forage potential were weighted toward the terrestrial lichen rating with the exception of when arboreal lichen potential was greater than terrestrial lichen potential, in which case, the caribou forage potential took an intermediate value.

2. Bearhole/Redwillow Caribou Herd Winter Living Habitat Suitability

   - In the elevational range of 600 – 1200 m, Habitat Suitability generally increased with Caribou Forage Potential. Mature structural stages (5 – 7) had higher ratings than younger stages (2 and 3) for each level of Caribou Forage Potential. At elevations above 1300 m and below 600 m (note that is below the minimum elevation in the LSA), Habitat Suitability ratings were Very Low. Between 1200 and 1300 m, ratings were transitional between best possible ratings in the 600 – 1200 m range and Very Low above 1300 m.

   - Habitat suitability for areas of structural stages 1 (i.e. sparse/cryptogam) and 4 (i.e. pole/sapling) were Very Low.

   - Areas of slope greater than 30 degrees also had Very Low ratings.

3.1.8 Bearhole/Redwillow Herd Growing Season Habitat Suitability

The following describes the Bearhole/Redwillow herd growing season habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 4) followed by assumptions used to create the model.

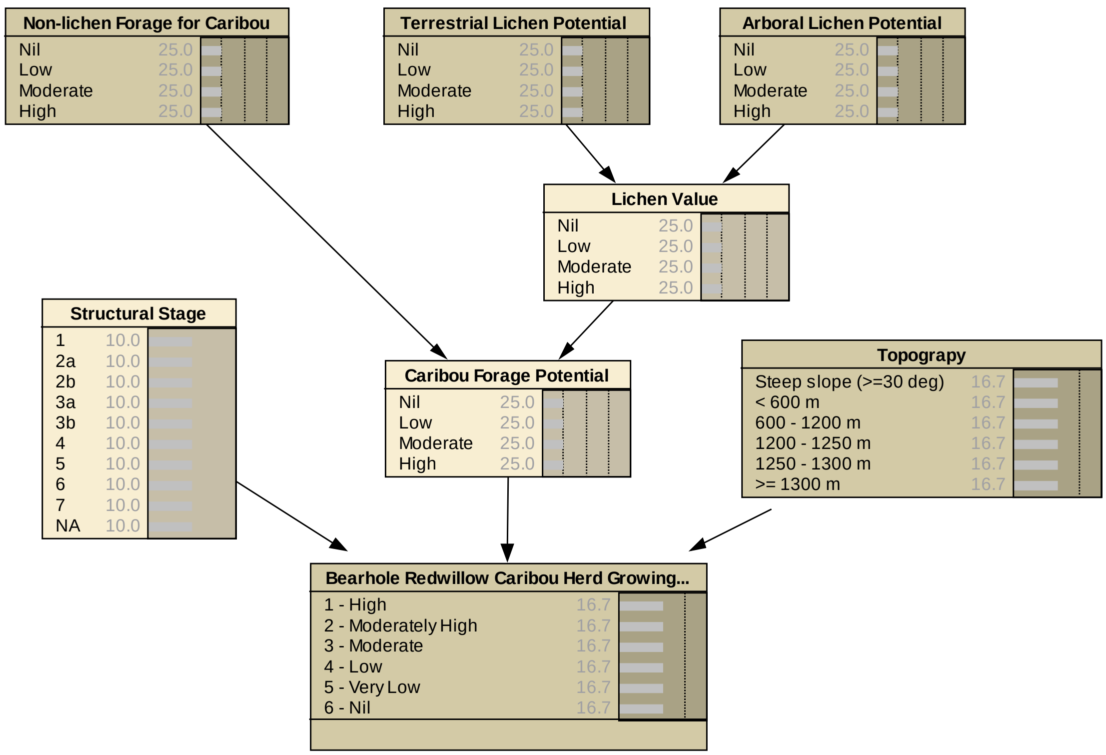

Figure 4. **Species model for Woodland Caribou, Bearhole/Redwillow Herd, Growing Season Living Habitat Suitability.**

3.1.8.1 Model Assumptions

1. Habitats with a slope of greater than 30 degrees are restrictive.
2. All areas of structural stage 4 (i.e. Pole/Sapling) are avoided as this stage has the thickest canopy closure which is generally avoided by caribou.
3. As some individuals of this herd move to alpine and others remain in low elevation for the summer months, this model essentially assumed a combination of the Quintette summer model (for individuals that use the alpine) and the Bearhole/Redwillow winter model (individuals that use low elevation).
4. In the growing season non-lichen forage is preferred over lichen. However, caribou forage potential was weighted toward lichen value (specifically terrestrial lichen over arboreal lichen) rather than non-lichen forage due to the association of terrestrial lichen with habitat types that caribou prefer.
5. Arboreal lichen feeding is also opportunistic.

3.1.8.2 Model Description

1. Lichen Value

   - Ratings of lichen value were weighted toward the terrestrial lichen rating with the exception of when arboreal lichen potential was greater than terrestrial lichen potential, in which case, the caribou forage potential took an intermediate value.

2. Caribou Forage Potential

   - Rankings of lichen value were entirely weighted toward the lichen value (rather than non-lichen forage). Non-lichen forage was used only to upgrade habitats with no lichen value to low forage potential if they had some non-lichen forage.

3. Bearhole/Redwillow Caribou Herd Growing Season Habitat Suitability

   - Habitat Suitability ratings generally increased with caribou forage potential. Above 1100 m, Habitat Suitability was rated like the Quintette Growing Season model (i.e. the highest ratings were above 1500 m elevation and ratings decreased gradually between 1500 m and 1100 m). Below 1100 m, Habitat Suitability was rated like the Bearhole/Redwillow winter model (i.e. mature structural stages (5 – 7) had higher ratings than younger stages (2 and 3) for each level of Caribou Forage Potential).

   - Areas of slope greater than 30 degrees also had Very Low ratings.

   - Habitat suitability for areas of structural stages 4 (i.e. pole/sapling) was Very Low.

3.1.9 Generalized Woodland Caribou Winter Habitat Suitability

The following describes a generalized winter habitat suitability model for woodland caribou. A diagram of the Bayesian belief model is presented first (Figure 5) followed by a description of the model.

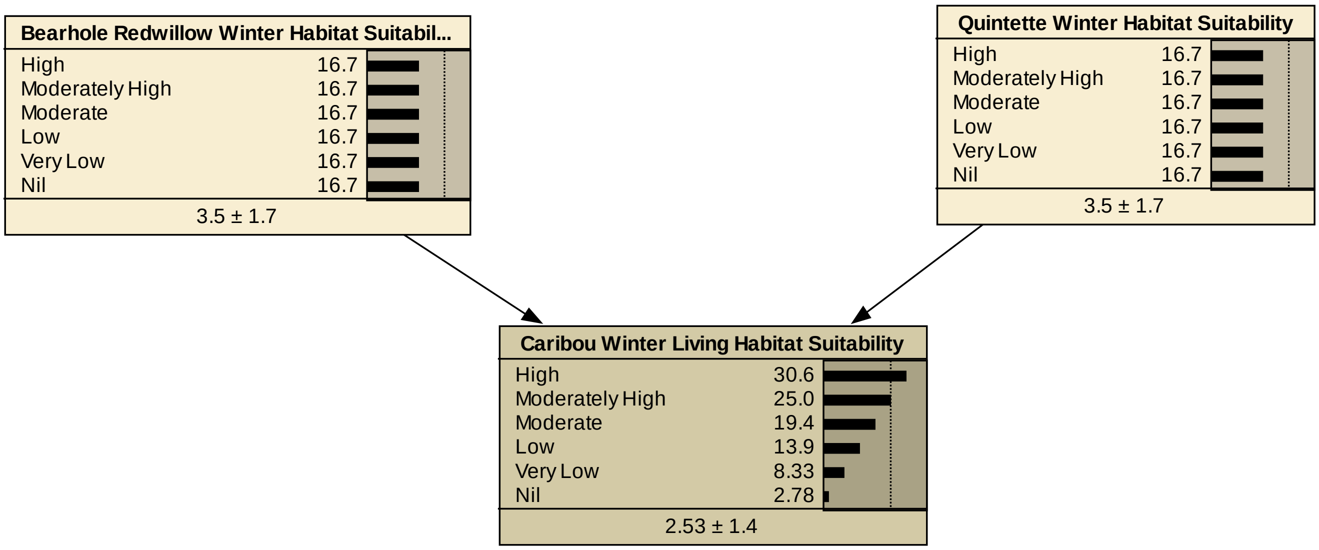

Figure 5. **Species model for Woodland Caribou, Winter Living Habitat Suitability.**

3.1.9.1 Model Description and Assumptions

The generalized winter habitat suitability model for woodland caribou is a combination of the Bearhole/Redwillow Winter Habitat Suitability and the Quintette Winter Habitat Suitability. It assumes that the rationales and all the model assumptions used in the creation of the individual models are applicable to a larger model that identifies potential woodland caribou winter habitat. The Caribou Winter Habitat Suitability takes on the highest habitat rating as presented by either the Bearhole/Redwillow or Quintette model. In this way, the rationale of both models was maintained.

3.1.10 Generalized Woodland Caribou Growing Season Habitat Suitability

The following describes a generalized growing season habitat suitability model for woodland caribou. A diagram of the Bayesian belief model is presented first (Figure 6) followed by a description of the model.

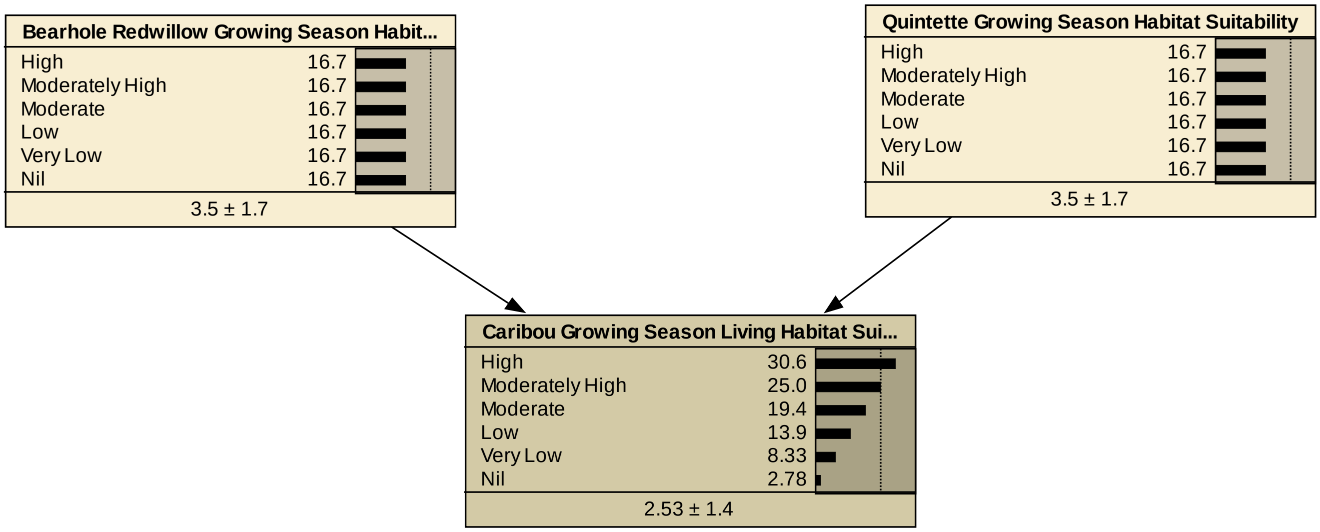

Figure 6. **Species model for Woodland Caribou, Growing Season Living Habitat Suitability.**

3.1.10.1 Model Description and Assumptions

The generalized growing season habitat suitability model for woodland caribou is a combination of the Bearhole/Redwillow Growing Season Habitat Suitability and the Quintette Growing Season Habitat Suitability. It assumes that the rationales and all the model assumptions used in the creation of the individual models are applicable to a larger model that identifies potential woodland caribou growing season habitat. The Caribou Winter Habitat Suitability takes on the highest habitat rating as presented by either the Bearhole/Redwillow or Quintette model. In this way, the rationale of both models was maintained.

3.2 BLACK-THROATED GREEN WARBLER

3.2.1 Distribution

Although relatively common across the southern boreal forest in North America, in British Columbia, the Black-throated Green Warbler is found only in the northeastern section of the province. It occurs primarily in the Peace Lowland of the Boreal Plains ecoprovince (Morse and Poole 2005, MWLAP 2004b), and has also been found within the Taiga Plains and Sub-Boreal Interior ecoprovinces (MWLAP 2004b). There are no observations of confirmed[10] breeding within the Regional Study Area (RSA); however, there are six observations of possible[11] breeding within or near the RSA (BCBBA 2008). Confirmed breeding records for this species occur north of the RSA, near Chetwynd, Dokie Ridge, Charlie Lake and near Fort St. John (BCBBA 2008).

The RSA is likely at or near the current range limit of the species within B.C. (M. Phinney (2011a), *pers. comm.*). If present within the RSA, the warbler is likely restricted to mixedwood forest of low elevation slopes and valley bottoms within the following biogeoclimatic zones: BWBSmw, BWBSwk1 and SBSwk2 (Saxena and Bilyk 2000). Within the BWBS, the warbler has been primarily recorded in the BWBSmw variant (Cooper *et al.* 1997). Over its range, observations of the warbler primarily occur within the elevational range of 650 to 800 m, but it may occur at elevations over 1200 m (Morse and Poole 2005). Within the RSA, it is expected to inhabit areas up to 900 or 1000 m (M. Phinney (2011b), *pers. comm.*).

3.2.2 Threats and Status

The Black-throated Green Warbler has a large breeding range over North America and is generally abundant over this range (Morse and Poole 2005). Consequently, this warbler is not a listed species by COSEWIC and is globally assessed as widespread, abundant and secure (BC CDC 2011; Table 6). In British Columbia, it is blue-listed and an identified wildlife species. There are no Wildlife Habitat Areas under the Identified Wildlife Management Strategy for Black-throated Green Warbler within the RSA (MOE 2009a).

The species is blue-listed in B.C. due to its restricted distribution and relatively small populations within the province (Cooper *et al.* 1997). It is believed that the species expanded its range into the B.C. Peace Region in the latter half of the twentieth century. Although there is little data on the population size within B.C., the warbler is thought to be at least fairly common in specific locales of mature mixedwood stands southwest of Dawson Creek in comparison to other warblers (Cooper *et al.* 1997). As this species displays a high degree of site fidelity to breeding areas, and its populations are likely concentrated to a small range within B.C., the warbler population is vulnerable to population declines caused by human or natural events.

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[10] Observations of confirmed breeding include a nest with eggs or young, an adult carrying a fecal sac or food for young, an adult leaving, occupying or entering a nest, fledged young, a used nest or egg shells, distraction display and nest building (for most species) (BCBBA 2008).

[11] Indicators of possible breeding include an observation of the species, a singing male(s) or breeding calls within suitable nesting habitat during the breeding season (BCBBA 2008).

The Black-throated Green Warbler is a forest-interior species and therefore is sensitive to forest fragmentation (Morse and Poole 2005). This applies to both its breeding range in North America and to its preferred winter habitats in Mexico, Central America and the West Indies (Morse and Poole 2005). The Black-throated Green Warbler has been noted as avoiding forests that are fragmented by such activities as forestry and agriculture (Hobson and Bayne 2000). The primary habitat threat in B.C. is forest harvesting especially of mature mixedwood and spruce stands (Cooper *et al.* 1997). The warbler is not overly sensitive to human activities except those that degrade or destroy breeding habitat or forage abundance (e.g. timber harvesting, vegetation removal, pesticide application; Cooper *et al.* 1997).

Table 6. Status of Black-throated Green Warbler (*Dendroica virens*) (BC CDC 2011).

RISC Species Code	B-BTNW
Provincial Status	S3B – Special Concern
B.C. List	Blue
Identified Wildlife (Yes/No)	Yes
COSEWIC Status	N/A
Global Status	G5 = demonstrably widespread, abundant, and secure

3.2.3 Habitat Requirements

3.2.3.1 Introduction

Over its range, the Black-throated Green Warbler's habitat is varied and encompasses the full range of forest types including purely coniferous, mixedwood, and purely deciduous (Morse and Poole 2005, Cooper *et al.* 1997). It is generally agreed upon that some component of their habitat requirement is coniferous. In B.C., information on habitat use by the Black-throated Green Warbler is limited (Cooper *et al.* 1997). Their breeding habitat is generally described as mature and old-growth mixedwood forest and transitional areas of coniferous and deciduous forest. The warbler in its B.C. range uses purely deciduous stands very infrequently; however, just a few mature conifers in a stand may attract the species (Cooper *et al.* 1997).

In this study, the life requisite that was rated for Black-throated Green Warbler was RE (reproducing[12]). This requisite was chosen for rating as it incorporates a number of habitat requirements including those for feeding, nesting and security that must be met in the breeding season (i.e. spring/early summer). Habitats could be rated separately for these requirements; however, feeding and nesting habitat requirements are the same at this time of year (MWLAP 2004b). Security/thermal habitat requirements are met by habitat attributes that provide for foraging and reproducing habitats and were not rated separately. Post-breeding,

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12 The reproducing life requisite for Black-throated Green Warbler inherently occurs in the spring season, which generally includes the months of May and June as defined for the Subboreal Interior ecoprovince per the Chart of Seasons by Ecoprovince (MELP 1999).

living habitat could also have been rated but this habitat is expected to be more diverse and difficult to rate and therefore this option was not selected for this study.

3.2.3.2 Reproducing

Breeding habitat requires habitat attributes for feeding, nesting and security. During breeding season the warbler forages on forest insects, usually along conifer branches, within the mid- to upper canopy (Morse and Poole 2005, Cooper *et al.* 1997). Forage insects are primarily lepidopteran caterpillars, but also include true bugs, spiders and beetles. Stands with a higher deciduous component than the nesting habitat may be used more heavily for foraging during the post-breeding/fledgling season. Nesting habitat may require a component of mature conifer trees. If purely deciduous forests are used, preference for old-growth aspen (>120 years) has been demonstrated in Alberta (J. Schieck in Cooper *et al.* 1997). Nesting occurs primarily in mature conifers, usually between 2 to 8 m above ground, but occasionally up to 20 m above ground (Morse and Poole 2005). Nests are usually close to the trunk, but may also be farther out in a branch fork (Cooper *et al.* 1997).

Consequently, breeding habitat is typically mature to old-growth mixedwood stands in British Columbia. Structural stages 6 (i.e. mature forest, 80 – 140 years) and 7 (i.e. old forest, greater than 140 years) are preferred (MWLAP 2004b). Preferred mixedwood stands are usually white spruce with trembling aspen and/or balsam popular. Primarily deciduous forest may also be used if there are a few veteran spruce trees in the canopy (Cooper *et al.* 1997, Saxena and Bilyk 2000). Stand structure may be variable but the stands used tend to have a mesic moisture regime (Cooper *et al.* 1997). Typical understory plant species include: rose, baneberry, highbush-cranberry, bunchberry, fireweed, kinnikinnick, mosses, peavine and American vetch (Cooper *et al.* 1997).

In a recent local study, Preston *et al.* (2007) examined habitat attributes recorded in the vicinity of singing Black-throated Green Warblers. Since singing males indicate possible breeding, these attributes characterize suitable habitat within the RSA. Typical habitat included conifer-dominated stands greater than 80 years old with low shrub cover and high herbaceous cover. Sites tended to be relatively wet more often than dry moisture regimes. The most common tall shrub (>2 m) was alder, while the most common short shrubs (<2 m) were rose, twinberry and highbush-cranberry. The most common herbs were bunchberry, coltsfoot, grass and fireweed. Slopes were generally shallow at less than 15°.

Recent research has indicated that Black-throated Green Warbler may avoid riparian habitats, opposing previous documentation that this was the primary habitat for the species (Phinney 2003). Although some Black-throated Green Warbler occupy riparian habitat, preferred habitat in northeastern B.C. includes upland mature/old aspen-spruce mixedwood stands. Quantifiable ecosystem attributes for Black-throated Green Warbler used in this study are presented in Table 7.

Table 7. Quantifiable ecosystem attributes for Black-throated Green Warbler (modified from Saxena and Bilyk 2000).

Season	Life Requisite	Ecosystem Attributes
Spring	RE	• tall, mature and old-growth mixedwood forest and transitional areas of coniferous and deciduous forest (i.e. middle to late seral-stage) • structural stages 6 and 7 • primarily deciduous forest may be used if there are a few mature or veteran conifers • if purely deciduous forests are used, preference for old-growth aspen (>120 years) • mesic moisture regime, wetter sites preferred over drier • typical understory plant species include: alder, rose, baneberry, twinberry, highbush-cranberry, bunchberry, fireweed, coltsfoot, grass, kinnikinnick, mosses, peavine and American vetch • low shrub cover and high herbaceous cover • slopes <15°

3.2.4 Ratings

As there is an intermediate level of knowledge on the habitat requirements of Black-throated Green Warbler in the RSA a 4-class rating scheme was used.

The warbler is most associated with the *white spruce-trailing raspberry-step moss* site series (BWBSmw/101) (Cooper *et al*. 1997). In the absence of a provincial benchmark, this site series is considered the best in the province against which habitats within the study area are rated.

3.2.5 Reproducing Habitat Suitability

The following describes the Black-throated Green Warbler reproducing habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 7) followed by assumptions used to create the model.

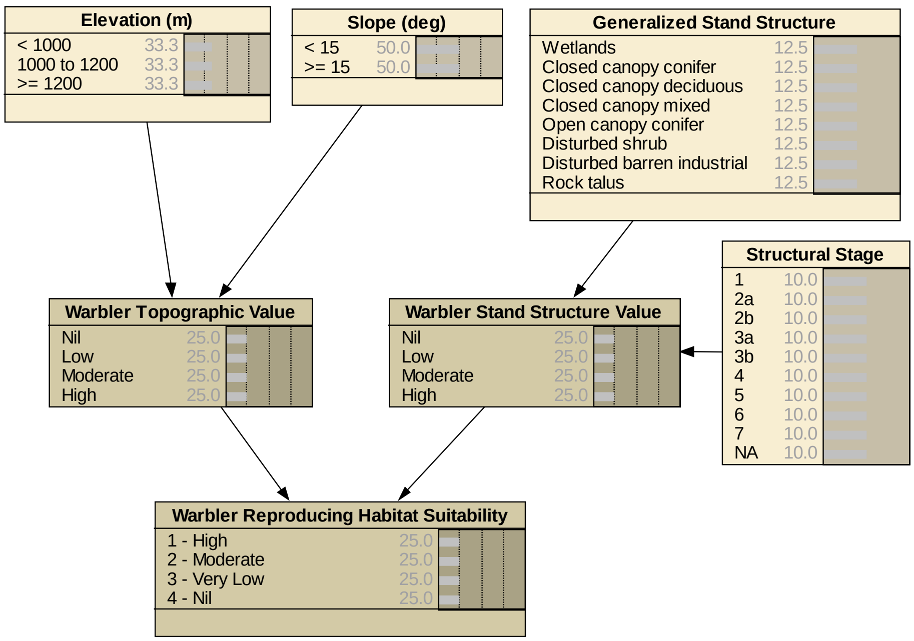

Figure 7. **Species Model for Black-throated Green Warbler Reproducing Habitat Suitability.**

3.2.5.1 Model Assumptions

1. Black-throated Green Warblers prefer sites with low elevation and low slope.
2. Nesting can occur only in mature forests (i.e. structural stage 5 – 7). It can occur in forest with at least a component of coniferous trees. Ideal forest type is closed canopy mixed forest, followed by closed canopy coniferous forest. Open canopy coniferous forest, closed canopy deciduous forest and wetlands are assumed to be the least favoured forest types.
3. Nesting cannot occur on disturbed barren industrial sites, rock talus or disturbed shrub areas.

3.2.5.2 Model Description

3. Warbler topographic value

   - Sites with low elevation (<1000 m) and low slope (<15°) were assigned a high topographic value. Sites with low elevation and high slope (>15°) were assigned a moderate topographic value. Sites with intermediate elevation (1000-1200 m) were assigned a low topographic value and sites with high elevation (>=1200 m) were assigned a nil topographic value.

4. Warbler stand structure value

   - Only sites with a structural stage of 5 or greater were considered to have any stand structure value. Older forests were generally considered to have higher stand structure value. Closed canopy mixed forest had the highest value (moderate to high). Mature and old growth closed canopy coniferous forest had intermediate habitat values (low to moderate). Open canopy coniferous forest, closed canopy deciduous forest and wetlands had the lowest habitat values (low). Disturbed shrub, disturbed barren industrial and rock talus had nil stand structure value.

5. Warbler Reproducing Habitat Suitability

   - Sites with nil stand structure value (i.e. structural stage < 5 or disturbed shrub/disturbed barren industrial/rock talus) had no habitat suitability. Sites with nil topographic value had Low habitat suitability (except when stand structure was also nil). Only sites with high values for both stand structure and topography were given high habitat suitability ratings. All other sites were ranked based on the average of their topographic and stand structure values.

3.3 MOUNTAIN GOAT

3.3.1 Distribution

Mountain goats are widely distributed through B.C. with an estimated population of 39,000 to 65,500 animals in the province (MOE 2010a). Approximately 6% of this number or 2000-4000 animals are estimated to occur in the Peace Region and the regional population is reported to be stable (MOE 2010a).

In terms of the region in proximity to the Murray River project, the oldest available estimate of goats in the area was from the Northeast Coal Study. The study area encompassed a 4300 square mile or 11,000 km^2 "core area" of proposed coal development that completely encompasses the 2300 km^2 Murray River Project RSA. The goat population for the Northeast Coal study area was estimated at 200 animals in 1977 (MOE 1977). Table 8 provides a summary of goat surveys conducted since this time. A direct comparison to the 1977 estimate was not possible because methods and study areas differ. However, the goat location data that were available could be overlaid with the Murray River RSA boundary to indicate what portion of goat observations fell within the RSA. These data show 21 goat locations were recorded within the RSA out of 60 observations in a Bullmoose Mountain survey in 1989, and 33 goats out of 362 mountain goats recorded in a 2003 survey were within the Murray River RSA (Table 8). This does not provide a population estimate for the RSA but can be considered a minimum estimate of goats that occurred.

In the 1980's, transplants occurred at two locations that overlap the regional study area of the Murray River Project in attempt to increase goat numbers in the region. There was a successful transplant of 20 goats at Bullmoose Mountain in 1983/1984 (MOE 2010a). In 1989, an inventory of the Bullmoose Mountain area reported a total of 60 animals, an August 1990 inventory reported 44 goats (MOE SPI), and approximately

110 goats were observed there in 2003 (MOE 2010a). Goats were transplanted unsuccessfully at Mount Spieker in 1989 (MOE 2010a).

Mountain goats in the Peace Region and in general occur in clumped distribution (Shackleton 1999) and based on existing survey data within the RSA there are a number of moderate abundance areas. Ungulate winter ranges have been delineated throughout the region based on known habitat that is suitable in combination with population survey data (Goddard 2003). The most suitable habitat in the RSA occurs in rugged, high elevation terrain concentrated in the western portion of the RSA.

Table 8. Population estimates for mountain goat relevant to the Murray River Project Regional Study Area (RSA).

Year	Source	Study Area	Survey Type	Total # Observations	Total # observations within RSA
1989	MOE-SPI	Bullmoose Mountain	Aerial census	60	21
1990	MOE-SPI	Bullmoose Mountain	Aerial census	44	0
1994	MOE-SPI	Bullmoose Mountain	Aerial census	99	0
2003	MOE-SPI	South Peace	Aerial census	362	33
2005-2008	MOE-SPI	Peace Region	Incidental observations	95	No UTMs

3.3.2 Threats and Status

The Northeast Coal Study Wildlife Program reported an estimated population of 200 animals based on field studies and a potential population of 2420 animals if habitat was in ideal condition (MOE 1977). The study categorized habitat into three capability classes with the best habitat estimated at supporting 22 goats per square mile and the least capable habitat supporting eight goats per square mile. The authors reported goat populations in the area declined sharply since access was created during coal and other resource developments. The authors postulated that new road access negatively affected the goat population at Bullmoose Mountain. Overhunting is a potential threat (Rice and Gay 2010) that may be aggravated by increased road access. Mountain goats are economically important in B.C. with annual license fees and associated value from residents totaling $535,000 and guide outfitter revenue generating $4 million annually (MOE 2010a).

Mountain goats and their habitat can be disturbed and potentially impacted by a number of other factors such as low flying aircraft (Goldstein *et al.* 2005, Cote 1996), predation, severe winter weather and disease (MOE 2010a). A study conducted by Goldstein *et al.* (2005) documented that fright responses of goats were linked to distance of helicopter overflights. Goldstein *et al.* (2005) attributed the boost in popularity of backcountry tourism activities such as heli-skiing, heli-hiking and sightseeing as a factor affecting goats.

Guidelines for aircraft use around wildlife for the Peace Region recommend a 2 km horizontal separation from goats (MOE 2008). In the Peace Region, January 15 to July 15 is a critical timing window for mountain goats and November 1 to January 14 is a cautionary timing window (MOE 2009b).

The mountain goat is provincially "yellow-listed" which is defined by the B.C. Conservation Data Center (BC CDC) as "apparently secure and not at risk of extinction." The BC CDC bases this status on parameters such as population, distribution and threat due to the loss of habitat. More than half of the world's population of mountain goats resides in B.C. where the population remains widely distributed and most mountain goat habitat is not under imminent threat (Wilson 2005). Mountain goat is not listed under the *Species at Risk Act*. Table 9 summarizes the provincial, federal and global status of the mountain goat.

There are designated Ungulate Winter Ranges (UWR) that apply to mountain goats within the Murray River Project RSA. These areas are for caribou primarily and mountain goats secondarily: UWR #U-9-002, units SPC 014 – 017, 046, 047. SPC 034 is primarily for mountain goats and secondarily for caribou.

Table 9. Status of mountain goat (*Oreamnos americanus*) (BC CDC 2011).

RISC Species Code	M-ORAM
Provincial Status	S4 – Not at risk, apparently secure and not at risk of extinction.
B.C. List	Yellow
Identified Wildlife (Yes/No)	No
COSEWIC Status	N/A
Global Status	G5 = demonstrably widespread, abundant, and secure

3.3.3 Habitat Requirements

3.3.3.1 Introduction

For Wildlife Habitat Suitability Rating, the generalized living life requisite for both the growing season and the winter season were selected. Rating "Living-Winter" and "Living-Growing" was suited to the level of information on the species requirements within the RSA and is consistent with wildlife habitat ratings methods (MELP 1999). Escape terrain is a dominating factor that determines overall habitat suitability (Hamel and Cote 2007, Poole *et al.* 2006, Scheck *et al.* 2006, Cote and Festa-Bianchet 2001). It makes biological sense to rate goat habitat suitability holistically for the living requisite rather than rate more specific requirements like forage separately.

Mountain goats stay near steep, rugged slopes in order to escape predation. Escape terrain is the most important factor influencing habitat selection by mountain goats, regardless of season (Poole *et al.* 2006, Scheck *et al.* 2006, Cote and Festa-Bianchet 2001). Numerous studies in B.C. have examined the angle of slope required for escape terrain and the distance requirement from escape terrain selected by mountain goats. Poole *et al.* (2006) reported that terrain greater than 40 degrees was selected as suitable habitat and the distance to escape terrain had more than four times greater weight in predicting habitat use than variables such as an inverse relationship to mature dense forest and positive relationships to solar radiation or ruggedness. Poole and Heard (2003) reported mean annual slope use among collared goats averaged 38º and that similar steepness of slopes was occupied in winter and the growing seasons. In a recent review of habitat models developed for mountain goats in B.C., Wilson (2007) determined that a slope range between 30º and 60º defined suitable escape terrain.

Hamel and Cote (2007) suggested that the proximity to escape terrain, especially by mountain goat females with young, was more important than the quality of forage sites. In terms of the most suitable distance to escape terrain, MOE (2010) summarized literature on goat habitat selection and reported that up to 400-500 m distance from escape terrain was selected, and that distance was typically less in the winter season. Some studies reported that mountain goats were most likely to be located less than 400 m of escape terrain (e.g. 150 m, Taylor and Brunt 2007). Two regional reports (Poole and Heard 2003, Scheck *et al.* 2006) recommended that habitat within 500 m of escape terrain should be considered important for mountain goats. Based on a workshop on mountain goats in B.C., Ayotte (2005) summarized that goats select habitat up to 150 m to 400 m from escape terrain.

Mountain goats are classified as generalist herbivores and diet composition between individuals likely will differ significantly depending on plant composition adjacent to their respective escape terrain locales. Generally, forage consists of grasses (>50%), forbs (30%) and browse (15%) species, growing within alpine meadows close to cliffs and rocky outcroppings (Hamel and Cote 2007).

Goats are known to make vertical migrations from high elevation in the summer to steep south facing subalpine forested and alpine area in the winter (Wilkinson 2000). Low elevations can also provide suitable habitat and locally in the RSA it is known that "canyon goats" exist in low elevations with escape terrain (Scheck *et al.* 2006). A hypothesis was presented in Ayotte's (2005) workshop summary that goats wintering in areas of high snowfall may make use of low elevation forests more than goats wintering in lower snow areas. Typical goat habitat in B.C. is thought of as the high elevation windswept ridges. There is high snow pack in the region of the Murray River Project and there are numerous anecdotes of goats using the lower elevation forested habitat.

3.3.3.2 Winter

Two factors influencing mountain goat habitat suitability are dependent on season: elevation and aspect. Snow depths influence available forage as well as mountain goats' ability to escape predators. Windswept ridgelines and rock outcroppings are preferentially selected due to lower snow depths, whereas in areas where snow loads are high, goats will frequently overwinter in mature forests just below the tree line, where the thick canopies provide high snow interception (Wilson 2005, Poole and Heard 2003). Poole and Heard (2003) reported that 90% of winter goat locations occurred within an elevation range of 1330 m to 2320 m during a mark/recapture study in the Robson Valley, B.C. In this study, habitat use occurred at minimum 500 m lower elevation in the winter than in summer. Habitat use was primarily within the alpine in the summer.

Although goats consume a wide range of forage, winter forage selection for mountain goats is more restricted and consists primarily of browse species not covered by snow. Fox *et al.* (1989) suggested up to 90% of mountain goat's winter diet consists of conifers, lichen and Vaccinium shrubs. In mild winters where snow depths are significantly lower than average, mountain goats will continue to consume summer forage such as grasses, sedges and rushes (Saxena and Bilyk 2000). Warm aspects may have more access to forage and have lower snow depths. Scheck *et al.* (2006) used habitat modeling to assist in delineating mountain goat winter range in the Peace Forest District. They used the attributes of greater than 42º slope and warm (134º – 285º) aspect to select suitable winter habitat.

3.3.3.3 Growing Season

Throughout most of the growing season, goats generally occupy rugged high elevation terrain above the tree line (Wilson 2005). Higher elevation alpine tundra areas are generally selected due to proximity to escape terrain and heat avoidance (Saxena and Bilyk 2000). In the spring, like most ungulates, goats frequently migrate to mineral licks in order to replenish nutrient deficiencies brought on by malnutrition during the harsh winter months. Mountain goats may travel relatively long distances away from escape terrain in otherwise poor goat habitat in order to access historically used mineral licks (Fox *et al.* 1989, Hengveld *et al.* 2004).

Quantifiable ecosystem attributes for mountain goat used in this study are presented in Table 10.

Table 10. Quantifiable ecosystem attributes for mountain goat.

Season	Life Requisite	Ecosystem Attributes
Winter	Living	• Proximity to escape terrain • Windswept ridges and rocky outcrops • Alpine • Mature forests below the treeline. Use of these areas can extend to at least 500 m lower in the winter than in the summer. • Warm aspects may be selected for lower snow depths and higher access to forage • Winter forage consists primarily of browse species not covered by snow, but prefer summer forage if available
Growing Season	Living	• Proximity to escape terrain • Primarily alpine • Summer forage includes grasses, sedges and rushes

3.3.4 Ratings

As there is a substantial level of knowledge on the habitat requirements of mountain goat in the RSA a 6-class rating scheme was used. The winter season provincial benchmarks for mountain goat are the MF/6 - Mountain Hemlock-Amabalis Fir/RO–Rock of the Mountain Hemlock moist maritime subzone (MHmm), and EF/6 - Engelmann Spruce-Subalpine Fir/RO–Rock of the Engelmann Spruce-Subalpine Fir dry cool subzone (ESSFdk) of the Nass Ranges (NAR) and Southern Park Ranges (SPK) ecosections within the Coast Mountains and Southern Interior Mountains respectively. The growing season provincial benchmarks are the Alpine Tundra (AT), AM – Alpine Meadow of the Southern Park Ranges (SPK) and Nass Ranges (NAR) ecosections within the Southern Interior Mountains and Coast Mountains. The provincial benchmarks are assigned a rating of "1" and provide a comparison against which habitats within the study area are rated (MELP 1999).

3.3.5 Winter Habitat Suitability

The following describes the mountain goat winter habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 8) followed by assumptions used to create the model and a description of the functioning of the model.

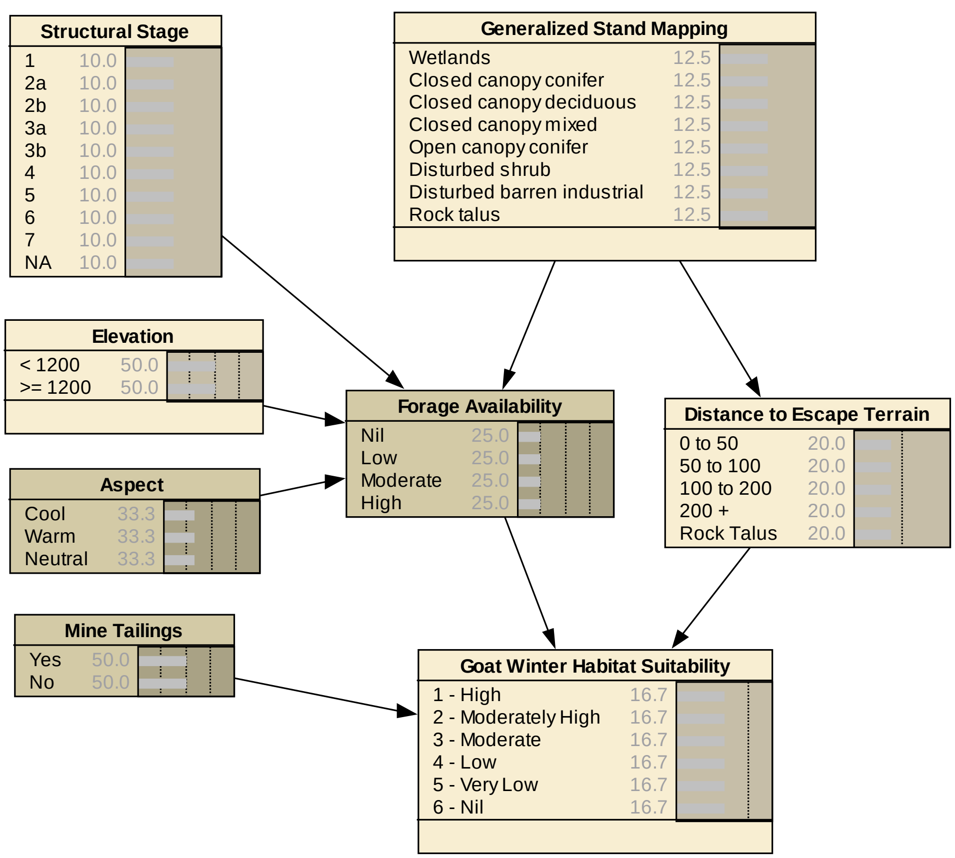

Figure 8. **Species Model for Mountain Goat Winter Living Habitat Suitability.**

3.3.5.1 Model Assumptions

1. Mountain goat habitat suitability is driven primarily by proximity to escape terrain followed by forage availability.

2. Escape terrain was defined as all areas with slope >30^0. Details on the delineation of escape terrain in this study are described in Appendix D.

3. Forage availability is limited by snow cover (determined itself by elevation, aspect and canopy closure) and vegetation. Vegetation quality and quantity is affected by type of vegetation and structural stage (which reflects proportions of tree, shrub and herb layers).

4. Above 1200 m, mountain goat winter forage availability on warm aspects was assumed to be similar to the growing season due to lower snow depths (e.g. windswept ridges). Note that elevation was not used to eliminate potential for presence of goats at lower elevations in any season as the potential presence of canyon goats in the study area cannot be ignored.

5. Habitats within 0 – 50 m of escape terrain and rock talus were considered to be the best habitat for mountain goats. As a conservative approach in this study to capture all potential escape terrain it was assumed that all rock talus can provide escape terrain.

3.3.5.2 Model Description

1. Forage Availability

   - Forage availability was generally highest for structural stages 2a and 2b, moderate for structural stages 3 and 5 – 7 and lowest for structural stage 4.

   - Forage availability in the winter season was the same (see Section 3.3.6.2) as the growing season at high elevations (>1200 m) and warm aspects, because these areas would have lower snow cover. Winter forage ratings were downgraded for other elevations and aspects due to presence of snow limiting access to forage. Barren industrial was assumed to provide a forage availability of Low.

2. Goat Winter Habitat Suitability

   - Habitat suitability decreased with increasing distance from escape terrain and decreasing forage potential.

   - Habitats within 0 – 50 m of escape terrain and rock talus had the highest suitability ratings.

   - In both the winter and growing season models, habitat suitability was driven primarily by proximity to escape terrain followed by forage availability; therefore escape terrain was given more weight than foraging potential in the habitat suitability nodes. In the winter model, because selected distance from escape terrain is typically less in the winter than in the growing season (MOE 2010), escape terrain was given even more weight over forage availability compared to the summer model. This was done in two ways (1) sites with good escape terrain (0 – 50 m and rock talus) and Nil forage availability were rated more highly than within the growing season model, and (2) habitat suitability ratings decreased more quickly 50 m beyond escape terrain in the winter model than the growing season model.

- Habitat more than 200 m from escape terrain was rated Very Low regardless of forage availability and tailings always had very low habitat suitability.

3.3.6 Growing Season Habitat Suitability

The following describes the mountain goat growing season habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 9) followed by assumptions used to create the model and a description of the functioning of the model.

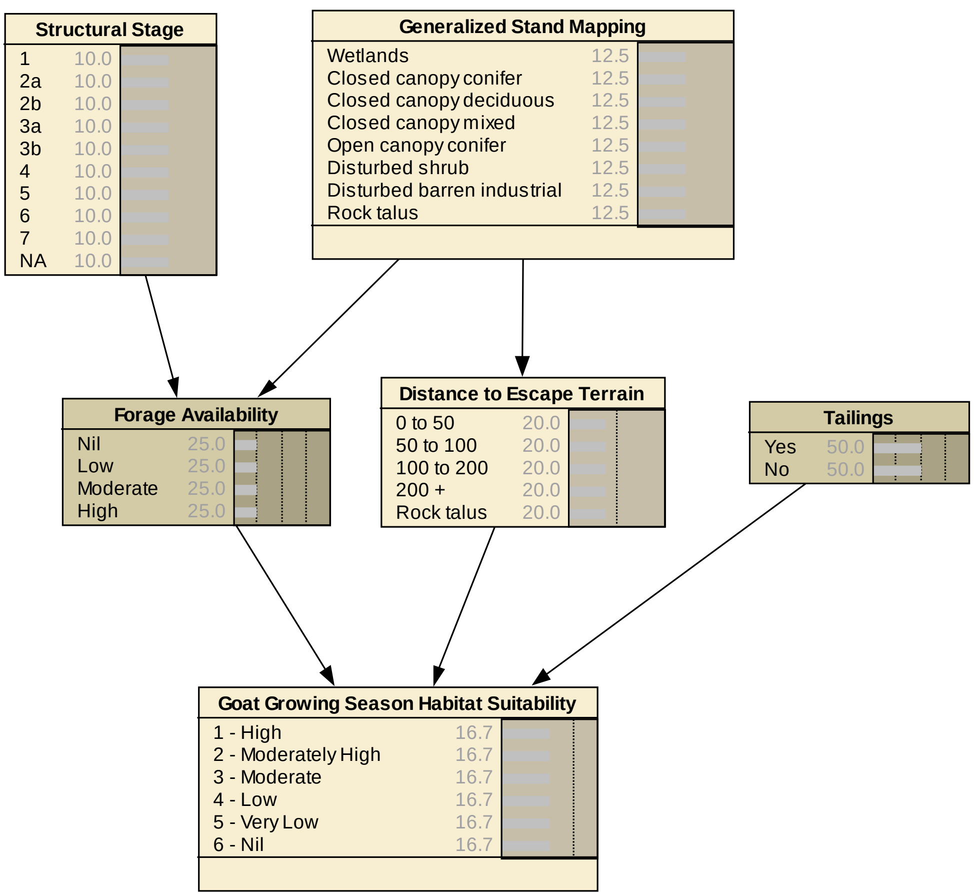

Figure 9. **Species Model for Mountain Goat Growing Season Living Habitat Suitability.**

3.3.6.1 Model Assumptions

1. Mountain goat habitat suitability is driven primarily by proximity to escape terrain followed by forage availability.

2. Escape terrain was defined as all areas with slope >30^0. Details on the delineation of escape terrain in this study are described in Appendix D.

3. Growing season forage availability is primarily influenced by vegetation quality and quantity which can be estimated by structural stage (which reflects proportions of tree, shrub and herb layers).

4. Habitats within 0 – 50 m of escape terrain and rock talus were considered to be the best habitat for mountain goats. As a conservative approach in this study to capture all potential escape terrain it was assumed that all rock talus can provide escape terrain.

3.3.6.2 Model Description

1. Forage Availability

   - Structural stages 1 and "NA" (i.e. non-vegetated areas) had Nil forage, stage 2 provided High forage, stages 3 and 5 – 7 provided Moderate forage, and stage 4 provided Low forage.

   - Barren industrial was assumed to provide a forage availability of Low.

2. Goat Growing Season Habitat Suitability

   - Habitat suitability decreased with increasing distance from escape terrain and decreasing forage potential.

   - Habitats within 0 – 50 m of escape terrain and rock talus were assigned the highest suitability ratings.

   - Habitat more than 200 m from escape terrain was rated Very Low regardless of forage availability and tailings always had very low habitat suitability

3.4 MOOSE

3.4.1 Distribution

In B.C., moose are widespread and abundant throughout most of the province with the exception of the interior grasslands and the Pacific coastal islands (Rea and Child 2007). They are primarily a forest-dwelling species and are most common in boreal forest habitats (Shackleton 1999). In 2000, the provincial population estimate for moose was approximately 170,000 animals and over 70% of this population lived in northern B.C. (Blood 2000).

The MRP Regional Study Area occurs within one of the areas of highest moose abundance in the province (Rea and Child 2007). The RSA is located within Wildlife Management Unit (MU) 7-21 of the Peace Region. An estimated 40,000 to 80,000 moose reside in the Peace Region (Hatter 1998 in Rea and Child 2007). Within the MU, the total population was last estimated at 2,044 moose[13] and the moose density was 0.30 moose/km^2 (Rowe 2006).

Moose in the foothills area of the Peace Region migrate between high elevation summer habitats and lower elevation winter habitats (Goddard 2003, WCCC 2010). However, extremely high elevations such as Alpine Tundra (as high as 1500 m, Goddard 2003), are generally avoided due to the lack vegetation and tree cover (Rea and Child 2007). All biogeoclimatic units that occur in the RSA contain suitable habitat, and depending on season, all of the elevational ranges exhibited in the RSA are suitable habitat unless there is an existing habitat limitation. Examples of a habitat limitation would be lack of suitable forage and vegetation, human activity, or deep snowpack (Rea and Child 2007).

3.4.2 Threats and Status

Moose is not a listed species by COSEWIC and is globally assessed as widespread, abundant and secure (BC CDC 2011, Table 11). In B.C., it is yellow-listed or not at risk and is not an identified wildlife species. There are no designated ungulate winter ranges for moose within the RSA; although, there is an UWR (U-9-001, SPE-023) for elk, mule deer and moose near the RSA north of Bullmoose Creek. Bullmoose Creek enters the Wolverine River north of the RSA.

Moose was selected as one of the seven species for habitat suitability ratings in the LSA due to its socioeconomic value to the region through subsistence and recreational hunting. Currently, MU 7-21 is a "moderately hunted" management unit (Rowe 2006). The overall population trend of moose in the Peace Region appears variable, with some reports of population declines (Rea and Child 2007).

Threats to moose populations come from both natural and human-caused sources. Winter weather severity, predation and disease can all have a significant effect on moose populations. However, within managed populations, hunting is usually the major cause of mortality (Rea and Child 2007). Land development and industrial activity can have both positive and negative effects on moose and their habitat. When mature forest habitats are replaced by early seral habitats, the quality of moose habitat can increase due to increased amounts of woody browse (Eastman 1977, Westworth *et al.* 1989). However, development can also present a threat to moose populations through impacts to important habitat features such as mineral licks, calving sites, aquatic or semi-aquatic feeding areas, travel corridors or mature forest edges that provide shelter and security (Rea and Child 2007, Wall *et al.* 2011). Additionally, the development of resource roads and other linear corridors can lead to increased mortality of moose through vehicular collisions (Child *et al.* 1991) and increased hunting pressure to the local moose population (Rea and Child 2007). Disturbance by human activities such as recreation, hunting, snowmobiling and using other machinery can also be a stressor if it

[13] +/-19% at 90% confidence

displaces animals to less suitable habitats (Colescott and Gillingham 1998); however, moose have been shown to habituate to regular human activity (Westworth *et al.* 1989).

Table 11. Status of moose (*Alces americanus)* (BC CDC 2011).

Species Code	M-ALAL[14]
Provincial Status	S5 - demonstrably widespread, abundant, and secure
B.C. List	Yellow
Identified Wildlife (Y/N)	N
COSEWIC Status	N/A
Global Status	G5 = demonstrably widespread, abundant, and secure

3.4.3 Habitat Requirements

3.4.3.1 Introduction

To meet the objectives of this study, moose habitat was assessed for the generalized life requisite "living" at a two-season level. This was appropriate given the level of information on the species requirements within the RSA and the degree to which moose habitat for various life requisites can be separated. The living requisite primarily depends on both security requirements and forage. Habitat selection by moose in all seasons is a balance between the presence of suitable forage with cover and other influences such as predation, human activities and snow cover (Rea and Child 2007).[15] In this study, we assessed the living requisite in two seasons: winter and growing.

3.4.3.2 Habitat Requirements

Moose are generally browsers that eat tree and shrub leaves and shoots, deciduous and coniferous leaves, and twigs year-round (Rea and Child 2007). Twigs are especially consumed in the winter months; however, if available, fallen leaves are preferred over twigs due to their higher nutritional value (Rea and Child 2007). The primary winter forage is willow; however, other winter forage species include red-osier dogwood, balsam poplar/black cottonwood, paper birch, trembling aspen, Saskatoon, highbush-cranberry, false box and subalpine fir. Bark stripping of aspen, willow, and balsam poplar also occurs in the winter (Rea and Child 2007). In late winter, forage may shift to coniferous trees such as subalpine fir as snow depth increases. Preferred growing season forage includes leaves of shrubs, herbs and aquatic vegetation such as horsetail, burweed, and submerged pondweed (Saxena and Bilyk 2000).

To access their preferred forage species, moose use a combination of both stable and transitory habitats. Stable habitats can be expected to provide shrubby browse over the long term and include high elevation

[14] The accepted RISC code for moose is ALAM; however, the Integrated Taxonomic Information System (ITIS) accepts *Alces alces* as the species name for moose. Therefore, the code used by this study is ALAL.
[15] Other influences include seasonal requirements, competition, climate, pathogens and insects (Rea and Child 2007).

shrub communities and riparian areas along watercourses. Transitory habitats are those areas of forest in early stages of regeneration due to having been disturbed by natural (e.g. fire, beaver activity) or human (e.g. timber harvesting, land clearing) agents, and therefore, can provide an abundance of shrubby and herbaceous forage until the stand reaches a more mature structural stage (Rea and Child 2007).

3.4.3.3 Winter

In the Peace Region, winter habitat tends to be shrubby areas of valley bottoms and low to mid elevation forest stands in an early to mid-seral stage (Goulet and Haddow 1985 in Goddard 2003). In this region, a number of moose population surveys have used an elevation of 1200 m as the upper limit for winter survey (Walker *et al.* 2007 [northern Williston], Demarchi 2000 [northern Williston], Heard *et al.* 1999 [Prince George region]). MacKay (2008) used an upper elevation limit of 1300 m for a population survey conducted in the Cariboo Region and Goddard (2003) suggested an upper elevation limit of 1500 m based on a number of regional studies. However, based on a personal communication with S. McNay and D. Heard, Demarchi (2000) concluded that suitable winter habitat in the Peace Region occurs predominantly at elevations below 1200 m with areas above 1200 m supporting only very low population densities. Preferred winter habitats include riparian and alluvial shrubby areas, burns, regenerating cutblocks and wetlands (Goddard 2003). Areas of gentle slopes, exposed southerly slopes with birch and willow and aspen stands and a favourable snow pack are preferred (Rea and Child 2007, Poole and Stuart-Smith 2006). Dense forest stands are also selected for shelter, food and predator avoidance (Coady 1974, Rea and Child 2007).

In winter, snow depths exceeding 70-100 cm restrict movements of moose as does wet, dense or crusted snow (Rea and Child 2007). Annual snowfall in the BWBSmw and BWBSwk1 is a range between 110 and 332 cm with averages of 156 cm and 241 cm each (Delong *et al.* 2011). In the SBSwk2, the annual snowfall ranges from 210 to 1075 cm and averages 786 cm (Delong 2004). The ESSF can receive up to 220 cm of precipitation annually with 50-70% of this amount accumulating as snow. It is common for the maximum snowpack to range from 100 to 400 cm (Coupé *et al.* 1991). Moose generally leave the ESSF during winter due to the deep snowpack, but are common in the BWBS and SBS. In particular, the BWBS is important overwintering habitat for ungulates (Meidinger and Pojar 1991, Goddard 2003). Most ideal habitats include both forage and shelter within close proximity to each other. For example, disturbed areas with regrowth of browse species, which are primarily shrubs of structural stage 3a and 3b, associated with nearby mature stands provide both forage and cover (WCCC 2007b). In years of low snowfall accumulations, moose that utilize mid-elevations in mountainous areas or subalpine habitats in the summer months may remain in these areas during the winter (Rea and Child 2007, Goddard 2003). During winter, moose are most likely to be found within the BWBS and SBS biogeoclimatic zones, while the ESSF may provide less suitable winter habitat as suggested by a number of studies in the Peace Region (Goddard 2003).

3.4.3.4 Growing Season

Moose are less limited in the growing season and their habitat covers a broader area. Moose summer habitat typically includes shrublands and riparian areas. Some moose move upslope to alpine fir thickets, while others may remain in valley bottoms year round (Rea and Child 2007). Wetlands, beaver ponds and lakes are often visited in the growing season to access aquatic vegetation (Rea and Child 2007).

Quantifiable ecosystem attributes for moose used in this study are presented in Table 12.

3.4.4 Ratings

As there is a substantial level of knowledge on the habitat requirements of moose in the RSA a 6-class rating scheme was used.

The winter season provincial benchmark for moose is the Boreal White Spruce-Trembling Aspen (BA/1) broad ecosystem unit of the moist warm subzone of the Boreal White and Black Spruce biogeoclimatic zone (BWBSmw). This unit is within the Peace Lowland (PEL) ecosection of the Boreal Plains. The provincial benchmark is assigned a rating of "1" and provides a comparison against which habitats within the study area were rated (MELP 1999).

The growing season provincial benchmark for moose is the White Spruce-Balsam Poplar Riparian (PR/1) broad ecosystem unit of the moist warm subzone of the Boreal White and Black Spruce biogeoclimatic zone (BWBSmw). This unit is within the Peace Lowland (PEL) ecosection of the Boreal Plains. The provincial benchmark is assigned a rating of "1" and provides a comparison against which habitats within the study area were rated (MELP 1999).

Table 12. Quantifiable ecosystem attributes for moose (modified from Saxena and Bilyk 2000).

Season	Life Requisite	Ecosystem Attributes
Winter	LI	• low elevation valley bottom and low to mid elevation forest stands in an early to mid seral stage and riparian and alluvial areas, burns, cutblocks, wetlands are selected year-round • elevations greater than 1200 m will have very low value to moose in winter • transitional elevations of 1000-1500 m will have limited value, depending on the stage of winter and severity of snowpack • tree and shrub leaves and shoots, deciduous and coniferous leaves and twigs are eaten year-round • fallen leaves are preferred in winter months, until they are no longer available • twig forage is important in winter • winter forage species: willow, red-osier dogwood, balsam poplar/black cottonwood, paper birch, trembling aspen, Saskatoon, highbush-cranberry, false box, subalpine fir • gentle slope • exposed southerly aspects • snow depths not exceeding 70 cm • primarily SBS and BWBS biogeoclimatic zones
Growing	LI	• low elevation valley bottom and low to mid elevation forest stands in an early to mid seral stage and riparian and alluvial areas, burns, cutblocks, wetlands are selected year-round • tree and shrub leaves and shoots, deciduous and coniferous leaves and twigs are eaten year-round • preferred forage includes leaves of shrubs and herbs and aquatic vegetation (e.g. horsetail, bur weed, submerged pondweed) • species in wetlands are an important source of forage (e.g. horsetails, sedges, pondweed, bur weed, yellow water lily and water arum) • increased use of high elevations (i.e. ESSF, BAFA) compared to winter season, but some moose remain in valley bottom floodplains year-round • all SBS and BWBS habitats used extensively

3.4.5 Winter Habitat Suitability

The following describes the moose winter habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 10) followed by assumptions used to create the model and a description of the functioning of the model.

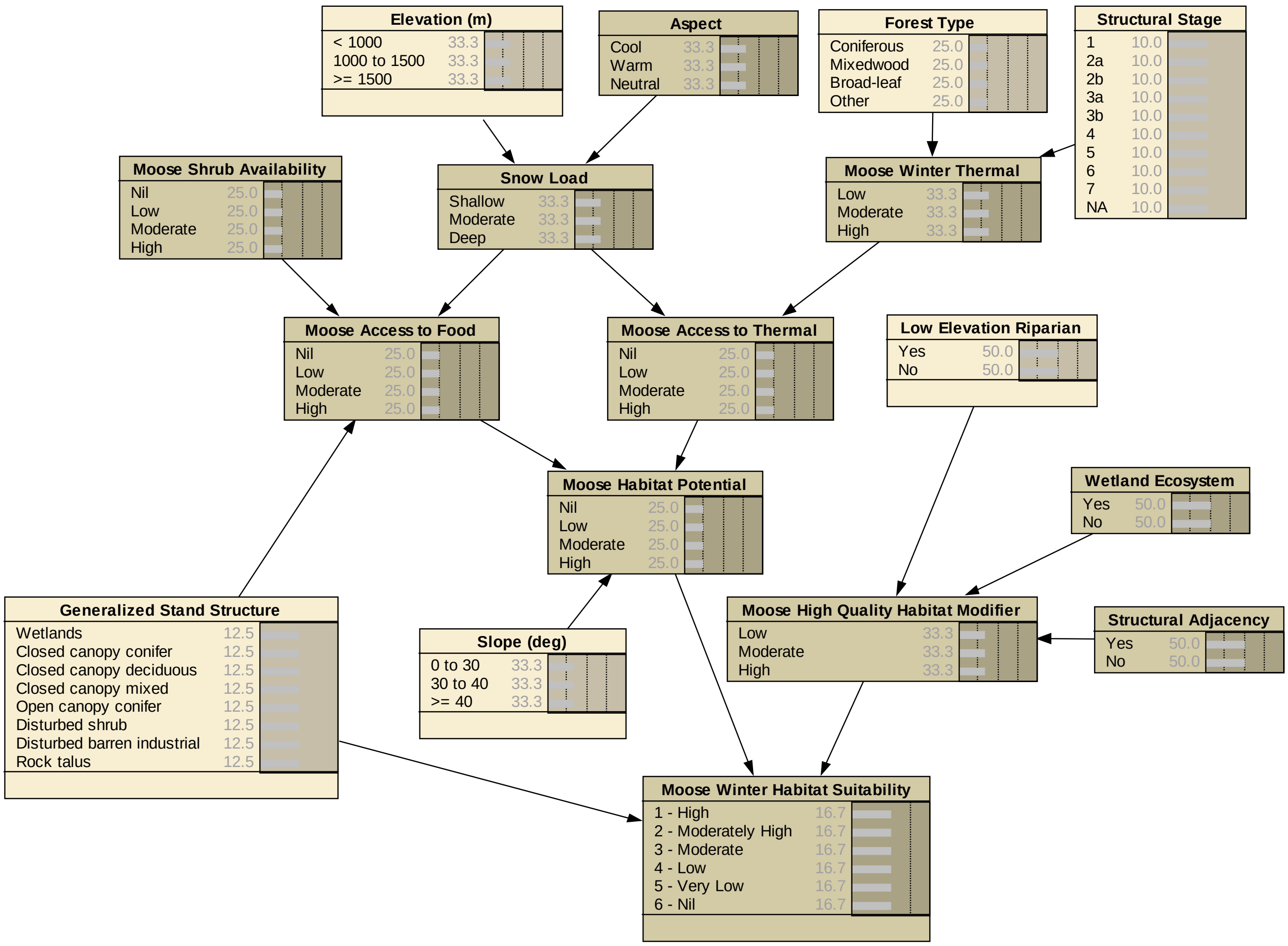

Figure 10. **Species Model for Moose Winter Living Habitat Suitability.**

3.4.5.1 Model Assumptions

1. Snow load impairs access to food and thermal/security elements. Snow depths were assumed to increase with elevation and be higher in areas of cooler aspects than warmer and neutral aspects.

2. Very deep snow completely restricts moose access to food and thermal cover, while shallow snow does not restrict access. Intermediate snow depths increasingly restrict access as snow depths increase.

3. ESSFmv2 starts approximately at 1200 m in study area (according to BEC maps). Snow load in winter is restrictive above this elevation.

4. Moose prefer slopes of less than 30%. Slopes of greater than 40% were assumed to be restrictive and therefore unused. Slopes between 30 and 40% are used intermittently.

5. Riparian habitats, wetlands and areas with structural adjacency (i.e. areas in which a combination of shrubby structural stages for foraging and a more mature structural stage for shelter are present together) are preferred.

6. Shrublands (e.g. burns, cutblocks) provide higher quantity of food year-round. Regenerating cutblocks (i.e. structural stages 2 and 3) provide high quality habitat in winter.

7. Fl (i.e. low bench) and Fm (i.e. middle bench) are ecosystem units that are flooded periodically. They were assumed to provide similar habitat value as wetlands due to high amounts of willow, alder and *Populus balsamifera*.

8. Moose often require shelter from adverse thermal conditions or snow loads in the winter. In low temperatures and/or deep snow, thermal cover is sought out in the form of conifer stands with high canopy cover. Cover is also used for security from predators.

9. Streams above 1000 m provide no significant increase in habitat value due to high snow load in winter. Below 1000 m snow load is less and high value shrub and herbs may still be accessed.

3.4.5.2 Model Description

1. Snow Load

    - Snow load was deep at high elevations (<=1200 m). At intermediate elevations (1000 – 1200 m), snow load was deep in cool aspects and moderate in neutral and warm aspects. At low elevations (<1000 m), snow load was moderate in cool aspects and shallow in neutral and warm aspects.

2. Moose Winter Thermal

    - Moose Winter Thermal values were Low for young structural stages (i.e. <3b) and increased as structural stage increased. Rankings were generally highest for conifer forests, followed by mixed and broadleaf forests.

3. Moose Access to Food & Moose Access to Thermal

    - Moose Access to Food and Thermal cover decreased with increasing snow load. Deep snow loads had low or nil Access to Food and Thermal cover. Shallow snow loads were considered non-restrictive and therefore sites maintained the Moose Winter Feeding or Winter Thermal rating assigned according to shrub presence or forest type and structural stage (respectively). Moderate snow loads had decreasing values of Access to Food and Thermal.

- The values Moose Access to Food of shrublands were rated higher than the remaining categories of generalized stand structure.

4. Moose Habitat Potential

- Sites with steep slopes (>=40%) had no habitat potential. Intermediate slopes (30 – 40%) had low habitat potential, but if there was no access to thermal cover or food they had no habitat potential. Sites with gentle slopes (<30%) ranged from low to high habitat potential based on the average of access to food and access to thermal cover.

5. Moose High Quality Habitat Modifier

- The high quality habitat modifier was assigned a high value if a site had both structural adjacency and riparian and/or wetland habitat. The modifier had a moderate value if only one of these features was present (i.e. structural adjacency or riparian and/or wetland). It had a low value for sites with neither structural adjacency nor riparian habitat.

6. Moose Winter Habitat Suitability

- Moose Winter Habitat Suitability ratings generally reflected the Habitat Potential for sites with elevations less than 1200 m. Sites possessing structural adjacency, riparian and/or wetland habitat or were a low elevation cutblock were upgraded to a higher habitat suitability compared to surrounding similar areas. All sites at elevations greater than 1200 m were considered to have Very Low habitat suitability. Disturbed barren industrial and rock talus sites also had Very Low habitat suitability.

3.4.6 Growing Season Habitat Suitability

The following describes the moose growing season habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 11) followed by assumptions used to create the model and a description of the functioning of the model.

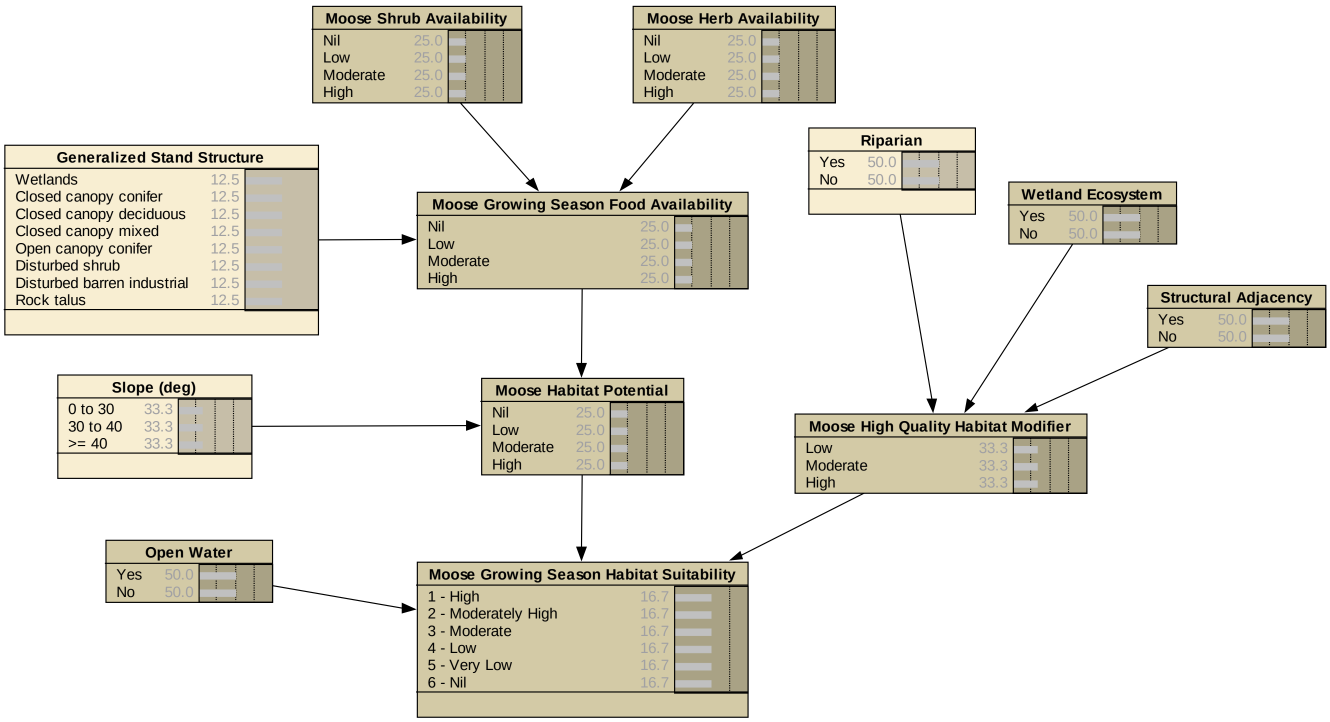

Figure 11. **Species Model for Moose Growing Season Living Habitat Suitability.**

3.4.6.1 Model Assumptions

1. Moose prefer slopes of less than 30%. Slopes of greater than 40% were assumed to be restrictive and therefore unused. Slopes between 30 and 40% are used intermittently.

2. Shrublands (e.g. burns, cutblocks) provide higher quantity of food year-round.

3. Fl (i.e. low bench) and Fm (i.e. middle bench) are ecosystem units that are flooded periodically. They were assumed to provide similar habitat value as wetlands due to high amounts of willow, alder and Populus balsamifera.

4. Water features including OW (shallow open water), PD (pond) and LA (lake) provide high quality aquatic vegetation during the growing season.

3.4.6.2 Model Description

1. Moose Growing Season Food Availability

- Disturbed barren industrial and rock talus sites were assigned nil forage availability. For most of the other stand types forage availability was based on an approximate average of moose shrub availability and moose herb availability. However the values of food availability of shrublands were rated higher than the remaining categories of generalized stand structure.

2. Moose Habitat Potential

   - Sites with steep slopes (>=40%) had no habitat potential. Moose Habitat Potential took the value of food availability on shallower slopes (<40%), with the exception of sites with an intermediate slope (30 – 40%) and high forage availability. These sites were restricted to a moderate habitat potential.

3. Moose High Quality Habitat Modifier

   - The high quality habitat modifier was assigned a high value if a site had both structural adjacency and riparian and/or wetland habitat. The modifier had a moderate value if only one of these features was present (i.e. structural adjacency or riparian and/or wetland). It had a low value for sites with neither structural adjacency nor riparian habitat.

4. Moose Growing Season Habitat Suitability

   - Moose Growing Season Habitat Suitability ratings generally reflected the Habitat Potential values. Sites possessing structural adjacency, riparian and/or wetland habitat were upgraded to a higher habitat suitability compared to surrounding similar areas. Water features such as open water, ponds and lakes were also upgraded to a level higher habitat suitability.

3.5 GRIZZLY BEAR

3.5.1 Distribution

Grizzly bears are distributed widely throughout B.C. with the exception of many coastal islands where a resident population of the species is unrecorded, including Queen Charlotte and Vancouver Islands. In B.C., grizzly bear range extends across northern British Columbia, southward to the Coast Mountains to about Jervis Inlet and down through the Rocky, Purcell and Selkirk Mountains to the U.S. border (B.C. Government 1995). They have been extirpated through much of the southern interior and Peace River regions of B.C. They are found in all biogeoclimatic units except BG (Bunchgrass) and CDF (Coastal Douglas-fir). Grizzly bears are wide-ranging in the types of ecosystems that they utilize, occurring in most broad ecosystem units and across a large gradient of elevations, from sea level to alpine tundra (MWLAP 2004c).

Provincially, the population for grizzly bears is estimated to be between 10,000 and 13,000 (MELP 1995). Grizzly bears found within the RSA are members of the Hart Grizzly Bear Population Unit (GBPU), which is 19,661 km^2. In 2004, the population estimate for the Hart GBPU was 386 individuals, with a density of 20 bears per 1000 km^2 (Hamilton *et al.* 2004). The current population is 71% of the habitat capability estimate for the area (Hamilton *et al.* 2004).

As with most species, home range size in grizzly bears is negatively correlated with general habitat quality (COSEWIC 2002b). Although no data are available to describe the ranges of grizzly bears in the RSA, the conclusions of a recent neighbouring study on habitat use by mountain bears may have application (Ciarniello *et al.* 2003). This research reported on bear habitat use for bears living in two separate landscapes and referred to them as plateau and mountain bears. The mountain landscape more readily applies to the RSA. In the Parsnip Grizzly Bear Project, Ciarniello *et al.* (2009) found that female mountain bears had an average home range of 58 km^2 (S.E.=8, N(home-ranges)=16). Male mountain grizzlies had an average home range of 672 km^2 (SE=153, N(home-ranges)=4).

3.5.2 Threats and Status

Grizzly bears are divided into two populations: the northwestern population which is listed as Special Concern and the prairie grizzly bear population which has been extirpated from Alberta, Saskatchewan and Manitoba (COSEWIC 2002b). In British Columbia, grizzly bears are on the provincial blue-list (BC CDC 2011, Table 13). Grizzly bears appear to be limited primarily by human-caused mortality from a variety of factors, and secondarily by habitat loss, alienation and fragmentation (Ciarniello *et al.* 2004; COSEWIC 2002b).

Most grizzly mortalities are from human activities, including legal harvesting, control killing for threatening human habitation or property, self-defense and poaching (McLellan *et al.* 2000; COSEWIC 2002b). Grizzly populations are limited entry hunted in most areas in Canada and licensed hunters kill over 450 grizzly bears each year (COSEWIC 2002b). Another 100 are known to be killed by other human causes and substantial numbers are killed and not reported. In British Columbia, grizzly bear hunting is limited by the number of hunting authorizations issued to resident hunters through a random draw, known as Limited Entry Hunting (LEH), and by quotas issued to guide outfitters for either resident or non-resident hunters (Austin *et al.* 2004). In the Peace Region, grizzly bear may be legally harvested by LEH in the spring from mid-April to mid-June and in fall from mid-August to end of October (MOE 2010b). Three authorizations were released for the spring season of 2011 for Wildlife Management Unit 7-21 within the RSA.

Human-caused mortality is exacerbated by increased levels of access (McLellan 1990; Mace *et al.* 1996). Literature reports that roads impact grizzly bears and that their use of habitat is constrained by roads. Studies have identified that the majority of grizzly deaths were caused by humans and occurred within 500 m of a road (Ciarniello *et al.* 2004; Summerfield *et al.* 2004). The effect of roads on grizzly bears has been debated. McLellan and Shackleton (1988) found that grizzly bears avoided even lightly-used roads, utilizing habitats within 100 m of roads less than expected. Conversely, other research has found that grizzly bears will utilize roaded habitats, although avoidance will increase in relation to ease of public access (e.g. open, restricted or closed, Wielgus *et al.* 2002) and amount of traffic (Mace *et al.* 1996).

Habitat loss, alienation and fragmentation also threaten grizzly bear populations in B.C. Human development often causes direct loss of preferred valley-bottom habitat (MWLAP 2004c) as well as habitat fragmentation by isolating islands of preferred wilderness habitat (Proctor *et al.* 2002). The fragmentation of habitat has been noted as a threat to grizzly populations, by limiting movement of grizzly bears across the broader landscape.

Regionally, the Hart GBPU is considered viable (Hamilton *et al.* 2004), although it is near the threshold for habitat effectiveness to support the current population (Johnstone 2004). As a result, the population is at risk of falling from the status of "viable" to "threatened". According to Johnstone (2004), the most substantive risk to the population is associated with improved access resulting in displacement of bears, increased hunting opportunities and poaching.

Table 13. Status of grizzly bear (*Ursos arctos*) (BC CDC 2011).

Species Code	M-URAR
Provincial Status	S3 – Special concern, vulnerable to extirpation or extinction
B.C. List	Blue
Identified Wildlife (Yes/No)	Yes
COSEWIC Status	Special Concern
Global status	G4 = Uncommon but not rare; some cause for long-term concern due to declines or other factors.

3.5.3 Habitat Requirements

3.5.3.1 Introduction

Grizzly bears are large omnivores that occupy a wide variety of habitats in British Columbia. As habitat generalists, grizzly bears can be found in habitats as diverse as temperate coastal rainforests and semi-desert arctic tundra.

Most grizzly bears in the interior portions of British Columbia occupy mountainous areas and rely on a variety of alpine and valley bottom habitats for food. Grizzly bears have a very broad diet, spending most of their time eating vegetation and fruits, such as berries, roots and corms and fresh shoots, but will also eat carrion, salmon, deer, moose, rodents and insects (COSEWIC 2002b; Zager and Jonkel 1983). Unlike grizzly bear populations along Pacific watersheds, grizzly bears in the Peace River drainage do not have ready access to spawning salmon to include as part of their diet (Ciarniello *et al.* 2003). Most grizzly bears eat primarily vegetation and berries, and their habitat associations are therefore strongly seasonal, reflecting local plant development. In mountainous regions, such as those found in the RSA, the variation in local plant development associated with varying elevation results in seasonal elevational migrations (Ciarniello *et al.* 2003). In berry season, some mountain bears made extended movements from their 'core' home ranges to burned over areas, such as those surrounding Hook Lake which contained abundant soapberry (*Shepherdia canadensis*) and blueberries (*Vaccinium membranaceum and V. ovafolium)*

Despite some variability, general patterns have been documented in the literature for seasonal habitat use of interior grizzly bear (McLellan and Hovey 2001; Ciarniello *et al.* 2003; Zager and Jonkel 1983). Seasonal movements of grizzly bears are based on food availability although these movements are highly variable and often dependent on other factors such as sex, age and social status. McLellan and Hovey (2001) observed interior grizzly bears denning within mountain habitat, traveling to plateau or flatland areas upon den emergence during the spring, foraging in a variety of habitats during the summer, and then moving back to the alpine and subalpine areas during berry season. Ciarniello *et al.* (2005) found that bears that lived in the mountains also denned in the mountains. Dens occupied by mountain bears were excavations into sloping ground or natural caves and tended to be placed at higher elevations. Very few dens were located in the mountain valley bottoms (Ciarniello *et al.* 2005). In Ciarniello *et al.* (2005), none of the mountain bears were recorded emerging from their dens and travelling to the plateau as recorded by McLellan and Hovey (2001). Instead, mountain bears denned for a longer duration than their plateau bear counterparts and remained within the mountains at den emergence.

Based on the distribution and observed use of habitats from other interior grizzly bear studies (McLellan and Hovey 2001), and more specifically, studies conducted in the adjacent Parsnip River (Ciarniello *et al.* 2003), seasonal habitat use for mountain grizzly bears are expected to show the following general trends:

> Spring – snow-free areas found in lower elevation valleys, wetlands, waterbody edges, alpine meadows and south-facing aspects to feed on emergent vegetation

Summer – later-melting slopes (mid-elevation cool aspects) to take advantage of newly emerging more succulent vegetation, young seral-stage openings (e.g. burns and cutblocks) for berries and subalpine and alpine meadows with Sitka valerian and rodents

Fall – young seral-stage openings (e.g. burns) for late berries and ants in burned stumps, open alpine herbaceous slopes for roots and rodents and carrion when available

In our study, the life requisites that were rated for grizzly bear reflect the expected seasonal habitat use, including: LI-P (living in spring[16]), LI-S (living in summer[17]) and LI-F (living in fall[18]). Living requisites (LI) that incorporate both feeding and security requirements were chosen for rating rather than rating habitats separately for these requirements. Our rationale is that it is more likely that grizzly bear habitat use is based on a favorable combination of features with an emphasis on forage but including elements of cover for security and bedding. Table 14 describes specific ecosystem attributes that provide for each of the grizzly bear life requisites rated by this study.

3.5.3.2 Spring

In the spring, grizzly bear feed primarily on emergent vegetation on south facing aspects and in avalanche chutes where snow is early to clear and soils are well developed. In south-eastern B.C., grizzlies were found to utilize lower elevation valley bottoms and avalanche chutes after emerging from their dens (McLellan and Hovey 2001). Results from the Parsnip River Grizzly Bear Study were somewhat similar although mountain bears in the Parsnip River study area did not move into forested environments tending to remain in alpine meadows and avalanche chutes (Ciarniello *et al.* 2003).

After emerging from their dens, grizzly bears spend most of their time in the spring foraging, feeding primarily on herbaceous forbs and grasses. Bears in the Parsnip River Grizzly Bear Study were observed feeding with high intensity on fireweed, common horsetail, glacier lily, alpine hedysarum, cow parsnip, bracted lousewort, Sitka valerian, bromes, sedges and blue grasses. Carcasses and moose (adults and calves) were also noted as being fed on with high intensity during the spring season on the plateau (Ciarniello *et al.* 2003).

Overall, mountain bears have shown a tendency to use the snow-free lower elevation portion of subalpine and alpine meadows in the spring, following the snowmelt up the mountain as the season progresses, thus tracking the early phenological stages of vegetation (Ciarniello *et al.* 2003). Based on field research in the Hart Ranges, grizzly bears found in the mountains used habitat at a mean elevation of 832.5 m, with a range of 677 to 1,092 m. Despite feeding at lower elevations during the spring, grizzlies in the Hart Ranges still

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[16] The spring season includes the months of May and June as defined for the Subboreal Interior ecoprovince per the Chart of Seasons by Ecoprovince (RISC 1999).

[17] The summer season includes the months of July and August as defined for the Subboreal Interior ecoprovince per the Chart of Seasons by Ecoprovince (RISC 1999).

[18] The fall season includes the months of September and October as defined for the Subboreal Interior ecoprovince per the Chart of Seasons by Ecoprovince (RISC 1999).

had a strong preference for non-forested areas and were seldom recorded in valley bottoms with old-age forested stands.

3.5.3.3 Summer

In the mountains, summer feeding areas are the most variable of the seasonal habitats and the habitats that are used are dependent on factors such as food availability, sex, reproductive status, age of the bear, competition from other bears and interactions with humans. During the summer season, Ciarniello *et al.* (2003) reported that some mountain bears made extended movements to access large burned over areas. For the majority of these bears this was the only time extended movement outside of their 'core' home range was recorded. Other mountain bears were not recorded to have made these extended movements in summer but rather remained to continue to take advantage of later emergent vegetation, moving to cooler aspects and higher elevations (Ciarniello *et al.* 2003), similar to southeastern B.C. bears (McLellan and Hovey 2001). During the summer, grizzly bears were recorded in the Hart Ranges and foothills, and were recorded at locations ranging from 1,024 to 1,732 m, with a mean elevation of 1,360. Areas of use tend to be non-forested, utilizing krummholz subalpine fir/slide alder/rhododendron communities, alpine meadows or young seral-stage openings, such as burns and cutblocks. The selection for young-age landscapes within the mountains is a reflection of bears moving to burns that produced an abundance of blueberries (*Vaccinium sp.*), soapberry (*Shepherdia canadensis),* and opportunities to forage on ants.

Common plant food items that are utilized during the summer include bracted honeysuckle, devil's club, soapberry, black huckleberry, velvet-leaved blueberry, glacier lily and white clover. Other food items that were used intensely during the summer include ants and microtines (Ciarniello *et al.* 2003). Most feeding on ants consists of ripping apart dead wood, flipping rocks and logs to reveal the ants.

3.5.3.4 Fall

Grizzly bear continue to utilize non-forested high-elevation alpine habitats into the fall, similar to those used in the summer. Unlike bears that migrate to valley bottoms during the fall to feed on spawning salmon, grizzly bears in the arctic drainage tend to be at higher elevations during the fall. The mean elevation of mountain grizzly bears in the Parsnip River Grizzly Bear study during the fall was 1,462 m, with a range between 1,226 to 1,824 m, slightly higher than during the summer months (Ciarniello *et al.* 2003). Similar to summer, grizzlies will feed on a range of foods such as berries, roots, insect larvae, herbaceous plants, grasses and sedges (McLellan and Hovey 2001, Ciarniello *et al.* 2003). In the mountains, foraging tends to be focused intently towards digging for the bulbs of glacier lily, *Hedysarum*, and to a lesser extent mountain sorrel. Bears will also dig for rodents. Bears will continue to feed on berries in the fall, however, in the mountains, a lot of the berries will have already turned. For those bears that focus on feeding on berries, they frequently use early-seral stage forest openings, particularly old burn sites and cutblocks. Intense bouts of feeding on ants and their larvae occur until the first hard frost (Ciarniello *et al.* 2003).

Table 14. Quantifiable ecosystem attributes for grizzly bear (modified from Saxena and Bilyk 2000).

Season	Life Requisite	Ecosystem Attributes
Winter	HI	• subalpine krummholz, parkland, alpine tundra • natural caves for natal dens, when available
Spring	LI	• south-facing slopes with well-developed soil • lower elevation valley bottoms with open forest canopies • south-facing herbaceous avalanche tracks cleared of snow
Summer	LI	• subalpine meadows and alpine tundra excluding rock, ice and snow, predominantly alpine meadows, herb fields and grasslands • krummholz subalpine fir/slide alder/rhododendron communities • early-seral stage openings (i.e. burns and cutblocks) with high berry production • herbaceous and shrubby avalanche tracks, especially north-facing • mid-elevation cool aspects
Fall	LI	• alpine tundra excluding rock and ice, meadow, herb fields and grasslands predominantly • young-seral stage openings (i.e. burns and cutblocks) with high berry production • mid- to high elevations

3.5.4 Ratings

As there is a substantial level of knowledge on the habitat requirements of grizzly bear in the RSA a 6-class rating scheme was used.

There are no formal provincial benchmarks available for grizzly bear in the interior. However, in a wildlife habitat modeling project completed by Sargent et al. (2010), the Engelmann Spruce-Subalpine Fir Dry Cool variant (ESSFdk) and Montane Spruce Dry Cool variant (MSdk) within the Border Ranges Ecosection was considered to be the benchmark for interior grizzly bears. The Border Ranges lies within southeastern BC in the East Kootenay's, and includes the Flathead Valley. A season was not specified in this document, but the benchmark was used for spring and fall rating. These habitats provide a rough comparison against which habitats within the study area were rated.

3.5.5 Spring Habitat Suitability

The following describes the grizzly bear spring habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 12) followed by assumptions used to create the model and a description of the functioning of the model.

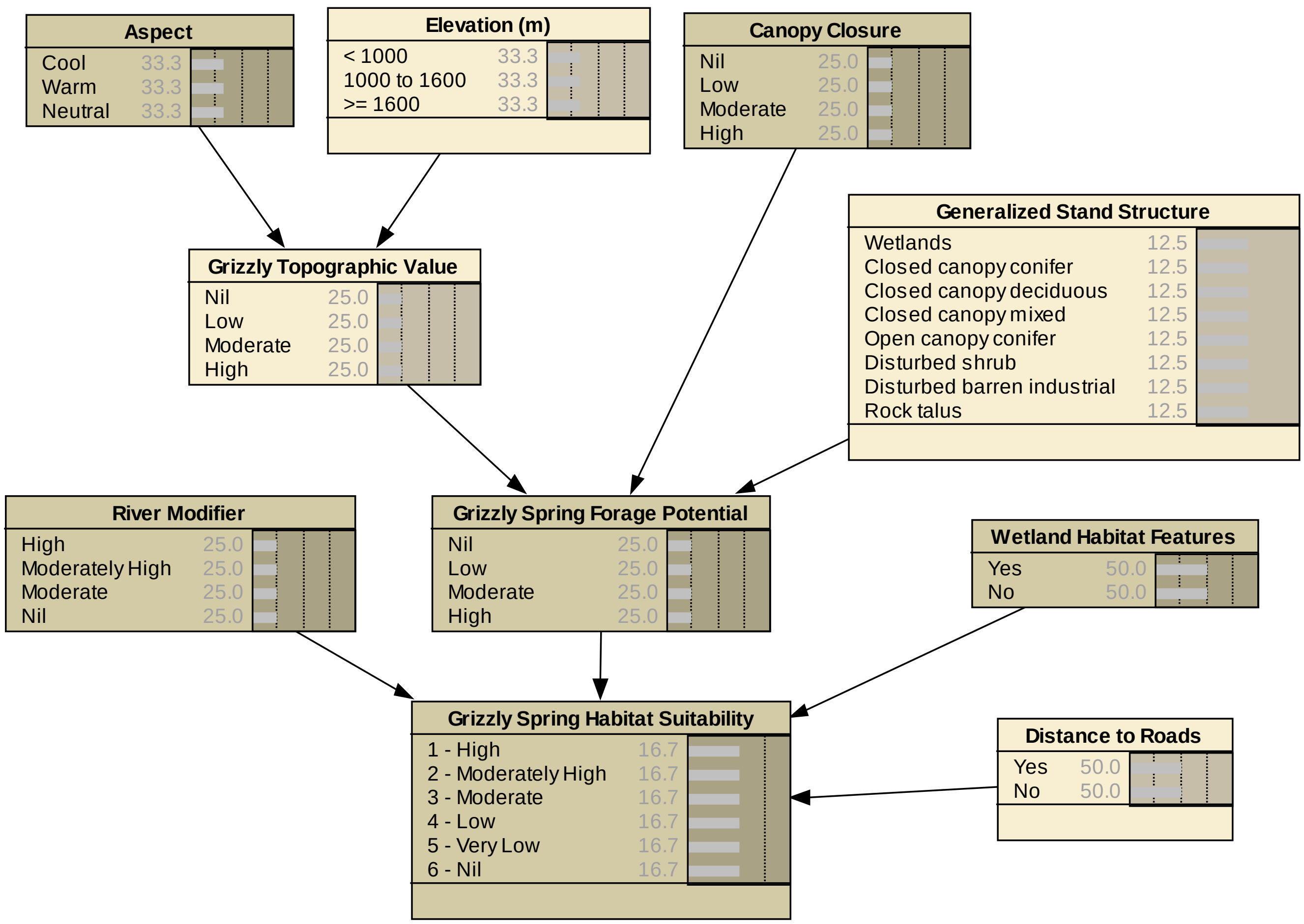

Figure 12. **Species Model for Grizzly Bear Spring Living Habitat Suitability.**

3.5.5.1 Model Assumptions

1. Grizzly bears avoid habitat within 500 m of roads and railways.

2. Grizzly bears take advantage of snow-free areas in the spring being lower elevation valley bottoms or flatland (e.g. interior bears in southeastern B.C. documented by McLellan and Hovey 2001) and/or alpine meadows and avalanche chutes (e.g. mountain bears in Parsnip River study area by Ciarniello et al. 2005). For the most conservative approach, we assumed that Grizzly bears in the study area could use either strategy.

3. Warm and neutral aspects become snow-free before cool aspects at the same elevation.

4. Imagery analysis using Google Earth revealed that there is not much alpine habitat in the RSA. Some exists on Mt. Hermann at elevations greater than 1600 m. These elevations assumed to be windswept and consequently snow-free in the spring. As a large portion of snow is removed via wind, aspect is less important for snow removal of these sites in spring.

5. Forests with lower canopy closure receive more insolation and become snow-free earlier than those with higher canopy closure.

6. The margins of water features including OW (i.e. shallow open water), PD (i.e. pond), LA (i.e. lake) and RI (i.e. river) become snow-free in early spring. Note that it is the areas immediately surrounding the feature which are higher value not the water body itself. However, as no large lakes are present in the RSA, it was assumed that the areas of these features could be used to represent surrounding habitat.

7. Wetlands provide increased habitat value due to high proportion of succulent vegetation.

8. Areas within 150 m of the Murray River were assumed to provide high value spring forage earlier than surrounding areas (regardless of canopy closure).

3.5.5.2 Model Description

1. Grizzly Topographic Value

   - Topographic value for low elevation sites (<1000 m) were low for cool aspects and high for neutral and warm aspects. Topographic value was moderate for mid-elevation sites (1000 – 1600 m) with warm aspects, while it was low for cool and neutral aspects at these elevations. All sites above 1600 m had moderate topographic values.

2. Grizzly Spring Forage Potential

   - Barren industrial and rock talus had no spring forage potential. For all other sites, forage potential increased with Grizzly Topographic Value and decreased with canopy closure.

3. Grizzly Spring Habitat Suitability

   - Grizzly Spring Habitat Suitability generally increased with spring forage potential.

   - Gibeau et al. (2001) removed habitat within 500 m of high human use (>100 human visits/month) within a predictive GIS based model of adult female grizzly bear security areas (in the Central Canadian Rocky Mountains). We assumed roads and railways in the RSA demonstrate similar human use and downgraded habitat values within this buffer by two values compared to similar sites outside the buffer.

- Habitat values of water features including OW (i.e. shallow open water), PD (i.e. pond), LA (i.e. lake) and RI (i.e. river) were increased by one level (within their respective habitat). Wetlands were also increased by one level.

- Warm and neutral aspects within the 150 m buffer surrounding the Murray River were given High ratings while cool aspects were given Moderately High ratings. Presence of roads within the river buffer were treated as the rest of the study area.

3.5.6 Summer Habitat Suitability

The following describes the grizzly bear summer habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 13) followed by assumptions used to create the model and a description of the functioning of the model.

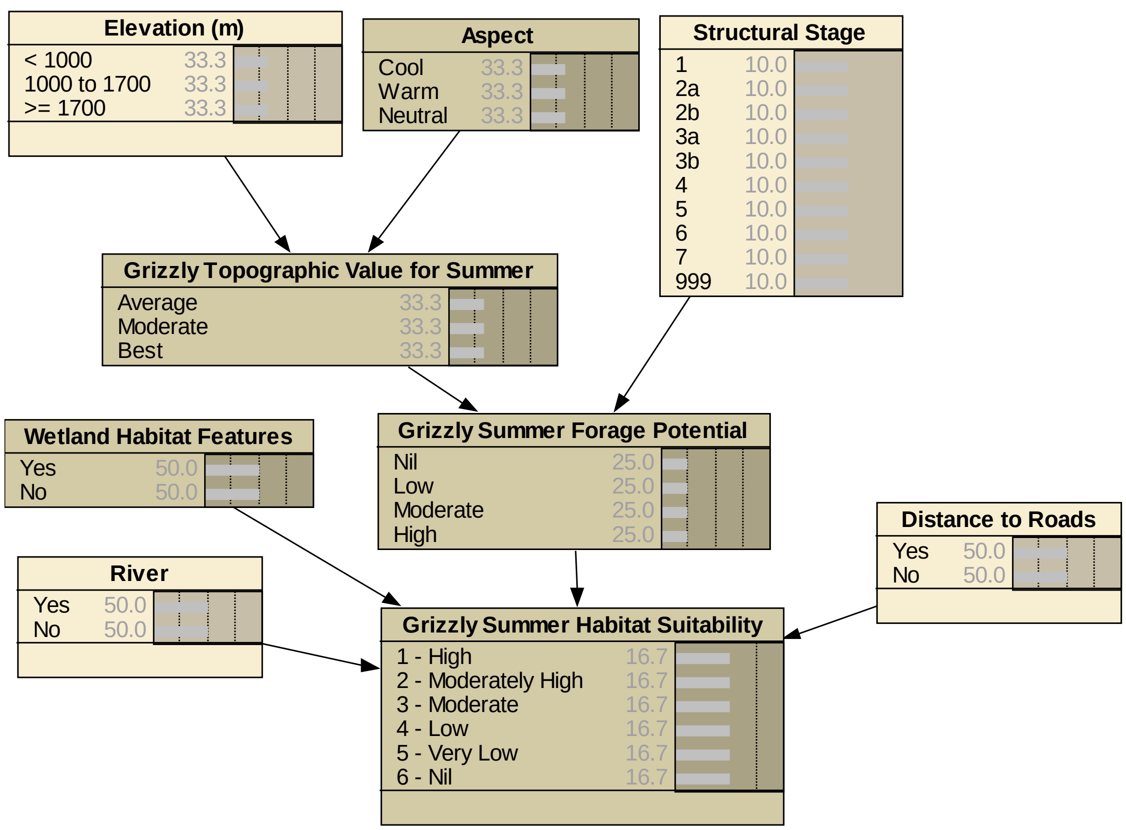

Figure 13. **Species Model for Grizzly Bear Summer Living Habitat Suitability.**

3.5.6.1 Model Assumptions

1. Grizzly bears avoid habitat within 500 m of roads and railways.

2. Sites with neutral or cool aspects in mid-elevation (1000 – 1700 m) are characterized by plants that emerge later in the season (i.e. summer) due to a later disappearance of snow compared to lower

elevations or warmer aspects. Mid-elevation sites with warm aspect and high elevation sites (>=1700 m) possess a plant community that emerged earlier in the season (i.e. spring). Low elevation sites (<1000 m) with warm or neutral aspects also possess plants that emerged earliest in the spring, while cool aspect sites likely displayed plant emergence in later spring.

3. Non-forested sites, alpine/krummholz and early seral stages such as burns and cutblocks (i.e. structural stages 2a, 2b, 3a, 3b) are preferred. Structural stage 4 possessed low herb and shrub cover due to high canopy closure in this stage.

4. Wetlands and the margins of water features including OW (i.e. shallow open water), PD (i.e. pond), LA (i.e. lake) and RI (i.e. river) provide increased habitat value due to high proportion of succulent vegetation that persists through the summer months. Note that it is the areas immediately surrounding the water features which are higher value not the water body itself. However, as no large lakes are present in the RSA, it was assumed that the areas of these features could be used to represent surrounding habitat.

5. Low-elevation riparian areas and fluvial benches along large rivers such as the Murray River and wetlands are preferred due to the presence of dense herb and shrub layers, including early season berries.

3.5.6.2 Model Description

The same description in the spring model concerning avoidance of a 500 m road and railway buffer applies to this model as well.

1. Grizzly Topographic Value for Summer

    - Sites with neutral or cool aspects in mid-elevation (1000 – 1700 m) were assigned the highest topographic value. Mid-elevation sites with warm aspect and high elevation sites (>=1700 m) were assigned moderate topographic values. Low elevation sites (<1000 m) with warm or neutral aspects were assigned low topographic values, while cool aspect sites were given moderate value.

2. Grizzly Summer Forage Potential

    - Grizzly Summer Forage Potential was nil for non-vegetated sites.

    - Structural stages 2a, 2b, 3a, 3b were assigned moderate or high forage potential for all topographic values (elevation and aspect combinations).

    - Structural stage 4 had low forage potential for all topographic values.

    - The forage potential for mature structural stages (i.e. 5 -7) reflected the topographic value.

3. Grizzly Summer Habitat Suitability

- Grizzly Summer Habitat Suitability generally increased with summer forage potential.
- Gibeau et al. (2001) removed habitat within 500 m of high human use (>100 human visits/month) within a predictive GIS based model of adult female grizzly bear security areas (in the Central Canadian Rocky Mountains). We assumed roads and railways in the RSA demonstrate similar human use and downgraded habitat values within this buffer by two values compared to similar sites outside the buffer.
- Habitat values of water features including OW (i.e. shallow open water), PD (i.e. pond), LA (i.e. lake) and RI (i.e. river) were increased by one level (within their respective habitat). Wetlands were also increased by one level.
- The area within the 150 m buffer surrounding the Murray River were given High and Moderately High ratings. Presence of roads within the river buffer were treated as the rest of the study area.

3.5.7 Fall Habitat Suitability

The following describes the grizzly bear fall habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 14) followed by assumptions used to create the model and a description of the functioning of the model.

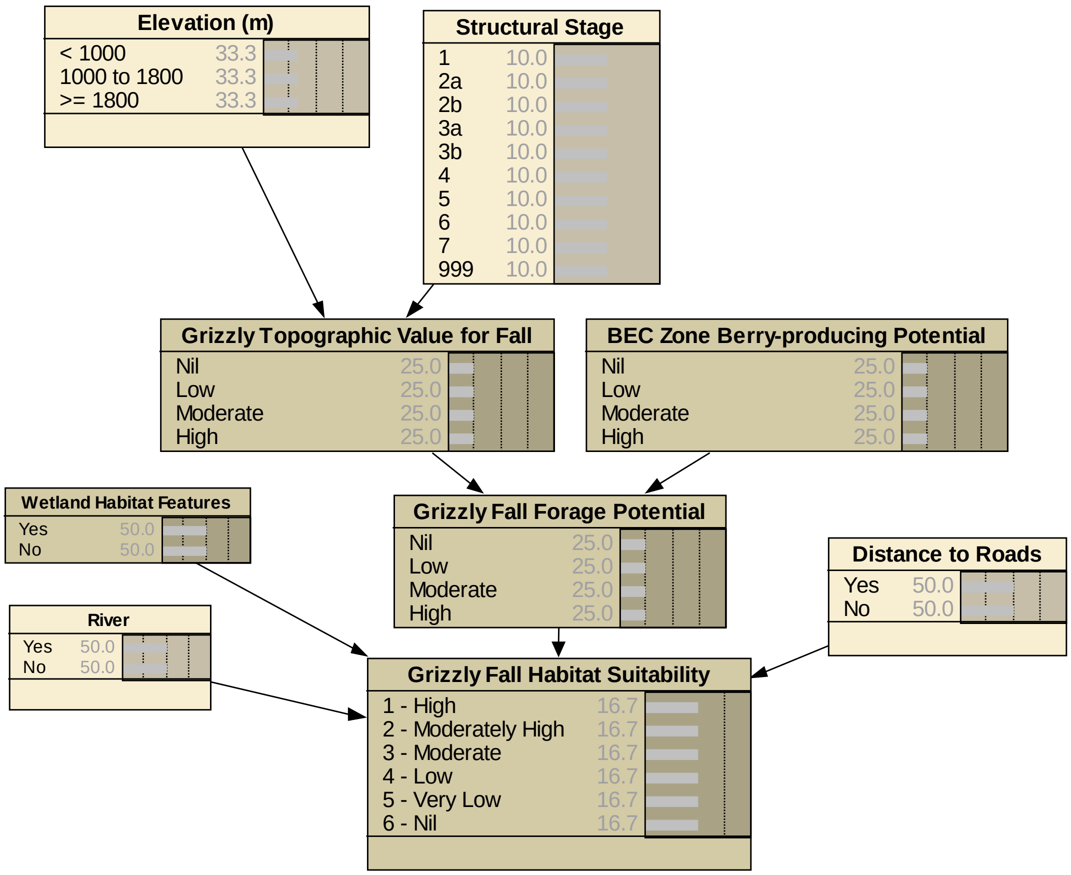

Figure 14. **Species Model for Grizzly Bear Fall Living Habitat Suitability.**

3.5.7.1 Model Assumptions

1. Grizzly bears avoid habitat within 500 m of roads and railways.
2. Mid- to high elevation sites are preferred. Sites at higher (i.e. >1800 m) and lower (i.e. <1000 m) elevations are less valuable.
3. Sites that support berry-producing plants have higher value for grizzly bears in fall. Therefore Grizzly select for burns and cutblocks in early stages of regeneration (i.e. structural stages 2a, 2b, 3a, 3b). Structural stage 4 possessed low herb and shrub cover due to high canopy closure in this stage.
4. Wetlands and the margins of water features including OW (i.e. shallow open water), PD (i.e. pond), LA (i.e. lake) and RI (i.e. river) provide increased habitat value due to high proportion of succulent

vegetation that persists through the fall months. Note that it is the areas immediately surrounding the water features which are higher value not the water body itself. However, as no large lakes are present in the RSA, it was assumed that the areas of these features could be used to represent surrounding habitat.

5. Low-elevation riparian areas and fluvial benches along large rivers such as the Murray River and wetlands are preferred due to the presence of dense herb and shrub layers, including early season berries.

3.5.7.2 Model Description

The same description in the spring model concerning avoidance of a 500 m road and railway buffer applies to this model as well.

1. Grizzly Topographic Value for Fall

   - High elevation (>=1800 m) sites had a low topographic value across all structural stages. Low elevation sites (<1000 m) were rated as low to high and mid-elevation sites (1000 – 1800 m) were rated as moderate to high depending on structural stage. Young structural stages (2a - 3b) were given higher values than older stages (>4); sites with no vegetative cover (NA or 1) were given no value for all elevations. Structural stage 4 always had a Low topographic value.

2. Grizzly Fall Forage Potential

   - Grizzly Fall Forage Potential was an approximate average of topographic value and berry-producing potential, weighted very slightly toward topographic value.

3. Grizzly Fall Habitat Suitability

   - Grizzly Fall Habitat Suitability generally increased with fall forage potential.

   - Gibeau et al. (2001) removed habitat within 500 m of high human use (>100 human visits/month) within a predictive GIS based model of adult female grizzly bear security areas (in the Central Canadian Rocky Mountains). We assumed roads and railways in the RSA demonstrate similar human use and downgraded habitat values within this buffer by two values compared to similar sites outside the buffer.

   - Habitat values of water features including OW (i.e. shallow open water), PD (i.e. pond), LA (i.e. lake) and RI (i.e. river) were increased by one level (within their respective habitat). Wetlands were also increased by one level.

   - The area within the 150 m buffer surrounding the Murray River were given High and Moderately High ratings. Presence of roads within the river buffer were treated as the rest of the study area.

3.6 FISHER

3.6.1 Distribution

Fishers (*Martes pennanti)* are found only in North America and occupy coniferous and mixed deciduous-coniferous forests across most of Canada and disjunct parts of the United States. Throughout their range, fishers occur in low numbers, and the species is relatively less abundant in western Canada compared to eastern populations (Proulx *et al.* 2004, Hatler *et al.* 2008). In B.C., fisher can occur throughout the mainland regions of the province, but are very rare throughout much of the southern interior and west of the Coast Mountains; the majority of the provincial population is found in the central interior and northeast regions of the province (Lofroth 2004, Hatler *et al.* 2008). The current population estimate for B.C. is between approximately 1,400 and 3,700 individuals (Lofroth 2004).

Fishers occupy low to mid-elevation forested habitats, typically avoiding open areas (Weir and Almuedo 2010). Throughout their range, they can be found at elevations up to 2,500 m, but the majority are found below 1,000 m (Powell and Zielinski 1994). In B.C., they are most commonly found in variants of the Boreal White and Black Spruce (BWBS), Interior Douglas-fir (IDF), Montane Spruce (MS), Sub-boreal Pine-Spruce (SBPS) and Sub-boreal Spruce (SBS) biogeoclimatic zones, with the highest densities in the BWBSmw, IDFdk3, IDFdk4, SBPSmc, SBPSxc and SBSdw subzones (Weir and Almuedo 2010).

The Peace Region, in particular, the southern Peace Region, is believed to be one of the most productive areas for fisher in B.C. (Lofroth 2004, Weir *et al.* 2011). As of 2003 the abundance of fisher within the Peace was estimated at 548 - 1,300 adult individuals (Weir 2003). Habitat capability mapping for the province has designated the southern Peace Region as an area of *Very High* and *High* habitat capability for fisher with estimated densities of 9.6 to 20.6 and 6.6 to 15.4 fishers/1,000 km^2, respectively (Lofroth 2004). These estimates are consistent with the results of research conducted by Weir *et al.* (2011) in the Kiskatinaw Plateau and Peace Lowlands ecosections (to the south and west of Dawson Creek, an area designated as *Very High* capability by Lofroth 2004), which found an average density of 18.4 fishers/1000 km^2 in early winter and 16.3 fishers/1000 km^2 in late winter in the boreal mixed-wood forests of the BWBSmw biogeoclimatic zone. In comparison, research by Weir and Corbould (2006) in the SBS biogeoclimatic zone in the Williston Reservoir area of the Omineca Region (an area designated as *High* capability by Lofroth 2004) found an average density of 11.2 and 8.8 fishers/1,000 km^2, respectively, in the early and late winter. Although this study was outside of the Peace Region, the authors suggest that these estimates are representative of other SBS-zone landscapes in the province.

The MRP Regional Study Area overlaps the Hart Foothills Ecosection within the Canadian Rocky Mountains Ecoregion, and the Kiskatinaw Plateau Ecosection of the Southern Alberta Upland Ecoregion; biogeoclimatic subzones within the RSA include the BWBSwk1, BWBSmw, SBSwk2, ESSFmv2, ESSFmvp, ESSFwc3, ESSFwcp, and ESSFwk2 and BAFAun. Most of the region has been rated as *High* capability for fisher in provincial-level mapping, but it borders areas of *Rare* to *Nil* habitat capability to the west and southwest as it transitions to the Rocky Mountains. Within the RSA, we expect fisher to be found in forested habitats at lower to mid-elevations throughout the study area; specifically, within the BWBS and

SBS subzones and possibly the lower areas of the ESSF. Habitat capability is expected to be highest within the BWBSmw, although habitat suitability will depend on the current state of the local ecosystems and the level of anthropogenic disturbance (e.g. forestry, oil and gas development, etc.). Densities within the BWBSmw could potentially be as high as those observed by Weir *et al.* (2011) during the studies near Dawson Creek (average density of 18.4 and 16.3 fishers/1000 km^2 in early and late winter, respectively).

3.6.2 Threats and Status

Globally and nationally, fisher populations are considered widespread and secure; however, within British Columbia there is more concern due to local extirpations in the southern interior of the province and overall lower densities as compared to eastern populations (Banci 1989, Weir 2003). Currently in B.C., fishers are blue-listed (Table 15) indicating that they are a species of Special Concern within the province. Fisher are also provincially designated as "Identified Wildlife" under the Identified Wildlife Management Strategy (IWMS-BC) and the Dawson Creek Land and Resource Management Plan has identified the maintenance of viable and healthy furbearer populations as a regional objective (PRCI 2010).

The primary threat faced by fisher is the loss of forested habitat as a function of anthropogenic change (Proulx *et al.* 2004). Development activities that occur on forested land, such as logging, hydro-electric operations, mining and agricultural land clearing can remove critical habitat for the species (Weir 2003). Due to their strong association with late successional forests, harvest practices which focus on this forest type may have significant impacts on fisher (Weir 2009). Furthermore, forest management practices that suppress disease, death and decay can be detrimental because they prevent processes which facilitate the creation of suitable denning and resting sites (Weir and Almuedo 2010).

In addition to habitat changes, fisher populations also face threats from trapping. Trapping influences population dynamics by altering reproductive and mortality rates and affects local density and spatial organization (Weir 2003, Arthur *et al.* 1989, Powell and Zielinski 1994). These effects may be exacerbated when resource development enables access to new areas for trappers, which can increase mortality rates within populations that were previously acting as source populations (Weir 2003). In the Peace Region, trappers may legally harvest fisher between November 1st and February 15th, although harvests have declined over the past 30 years (Weir 2003, 2009).

Table 15. Status of fisher (*Martes pennanti*) (BC CDC 2011).

Species Code	M-MAPE
Provincial Status	S2S3 – S2 = Imperiled, S3 = Special concern, vulnerable to extirpation or extinction
B.C. List	Blue
Identified Wildlife (Yes/No)	Yes
COSEWIC Status	N/A
Global status	G5 = demonstrably widespread, abundant, and secure

3.6.3 Habitat Requirements

3.6.3.1 Introduction

Two categories of habitat requirements were rated for fisher in the habitat model: living all seasons and birthing habitat. In general, life requisites such as foraging, thermal cover and resting habitat characteristics for fisher are inter-related and are required year round; as a result, seasonal habitat use by fisher in the study area was combined for all seasons. The exception to this is the reproduction period, when specific habitat features are required. Assessing the generalized life requisite, "living", at a one-season level, in combination with rating "birthing" was sufficient to meet the study objective.

Fisher is a forest-dwelling species. In the west, they are most commonly associated with older coniferous forests (Hatler *et al.* 2008); however, habitat selection appears to revolve more around forest structure than forest type and a variety of forested habitats may be used (Badry 2004). Important structural features include the presence of coarse woody debris (CWD), snags and thick overhead cover composed of multiple layers (trees, saplings, shrubs, etc.).

Fishers are a medium-sized generalist carnivore. In most areas, snowshoe hare are the most common and important prey item but they consume a large variety of other foods (Hatler *et al.* 2008) and are readily able to switch food sources to adapt to the most available food source (Badry 2004). For example, while dense regenerating forests provide opportunities to catch snowshoe hares, in late successional forests voles and squirrels are more likely food sources (Weir and Almuedo 2010). Other food sources include other small rodents, woodchucks, porcupines, grouse, muskrat, other carnivores such as mink or marten, carrion, and less frequently, vegetation, fish and snakes (Badry 2004, Hatler *et al.* 2008, Weir and Almuedo 2010). The adaptability of the food habits of fisher allows for utilization of variable forest types and for the use of good patches within less suitable stands (Weir and Almuedo 2010). Many important prey species are strongly associated with shrub cover and CWD making these significant aspects of foraging habitat (Badry 2004).

Fisher habitat use is strongly associated with overhead cover. This has generally been believed to be a response to protection from predators (Weir 2003, Weir and Almuedo 2010); although prey species may also be more abundant in these habitats (Hatler *et al.* 2008). Regardless, fishers are usually found in or near forest patches with at least 30% canopy cover and a productive understory (Badry 2004). Areas with little cover, including non-forested wetlands, recent cutblocks, and other cleared areas are generally avoided (Weir and Almuedo 2010); as such, corridors among suitable patches are important habitat features (Badry 2004). Overhead cover is also particularly important in the winter, as fishers are poorly adapted to travelling in deep, soft snow (Raine 1983) and forest stands with a moderate canopy closure of conifers can provide important snow interception to facilitate travel (Weir 2003).

Fishers use a variety of different habitat structures as rest sites throughout the year, which are selected to provide both for protection from predators and thermal cover. The type of structure used will depend on availability and on the ambient temperature; however, typical rest sites include large tree branches or rust brooms, CWD, tree cavities and ground sites. Overall, tree sites (branches, rust brooms, etc.) are preferred; however, at temperatures below -11°C, greater thermal cover is required and can be achieved by taking cover in large logs to capitalize on insulation provided by snow (Weir and Corbould 2008). Specific structural habitat associations for resting are shown in Table 16. Quantifiable ecosystem attributes used by this study are presented in Table 17.

3.6.3.2 Living – All Seasons

A fisher's home range must provide all of its foraging, thermal and security cover, and resting and reproductive habitat needs throughout the year. Fishers are generally solitary animals and have intrasexually exclusive home ranges. In B.C., fisher home ranges are relatively large compared to other regions. Studies in north-central and north-eastern B.C. have estimated home range size (95% fixed kernel estimate) at 49 km^2 for female fisher and 219 km^2 for male fisher in the SBS biogeoclimatic zone near the Williston Reservoir (Weir and Corbould 2008), and 32 km^2 and 199 km^2 for female and male fisher, respectively, in the BWBS biogeoclimatic zone near Dawson Creek (Weir 2009).

Habitat selection by fisher occurs at several levels, and studies within B.C. have found a variety of attributes that influence habitat selection. In general, fisher habitat selection is positively associated with (summarized from Lofroth *et al.* 2011):

- forested ecosystems (primarily coniferous, but also mixed coniferous/deciduous stands);
- forested stands with 30-60% canopy cover;
- a productive understory, particularly with moderate values of high shrub cover (2-10 m tall);
- increasing volume of CWD, increasing number of pieces of CWD and larger pieces of CWD;
- warm aspects and gentle to moderate slopes, and
- mature and old structural riparian habitats.

In contrast, fisher habitat selection is negatively associated with non-forested habitats including non-vegetated areas, herb and shrub ecosystems and areas that have been recently logged (0-12 years).

Riparian and other moist, rich site series are integral components of the home ranges of fishers (Badry 2004). These forests tend to provide the structural complexity and high levels of coarse woody debris associated with high quality fisher habitat, in addition to providing large, old trees specifically used for birthing and rearing. Additionally, corridors among riparian and upland or riparian to riparian habitat areas are key requirements to allow movement among variable patch types within the home range of an individual (Badry 2004, Weir and Almuedo 2010).

3.6.3.3 Birthing

Reproductive dens are a critical habitat feature for female fishers. In B.C. fishers generally give birth between mid-March and early April (Hatler *et al.* 2008); reproductive dens must provide shelter for the female and her young from adverse weather conditions in the early spring and protection from potential predators. The reproductive den will be used for up to three months during the rearing period, although females will occasionally use up to three different den trees during this period (Weir and Corbould 2008). Females may re-use the same den in successive years (Weir and Almuedo 2010).

In B.C., reproductive dens are found exclusively within the cavities of trees (Lofroth *et al.* 2011); the majority of these trees are live, but declining due to disease or decay (Weir and Almuedo 2010). Researchers in B.C. have found that denning trees must meet very specific criteria: the tree needs to have some form of damage to the trunk (typically through frost cracks, burn scars, or large branches pulling out from the trunk) which provides access for decay organisms to the interior of the tree, this damage must be of particular dimensions to allow the female access to the interior of the tree while restricting access to larger predators, and the tree must be large enough to accommodate an interior cavity >30 cm in diameter (Weir and Corbould 2008, Lofroth *et al.* 2011, Weir *et al.* 2012). Studies in northern B.C. have found reproductive dens exclusively in trembling aspen (*Populus tremuloides*), balsam poplar trees (*Populus balsamifera* spp. *trichocarpa*), and black cottonwood (*Populus balsamifera* spp. *balsamifera)* (Weir and Corbould 2008, Weir *et al.* 2012), although use of lodgepole pine (*Pinus contorta*) and Douglas-fir (*Pseudotsuga menziesii*) has been documented in other regions of the province (Davis 2009). Dens are generally found in trees which are large relative to the surrounding stand – in the Williston region (Weir and Corbould 2008), den trees averaged 109 cm diameter at breast height (dbh) (black cottonwood), while in the Peace Region (Weir *et al.* 2012), den trees averaged 50 cm dbh (aspen) and 58 cm dbh (balsam poplar). At the broader scale, Weir *et al.* (2012) found that fisher dens in the Peace Region were most likely to be located in sites with a high mean dbh of aspen or balsam poplar trees, high vertical diversity index (i.e. high percent cover of the various layers of woody plants – tree, high shrub, low shrub) and little to no hard CWD. Dens were also more likely to be found within the center of a female's non-denning home range than on the periphery, and were found in a variety of ecosystem types but predominantly in young or mature deciduous-dominated forests on mesic or moist sites. Specific cavity tree requirements for the most commonly used zones which are found within the RSA are shown in Table 16.

Table 16. Key structural habitat requirements of fishers (adapted from Weir and Almuedo 2010).

Activity	BEC Zone	Habitat Characteristic
Resting, Security, Thermal Cover	SBS	• Rust brooms (≥40cm diameter) on hybrid spruce (≥40cm dbh) • Cavities (trunk rot) and large branches of aspen (*Populus tremuloides*) (≥50cm dbh) • Black cottonwood with internal decay (≥75cm dbh) • CWD (≥35 cm diameter, decay class 2-3, ≥10cm long), elevated from ground
	BWBS	• White (≥30cm dbh) and black spruce (≥20cm dbh) with rust brooms • Aspen (≥40 cm dbh) and balsam poplar (≥45cm dbh) with internal decay • Slash/debris piles (> 20m3)
Denning	SBS	• Black cottonwood (≥90cm dbh)
	BWBS	• Trembling aspen (≥40cm dbh) • Balsam poplar (≥50cm dbh)

Table 17. Quantifiable ecosystem attributes for fisher (modified from Saxena and Bilyk 2000).

Season	Life Requisite	Ecosystem Attributes
All	LI	• Found in low- to mid-elevation forested habitat – BWBS, SBS and lower elevation ESSF will be the primary biogeoclimatic zones • Structural stages 5 to 7 preferred, although structural stages 3 and 4 may also be used; structural stages 5 to 7 assumed to provide abundant resting sites • Avoidance of structural stages 1 and 2. • Gentle to moderate slopes • Coniferous or mixed coniferous-deciduous forests • Canopy closure between 30-60% • Multistoried canopy with a diversity of species is preferred • Abundant CWD and productive shrub layer provide foraging opportunities and abundant prey • Riparian and edge habitat typically provide abundant prey sources
Spring	BI	• Require large-diameter deciduous trees with interior cavities – species include trembling aspen, black cottonwood and balsam poplar • Suitable denning trees are often found along valley bottoms and riparian areas – BWBS and SBS will be the primary biogeoclimatic zones • Large diameter trees are expected to be most prevalent within structural stages 5 to 7 • Feeding, security/thermal, and resting habitats will be the same as above – selection for closed canopy forest with a diverse understory, CWD, gentle to moderate slopes etc.

3.6.4 Ratings

As there is a substantial level of knowledge on the habitat requirements of fisher in the RSA a 6-class rating scheme was used.

3.6.5 Living – All Seasons Habitat Suitability

The following describes the fisher living all seasons habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 15) followed by assumptions used to create the model and a description of the functioning of the model.

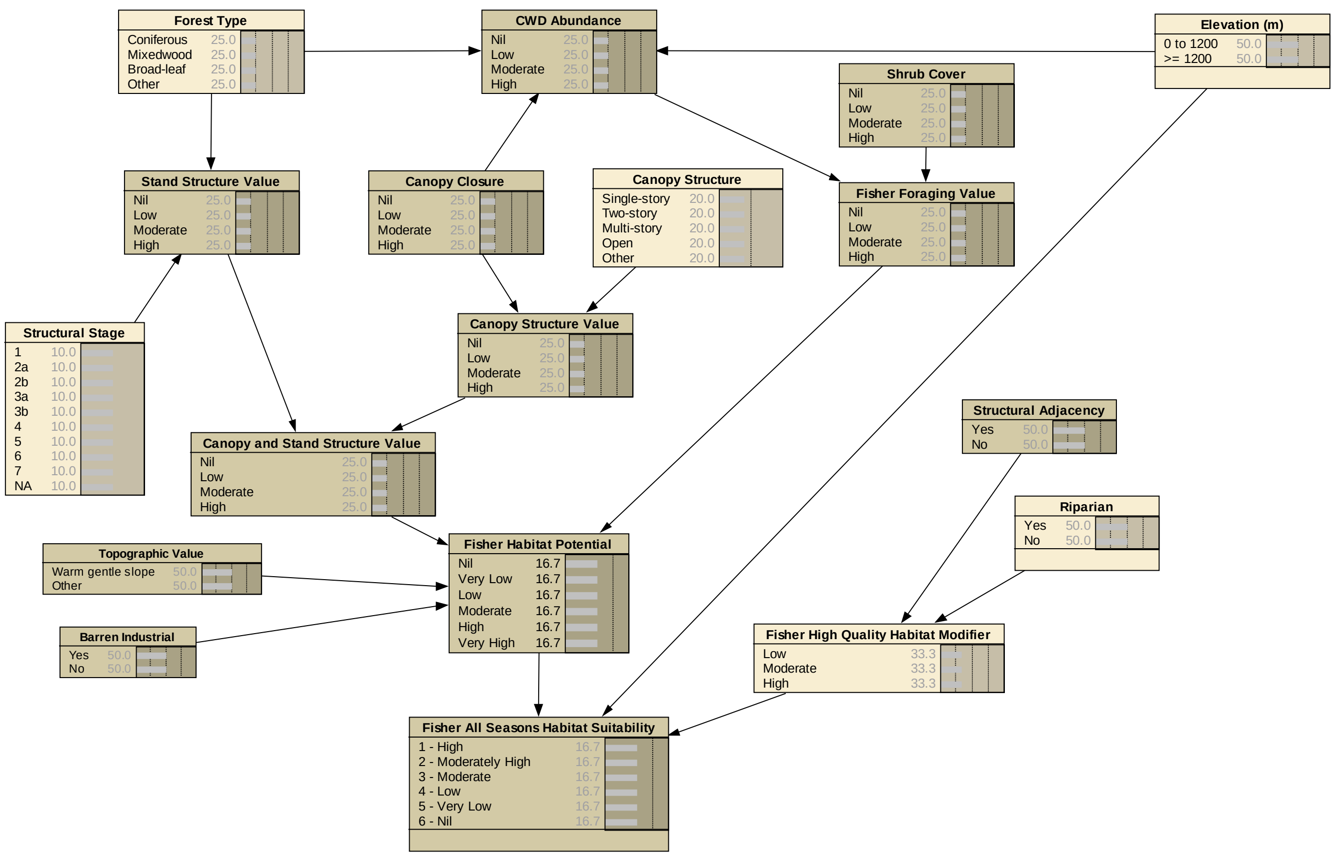

Figure 15. **Species model for Fisher All Seasons Living Habitat Suitability.**

3.6.5.1 Model Assumptions

1. Riparian habitats and areas in which a combination of mature structural stages (for shelter/resting sites) and shrubby structural stages (for foraging) are present are preferred.

2. Fisher are found in low- to mid-elevation forested habitat – mostly below 1000 m, in very low numbers above 1200 m and in low transitional numbers between these elevations.

3. Foraging opportunities increase with increasing shrub cover and CWD abundance due to higher prey abundance.

4. Higher canopy closures are preferred. As are more complex canopy structures with multistoried structures preferred over two-storied and single-storied/irregular canopies (respectively).

5. Coniferous and mixed forests are preferred over broadleaf forests.

6. Structural stages 5 to 7 are preferred over stages 3 and 4 due to abundant resting sites, while structural stages 1 and 2 are avoided.

7. Warm aspects on gentle slopes (<30 degrees) are preferred.

3.6.5.2 Model Description

1. Stand Structure Value

   - In coniferous and mixed forest types, Stand Structure Value increased with increasing structural stage. Structural stage 2a and 2b were assigned Low value, 3a/3b/4 Moderate value and structural stages 5 – 7 High value. Broadleaf forests were assigned Low Stand Structure Value, regardless of structural stage. Non-vegetated structural stages had no Stand Structure Value.

2. CWD Abundance

   - CWD Abundance was a surrogate-variable derived node. More information on its assumptions development and can be found in Appendix D.

   - CWD Abundance was considered Nil at sites without canopy closure. Generally, CWD Abundance increased with canopy closure, was higher for coniferous and mixed forest types than broadleaf forests and at lower elevations (<1200 m). CWD Abundance was rated higher in lower elevations (<1200 m) where canopy closure was low or moderate in coniferous or mixed forests compared to higher elevations (>1200 m).

3. Canopy Structure Value

   - Canopy Structure Value took into account amount of closer and complexity in structure. A high Canopy Structure Value was assigned when canopy closure was high and structure was multistoried. A moderate Canopy Structure Value was assigned when canopy closure was moderate and structure was multistoried or when canopy closure was high and structure was two-storied. . When canopy closure was Low (and with any stand structure type), when canopy closure was moderate (stand structure single- or two-storied, irregular or not applicable) or when canopy closure was high (stand structure single-storied, irregular or not applicable) Canopy Structure Value was also Low. Sites with no canopy closure were considered to have no canopy structure value

4. Fisher Foraging Value

    - Fisher Foraging Value was the average of CWD abundance and shrub cover.

5. Canopy and Stand Structure Value

    - Canopy and Stand Structure Value was generally the average of Stand Structure and Canopy Structure values with the exception of when Stand Structure is high, in which case, Canopy and Stand Structure value was also high. Canopy and Stand Structure value was nil if Stand Structure or Canopy Structure was nil.

6. Fisher Habitat Potential

    - Fisher Habitat Potential generally increased with Fisher Foraging Value and Canopy & Stand Structure Value. Habitat potential was higher on gentle slopes (<30 degrees) with warm aspects. Barren industrial sites had no habitat potential.

7. Fisher High Quality Habitat Modifier

    - The high quality habitat modifier was assigned a high value if a site had both structural adjacency and riparian habitat. The modifier had a moderate value if only one of these features was present. It had a low value for sites with neither structural adjacency nor riparian habitat.

8. Fisher All Seasons Habitat Suitability

    - Habitat suitability was considered Very Low if habitat potential was Very Low or Nil. Low elevation sites (<1000 m) had higher suitability values than similar high elevation sites (1000 – 1200 m and >=1200 m). All sites above 1200 m had Very Low habitat suitability values. Habitat suitability values increased with increasing habitat potential and moderate and high values of the Fisher High Quality Habitat Modifier (i.e. if sites were within riparian areas and/or areas displaying structural adjacency).

3.6.6 Birthing Habitat Suitability

The following describes the fisher birthing habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 16) followed by assumptions used to create the model and a description of the functioning of the model.

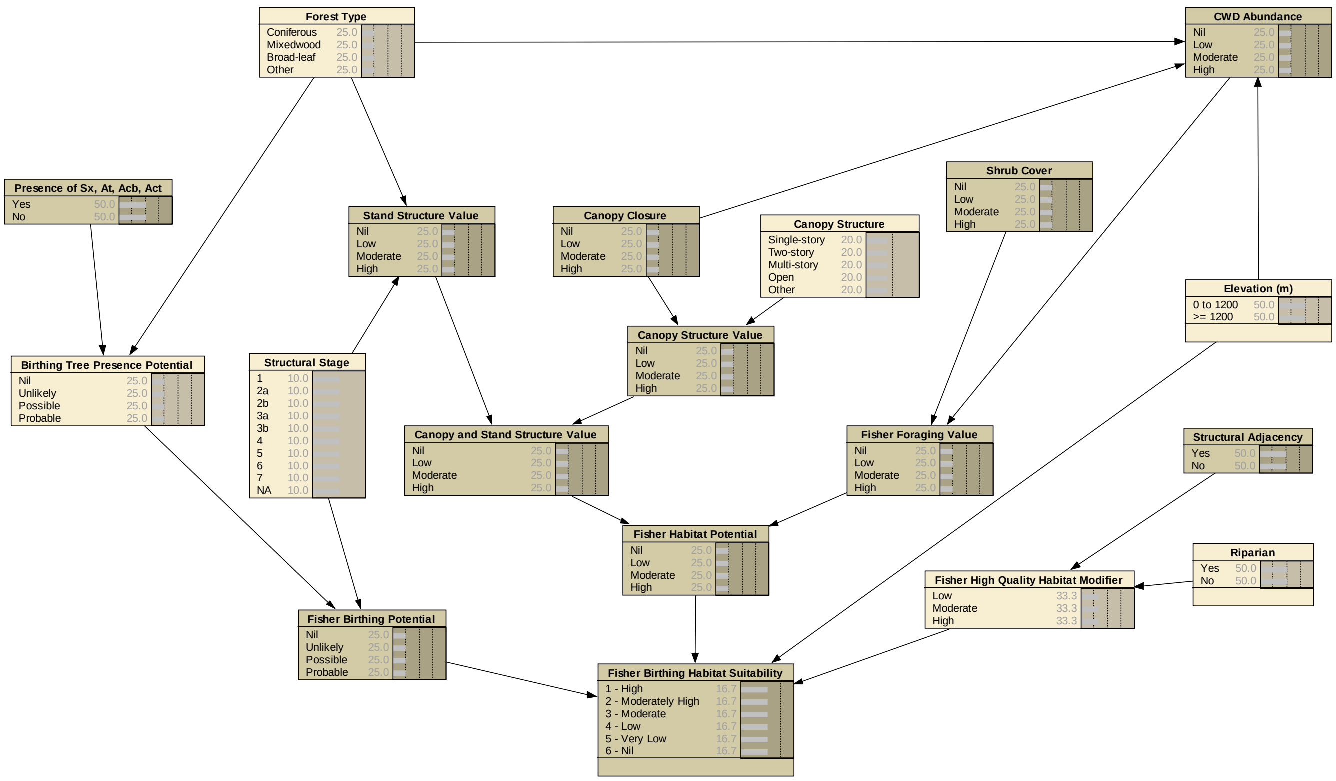

Figure 16. **Species model for Fisher Birthing Habitat Suitability.**

3.6.6.1 Model Assumptions

Model assumptions used in the Fisher Living – All Seasons Habitat Suitability model also apply to the Birthing Habitat Suitability model. Additional assumptions used in the birthing model are listed following:

1. Selection of habitat for birthing will be the same as selection of habitat for general living (i.e. All Seasons) but with an added element, that is, the presence of a tree suitable for a birthing den.

2. Trees capable of supporting a suitable birthing den must be large-diameter deciduous trees with interior cavities. These species include trembling aspen, black cottonwood and balsam poplar.

3. Large diameter trees are expected to be most prevalent within structural stages 5 to 7.

3.6.6.2 Model Description

The Birthing Habitat Suitability model functions as described in the Fisher Living – All Seasons Habitat Suitability model, but with additional nodes to explain birthing habitat potential. These additional nodes are listed following:

1. Fisher Habitat Potential

    - Fisher Habitat Potential was generally the average of Fisher Foraging Value and Canopy & Stand Structure Value. If foraging value or canopy & stand structure were nil then Habitat Potential was also nil.

    - Unlike the All Seasons model, this node did not take barren industrial and topographic value into account as birthing tree presence potential inherently assesses for the potential of trees (which are lacked by barren industrial). It was assumed that warm aspects on gentle slopes were less important than the presence of birthing trees to Habitat Potential and thus also absent from this model.

2. Birthing Tree Presence Potential

    - Birthing Tree Presence Potential was probable or possible in broadleaf forests depending on the presence or absence (respectively) of Sx, At, Acb, or Act. In coniferous and mixed forest types birthing tree presence potential was probable or unlikely depending on the presence or absence (respectively) of Sx, At, Acb, or Act. Non-forested areas had no birthing tree presence potential.

3. Fisher Birthing Potential

    - Fisher Birthing Potential was Nil in non-mature structural stages (i.e. <5). Birthing potential was higher for structural stages 6 and 7 than structural stage 5 and increased with Birthing Tree Presence Potential.

4. Fisher Birthing Habitat Suitability

    - Habitat Suitability was nil only when Habitat Potential was nil. When birthing potential was nil Habitat Suitability was Very Low. High elevation sites (>=1200 m) were rated Very Low. Habitat Suitability increased with Fisher Birthing Potential, Fisher Habitat Potential and Fisher High Quality Habitat Modifier.

3.7 ELK

3.7.1 Distribution

Elk (*Cervus elaphus*) once ranged from the Pacific to Atlantic coasts and from Mexico north to Canada, making it the most widely distributed member of the North American deer family (Shackleton 1999). In the early 1880's, elk were extirpated from eastern North America. In western North America, populations were dramatically reduced by market hunting, habitat loss, and severe winters (Shackleton 1999). By 1900, the original North American population of several million elk fell to provincial lows, with under an estimated 100,000 individuals (MOE 2000).

Currently, elk are found only in western North America where four sub-species are recognized: the Rocky Mountain elk (*Cervus elaphus nelsoni*); Roosevelt elk (*C. c. roosevelti*); Manitoba elk (*C. c. manitobensis*); and Tule elk (*C. c. nannodes*). Only Roosevelt elk and Rocky Mountain elk can be found in British Columbia. Roosevelt elk are found only on Vancouver Island and some watersheds in southwestern British Columbia (Quayle and Brunt 2003). Rocky Mountain Elk are considerably more abundant and are found in all of the ecoprovinces in British Columbia except the Coast and Mountains, Georgia Depression, Central Interior, and the Taiga Plains (Arthur 2003). During the 1900's, a combination of factors, including population management, milder winters and an increase in early seral forage areas resulting from fires and forest harvesting, have resulted in elk range expansion and population growth (Hengeveld and Wood 2001). Rocky Mountain Elk are mainly distributed across the south-central, the southeast and northeast regions of the province (Shackleton 1999; Arthur 2003).

The greatest number of Rocky Mountain Elk occurs along the western side of the Rocky Mountains from the Canada-USA border to the Kicking Horse River valley and west to the Kootenay Valley (Arthur 2003). Native populations also occur in the Omineca-Peace region of the province (MOE 2000). The largest distribution area in BC is in the Peace River region (Shackleton 1999). The elk population in the Peace-Liard region is mostly sparse, although there are some areas with higher densities including the Murray River. In the Peace-Liard region, the number of elk have increased at least threefold since the 1970's, likely due in part to extensive prescribed burning that has created favourable habitat for elk (Shackleton 1999). Approximately 6,200 Rocky Mountain elk currently reside in northern BC, including the Peace-Liard and Omineca regions (Hengeveld and Wood 2001).

Elk usually live in mountainous areas, although they do not necessarily need steep landscapes (MOE 2000). They can tolerate a range of climates, but they usually keep to regions where the snow remains shallow on winter ranges. Rocky Mountain Elk are often more migratory than the coastal Roosevelt subspecies, although migration distances between summer and winter ranges amongst Rocky Mountain Elk can vary widely (MOE 2000). Seasonal elevational movements and habitat use patterns by elk are a response to variable environmental conditions, particularly availability of palatable forage in the spring and summer and snow accumulation in the fall (Boyce 1991; Backmeyer 2000). Many populations migrate elevationally, ranging from valley bottom to high elevation habitats (Boyce 1991).

3.7.2 Threats and Status

Rocky Mountain elk is not a listed species by COSEWIC and is globally assessed as widespread, abundant and secure (Table 18; BC CDC 2012). In B.C., it is yellow-listed or not at risk and is not an identified wildlife species. There are no designated ungulate winter ranges for elk within the Regional Study Area; although, there is an UWR (U-9-001, SPE-023) for elk, mule deer and moose near the RSA north of Bullmoose Creek. Bullmoose Creek enters the Wolverine River north of the RSA.

Elk was selected as one of the seven species for habitat suitability ratings due to its socioeconomic value to the region through subsistence and recreational hunting. No population estimates are available for elk within the study area. However, elk have been increasing in numbers throughout the region (Goddard 2003). Some of these population increases can be attributed to prescribed burns, with burning programs having been implemented in the Williston Lake and Muskwa River areas. (Gillingham and Parker 2008; Backmeyer 2000; MOE 2000).

Threats to elk populations come from both natural and human-caused sources. Common natural threats that can have significant effects on elk populations include winter weather severity, predation and disease (MOE 2000). Winter snow conditions, and subsequently winter forage availability, are frequently reported as the primary limiting factors for elk (Goddard 2003; Skovlin 1982; MOE 2000). Wolves, cougars and bears are the main predators of elk in British Columbia (MOE 2000). Although predation can reduce the numbers of elk, over the long term the rate of reproduction is usually sufficient to maintain populations (MOE 2000). While elk are host to a wide range of parasites, bacteria and viruses, these pathogens usually only cause disease or death when the animals are severely stressed by malnutrition (MOE 2000; Shackleton 1999).

Human-related causes to elk deaths include hunting, highway and railway accidents, and conflicts with agriculturalists. Of these, the most common human-caused threat to elk is hunting (MOE 2000; Webb *et al.* 2011; McCorquodale *et al.* 2003). Predation from hunting may be a larger direct source of mortality than other human causes (Quayle and Brunt 2003) and may also have indirect impacts by causing elk to avoid high-quality habitat, thereby lowering the proportion of graminoids in their diet (Christianson and Creel 2007).

Industrial activity and land development can have both positive and negative effects on elk and their habitat (MOE 2000; Goddard 2003; Gillingham and Parker 2008). For example, logging creates early seral forests that provide good forage, but as regeneration closes the canopy, suitable forage species decline in cover. Similarly, cattle grazing can degrade some elk winter range (MOE 2000), but has also been used successfully to improve winter range forage quality (Anderson and Scherzinger 1975).

The expansion of resource roads and other linear corridors associated with development is frequently noted as a primary threat to elk. Shifts in elk distribution away from roads used by motorized vehicles have been well documented (e.g. Rowland *et al.* 2000; Ager *et al.* 2003; Gagnon *et al.* 2007). Increased road densities and access can lead to increased human disturbance and hunting pressure (Webb *et al.* 2011; McCorquodale *et al.* 2003). Human activities such as recreation and traffic can also be a stressor if it disturbs elk by displacing animals to less suitable habitats, altering migration timing or changing their diets (Cassirer *et al.* 1992; Millspaugh *et al.* 2001; Phillips and Allredge 2002; Wisdom *et al.* 2004; Naylor *et al.* 2009; Rogala *et al.* 2011). However, elk have been shown to habituate to predictable and harmless human activity (e.g. Thompson and Henderson 1998; Walter *et al.* 2006).

Table 18. Status of elk (*Cervus elaphus*) (BC CDC 2012).

Species Code	M-CEEL
Provincial Status	S5 – demonstrably widespread, abundant, and secure
B.C. List	Yellow
Identified Wildlife (Y/N)	N
COSEWIC Status	N/A
Global Status	G5 = demonstrably widespread, abundant, and secure

3.7.3 Habitat Requirements

3.7.3.1 Introduction

To meet the objectives of this study, elk habitat was assessed for the generalized life requisite "living" at a two-season level. This was appropriate given the level of information on the species requirements within the RSA and the degree to which elk habitat for various life requisites can be separated. The living requisite primarily depends on security/thermal requirements and forage. Habitat selection by elk in all seasons is a balance between the presence of suitable forage with cover and other influences such as predation, human activities and snow cover (Goddard 2003; MOE 2000). In this study, we assessed the living requisite in two seasons: winter and growing.

Winter habitat is the most critical to elk as seasonal conditions have an increasing impact on their survivorship (Arthur 2003). During winter, forage is scarce and of poor quality, snow restricts movement and energetic demands are high (Arthur 2003). Winter forage is not only critical to individual's survivorship, but also for reproduction. The key factor in reproductive success is the nutritional condition of the cow (Quayle and Brunt 2003). Access to high-quality winter browse improves pregnancy rates (Trainer 1971) and improves the chances of calf survival (Thorne *et al.* 1976).

Elk are classified as grazers, although their food selection is general and flexible depending on food availability (Gillingham and Parker 2008; Goddard 2003). Elk generally feed on grasses and other non-woody vegetation, but will utilize browse if required (Goddard 2003). As general herbivores, the types of forage utilized are diverse, and the relative importance of forages varies with subspecies of elk, season and herd. Rocky Mountain Elk consume a variety of grasses, sedges and forbs, as well as shrubs (Goddard 2003). Grasses and sedges are important winter food items for elk. In addition to the herb layer, shrubs are used, including Saskatoon, willow, twinberry, red-osier dogwood, rose, and aspen (Arthur 2003).

Rocky Mountain Elk often migrate seasonally, seeking newly-emergent herbaceous vegetation to forage on. During the summer, elk will often migrate to subalpine and alpine basins and avalanche tracks, which support lush herbaceous vegetation (MOE 2000). Given the opportunity, elk also forage on cultivated crops such as alfalfa and clover (MOE 2000). Rocky Mountain Elk prefer foraging in a mix of open grasslands and shrublands, or in open mixed conifer and deciduous forests. Preferred areas are often in the early stages of succession (structural stages 2 and 3), particularly following a fire, or in young cut-blocks following logging (Shackleton 1999). They also prefer forested habitats (generally structural stages 6 and 7 but also sometimes 5) for resting because they offer cover from predators and adverse weather conditions (Shackleton 1999).

3.7.3.2 Winter

Winter habitat use by elk is determined by forage availability, quantity and quality, snow depths and potentially the amount of disturbance (Goddard 2003). Typically, winter range consists of grasslands and early seral shrublands on low elevation, moderately sloping terrain with medium to dense forest thermal cover (Goddard 2003; Arthur 2003). Riparian areas are also a common winter habitat (Arthur 2003). In northeastern British Columbia, elk frequently prefer south-facing, seral brushfields or wind-swept, grass-dominated slopes during winter, except when deep or crusted snow causes them to seek timber (Hengeveld and Wood 2001; Gillingham and Parker 2008). Elk movements begin to be limited by snow depths greater than 40-50 cm (Irwin and Peek 1983). Periods of deep snow (greater than 40 cm) result in elk moving to habitats of high forage availability and low snow cover such as south-facing slopes (Irwin and Peek 1983). Snow depth limits forage availability in winter and can result in shifts in feeding behavior. At depths greater than 61 cm, elk have been observed switching from grazing on herbaceous vegetation to browsing on shrubs and trees (Skovlin 1982). Slopes used during the winter tend to be less than 18% (Arthur 2003).

In northeastern British Columbia, elk have been found to winter predominantly in post-fire grass and shrub communities, except during severe weather when conifer stands were used (Peck and Peek 1991). Forest edges and riparian vegetation associated with post-fire succession or logging may also provide high rated habitat to meet both forage and cover requirements of elk. In the Hart Foothills of the Peace Region, Goddard (2003) reports that south-aspect river-breaks along the Pine, Moberly, Murray and Wapiti Rivers provide excellent winter habitat for elk. In the Peace Foothills, along the north shore of the Peace Arm of Williston Lake, key winter range is along south aspects, with gentle slopes and generally below 1000 m elevation (Hengeveld and Wood 2001).

Studies in the Peace region have suggested that winter diets are largely determined by the habitat and what is available for forage (Goddard 2003). For example, in the Peace Arm during the winter, elk have been found to forage predominantly on grasses and, to a lesser extent, shrubs in aspen-grassland habitats. Forage species included *Elymus innovatus*, *Oryzopsis* spp., *Calamagrostis canadensis* and *Salix* spp (Corbould 1998). In contrast, elk in the Ospika River, also within the Peace region, were found to have winter diets dominated by lichens, with graminoids comprising a much smaller part of their diet (Corbould 1998). Habitats in this area were dominated by conifers with a lower percentage of grassland area. While grass and shrub-land habitats are preferred, elk can utilize an array of habitats for feeding.

Elk generally forage within 200 m of cover (Arthur 2003). Cover is used for security from predators and shelter from adverse thermal conditions. The degree to which elk require winter thermal cover varies with climatic conditions, particularly temperature and snow depths. Research supports that elk seek thermal protection from low temperatures in conifer stands with high canopy cover (Mowat 1999; Skovlin 1982). In winters characterized by very deep snow, thermal cover requirements are met by coniferous stands with trees a minimum height of 10-12 m and an average canopy closure exceeding 70% (Arthur 2003; Skovlin 1982). Stands ideal for winter thermal cover are a minimum of 4 ha in size (Arthur 2003).

Quantifiable ecosystem attributes used by this study are presented in Table 19.

3.7.3.3 Growing Season

As with the winter season, the optimal elk habitat during the growing season consists of open forage-producing sites interspersed with forested areas or other geomorphic features which provide security and thermal cover. During the summer, however, elk tend to utilize a broader variety of habitats (Peck and Peek 1991). In the growing season, elk typically prefer early successional stages, including grasslands, parkland, avalanche tracks, clear-cuts, burns, roadsides and forest openings (MOE 2000). Grasses and sedges are eaten extensively, as are broad-leaved herbaceous plants. Browse (i.e. twigs, bark and leaves from shrubs and trees) may be an important part of the summer and fall diet, depending on the availability of grasses and forbs (Christianson and Creel 2007; Arthur 2003).

Elk are often migratory, with movements being primarily a function of vegetation availability rather than snow depth. In the spring, elk often utilize valley bottom floodplains and drainages with fertile soils and high forage productivity and diversity, particularly for early spring green-up forage (Skovlin 1982; MOE 2000). In the summer, most Rocky Mountain Elk tend to migrate to areas with later green-up, particularly subalpine areas (Gillingham and Parker 2008), but also north-facing slopes, alpine basins and avalanche tracks, which support lush herbaceous vegetation (MOE 2000). Structural stages utilized for feeding during the growing season typically are 2 and 3, with some 6 and 7 where the understory is well-developed. Quantifiable ecosystem attributes used by this study are presented in Table 19.

Table 19. Quantifiable ecosystem attributes for elk.

Season	Life Requisite	Component	Ecosystem Attributes
Winter	LI	Feeding	• South-aspect • Gentle slopes • Early to mid seral stage areas, particularly burns and cutblocks, and mature stands with herbaceous understory – Structural stages 2, 3 and 6 and 7 • Riparian areas and river breaks are preferable. Other areas include agricultural areas and wetlands. • Below 1000 m in elevation • winter forage species: grasses (e.g. *Elymus innovatus*, *Calamagrostis canadensis*, *Oryzopsis* spp.), willow, Saskatoon, rose and other shrubs. In wetlands, also feed on sedges and horsetail.
		Security/ Thermal	• Coniferous-dominated forest stands • Trees greater than 10 m in height • Canopy closure of greater than 70% • Structural stages 4 to 7
Growing	LI	Feeding	• Begin season at low elevation valley-bottom and low to mid elevation forest stands in early to mid-seral stage, riparian and alluvial areas, burns, cutblocks and wetlands. • Summer feeding often takes place on north-facing slopes, subalpine and alpine basins and avalanche tracks, taking advantage of later green-up • Increased use of high elevations (i.e. ESSF, BAFA) compared to winter season • Structural stages utilized for feeding during growing season range from 2 to 7, although preference for 2 and 3, and 6 and 7 if there is suitable herbaceous cover in the understory • Grasses, sedges and forbs are eaten extensively • Will forage in cultivated fields on crops such as alfalfa and clover
		Security/ Thermal	• Coniferous or coniferous-dominated forest stands • Forest stand more than 3 m tall and 100 m wide • Structural stages 4 to 7

3.7.4 Ratings

As there is a substantial level of knowledge on the habitat requirements of elk in the RSA a 6-class rating scheme was used.

The winter season provincial benchmark for elk is the Boreal White Spruce-Trembling Aspen (BA/1) broad ecosystem unit of the moist cool subzone of the Spruce Willow Birch biogeoclimatic zone (SWBmk). This unit is within the Muskwa Foothills (MUF) ecosection of the Northern Boreal Mountains. The provincial benchmark is assigned a rating of "1" and provides a comparison against which habitats within the study area were rated (RIC 1999).

The growing season provincial benchmark for elk is the Subalpine Meadow (SM) seral stage of the moist cool subzone of the Spruce Willow Birch biogeoclimatic zone (SWBmk). This unit is within the Muskwa Foothills (MUF) ecosection of the Northern Boreal Mountains. The provincial benchmark is assigned a rating of "1" and provides a comparison against which habitats within the study area were rated (RIC 1999).

3.7.5 Winter Habitat Suitability

The following describes the elk winter habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 17) followed by assumptions used to create the model and a description of the functioning of the model.

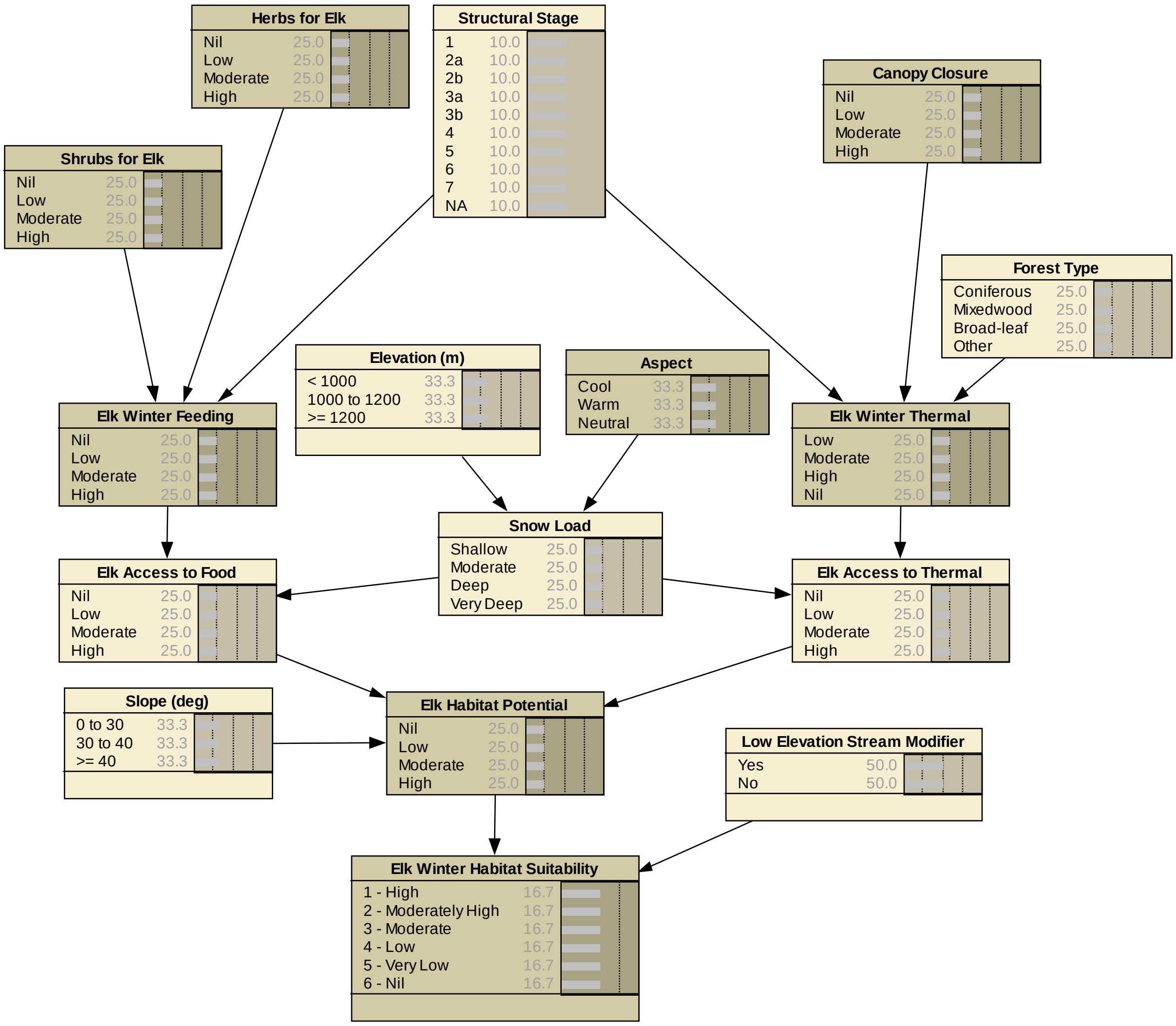

Figure 17. **Species model for Elk Winter Living Habitat Suitability.**

3.7.5.1 Model Assumptions

1. Snow load impairs access to food and thermal/security elements. Snow depths were assumed to increase with elevation and be higher in areas of cooler and neutral aspects (respectively) than warmer aspects.

2. Elk winter forage is variable and largely determined by the habitat and what is available. Both herbs and shrubs will be consumed, with herbs preferred over shrubs.

3. Very deep snow completely restricts elk access to food and thermal cover, while shallow snow does not restrict access. Intermediate snow depths increasingly restrict access as snow depths increase.

4. Elk often require shelter from adverse thermal conditions or snow loads in the winter. In low temperatures and/or deep snow, thermal cover is sought out in the form of conifer stands with high canopy cover. Cover is also used for security from predators.

5. Elk prefer gentle slopes. Slope less than 30% was used as most ideal. Slopes of greater than 40% were assumed to be restrictive and therefore unused by elk. Note that these cut-off points were used in part because it was a common habitat predictor also used in other species models.

6. Riparian areas of streams are preferred.

3.7.5.2 Model Description

1. Snow Load

   - Sites above 1200 m in all aspects were assigned a very deep snow load rating. Sites of cool aspect below 1200 m were considered to have deep snow loads. Warm aspect sites in the elevational range of 1000 – 1200 m had moderate snow load as did neutral aspect sites below 1000 m. Sites with warm aspect at low elevation (below 1000 m) were given shallow snow loads.

2. Elk Winter Feeding

   - Elk Winter Feeding ratings increased with increasing ratings of herbs and shrubs available for elk. Generally, Elk Winter Feeding ratings were given average values of the herb and shrub ratings, with slightly higher weight placed on the herb rating when shrub ratings were low. In most instances, structural stages 2 through 7 were rated similarly, with the exception of non-vegetated structural stages (i.e. NA and 1) which were assigned nil Elk Winter Feeding Value.

3. Elk Access to Food & Elk Access to Thermal

   - Elk Access to Food and Thermal cover decreased with increasing snow load. Regardless of the Elk Winter Feeding and Thermal ratings, Very Deep snow loads were considered restrictive to Access to Food and Thermal and therefore were assigned Nil ratings. Shallow snow loads were considered non-restrictive and therefore sites maintained the Elk Winter Feeding or Winter Thermal rating assigned according to herb and shrub presence or forest type and canopy closure (respectively). Moderate and deep snow loads had decreasing values of Access to Food and Thermal.

4. Elk Winter Thermal

   - Winter Thermal was assigned nil ranking for broad-leaved forests, non-vegetated sites and for mixed and coniferous forests in young structural stages (i.e. <4). For older mixed and coniferous forests, Winter Thermal had increasing values with increasing canopy closure.

5. Elk Habitat Potential

   - Sites where slope was high (>=40%) or there was no access to food and thermal cover were assigned Nil habitat potential. Sites where slope was low (<30%) Habitat Potential values increased with increasing rankings of Access to Food and Access to Thermal, weighted slightly toward Access to Food as thermal cover is not required at all times in the winter. Sites of intermediate slope (30 – 40%) were downgraded slightly from those of low slope.

6. Elk Winter Habitat Suitability

   - Elk Winter Habitat Suitability ratings generally reflected the Habitat Potential for sites with elevations less than 1200 m. All sites at elevations greater than 1200 m were considered to have Very Low habitat suitability. Sites within the riparian area of a stream, below 1000 m elevation and with Low habitat potential had an upgraded habitat suitability rating compared to surrounding non-riparian areas. Sites of Moderate and High value habitat potential were not upgraded within riparian areas as they were already considered high value habitat.

3.7.6 Growing Season Habitat Suitability

The following describes the elk growing season habitat suitability model. A diagram of the Bayesian belief model outlining the habitat variables and ecological relationships is presented first (Figure 18) followed by assumptions used to create the model and a description of the functioning of the model.

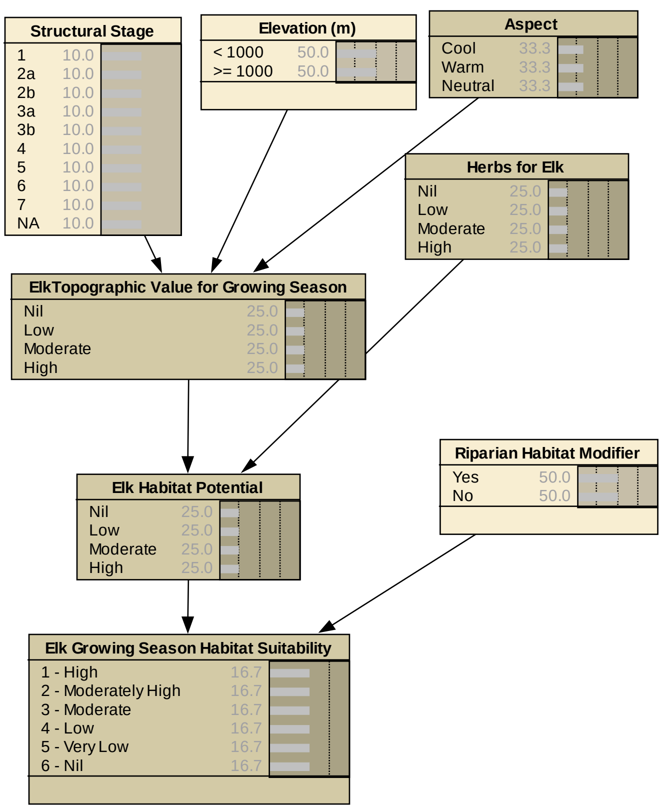

Figure 18. **Species model for Elk Growing Season Living Habitat Suitability.**

3.7.6.1 Model Assumptions

1. Elk avoid non-vegetated sites.
2. Herbs such as grasses, sedges and forbs are eaten extensively in the growing season.
3. Early to mid-seral stage (i.e. structural stage 2 and 3) areas such as riparian and alluvial areas, burns, cutblocks and wetlands are preferred for feeding on herbs. Structural stages 6 and 7 are also preferred if there is suitable herbaceous cover in the understory. Feeding can also occur in structural stages 4 and 5, although likely to a lesser degree.
4. Growing season feeding takes advantage of later green-up on cool aspects and high elevations (i.e. >1000 m).

3.7.6.2 Model Description

1. Elk Topographic Value for Growing Season
   - Sites at high elevation (>1000 m) and any aspect were assigned High topographic value if in structural stages 2 or 3, Low value if in structural stages 4 or 5 and Moderate value if in structural stages 6 or 7. Cool aspects below 1000 m were ranked similarly according to structural stage. Warm aspects below 1000 m were considered to have Low topographic value in all structural stages, while neutral aspects below 1000 m had intermediate rankings. Non-vegetated sites were considered to have no topographic value.
2. Elk Habitat Potential
   - Sites with no Herbs for Elk or Nil topographic value had no Elk Habitat Potential. Sites with Low topographic value had Low Habitat Potential, regardless of herb value. For all other sites, habitat potential was the average of forage herbs and topographic value.
3. Elk Growing Season Habitat Suitability
   - Elk Growing Season Habitat Suitability ratings generally reflected the Habitat Potential. Sites within the riparian area of a stream and with Low habitat potential had an upgraded habitat suitability rating (to Moderate) compared to surrounding non-riparian areas. Sites of Moderate and High value habitat potential were not upgraded within riparian areas as they were already considered high value habitat. Nil Habitat Potential was considered Very Low habitat suitability.

4 CONCLUSION AND RECOMMENDATIONS

Wildlife habitat suitability ratings have been developed within this study to measure the amount of habitat currently in the LSA for key wildlife species. Models were created to predict these ratings for a given life requisite of a given wildlife species. The models were produced using RISC standard Wildlife Habitat Ratings methods and were presented using Bayesian Belief Network diagrams. A total of 18 models were produced for seven different wildlife species including woodland caribou (Quintette LI-W, Quintette LI-G, Bearhole/Redwillow LI-W, Bearhole/Redwillow LI-G, General Woodland Caribou LI-W, General Woodland Caribou LI-G), Black-throated Green Warbler (RE), mountain goat (LI-W, LI-G), moose (LI-W, LI-G), grizzly bear (LI-P, LI-S, LI-F), fisher (LI-A, BI) and elk (LI-W, LI-G). Ratings were applied to the LSA using ecosystem units delineated by Terrestrial Ecosystem Mapping and other available GIS data inputs. The ratings were then mapped over the LSA for each species and life requisite.

The models and ratings have been constructed with an approach that will allow reviewers to consider the ecological relationships within each model. The framework of models developed with visual network diagrams facilitates discussion of concepts among representatives of different disciplines and experience. Rationale for the inclusion and influence of habitat predictors is inherent in model design; therefore, expert opinion used to develop the models is easily identified within consultation and review forums. Refinements of the ratings according to area or species-specific knowledge are possible and can be completed within the model design.

The TEM used for modeling the LSA provides a more precise picture of ecosystem characteristics than the PEM used for modeling the RSA. Ratings resulting from the RSA study (EDI 2012) and the LSA study will not be interchangeable and the LSA ratings should be used exclusively for the LSA. The overall purpose of developing wildlife habitat ratings is to support effects analysis and mitigation planning. During the next steps, wildlife habitat suitability can be summarized by the amount of suitable habitats within the LSA, habitat uniqueness can be assessed considering the amount of habitat in the LSA versus the RSA, and scenarios for effects assessment can be applied (e.g. Table 20). Planning can ensue to minimize potential impacts to wildlife habitat by identifying appropriate mitigation techniques.

Table 20. Example output of Effects Analysis and Mitigation Planning.

Species & Life Requisite	Habitat Rating	Area within LSA	Area within RSA	Option A, Proportion of Area Impacted	Option B, Proportion of Area Impacted
Mountain Goat, LI-W	1				
	2				
	3				
	4				
	5				
	6				

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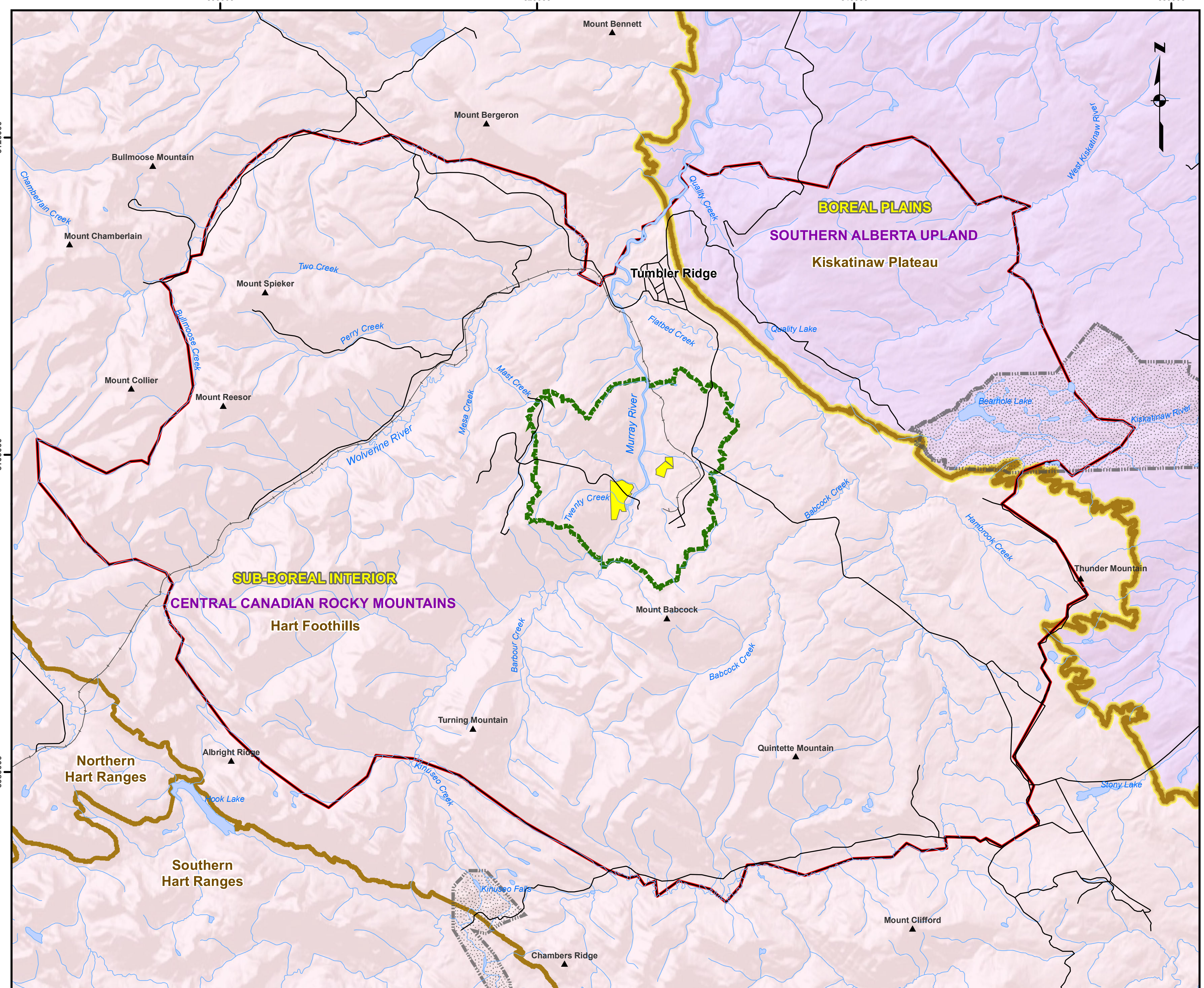
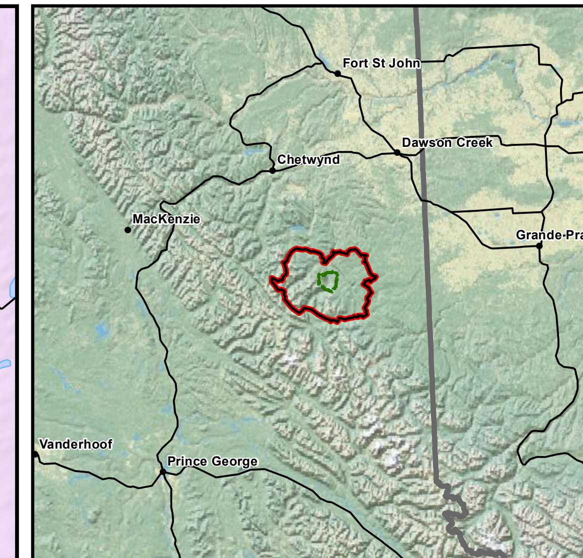
5.2 SPATIAL DATA DISCLAIMER

Maps presented in this document are a geographical representation of known features. Although the data collected and presented herein has been obtained with the utmost attention to quality, this document is not an official land survey and should not be considered for spatial calculation. EDI Environmental Dynamics Inc. does not accept any liability for errors, omissions or inaccuracies in the data.

APPENDIX A MAPS





LEGEND

Regional Study Area
Local Study Area
Potential Mine Surface Development Areas

Ecosection
Hart Foothills
Kiskatinaw Plateau
Northern Hart Ranges
Southern Hart Ranges

Ecoregion
Central Canadian Rocky Mountains
Southern Alberta Upland

Ecoprovince
Boreal Plains
Sub-Boreal Interior

250K National Topographic Database Data
Mountains
Railway
Road
Stream
Waterbody
Parks and Protected Areas

0 2.5 5 10 Kilometers

Scale: 1:250,000

Original Map Size 11x17in

Murray River Project

Map 1. Wildlife Regional and Local Study Areas

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	13-P-0108
Date: 11/12/2013	Data Sources: Refer to References Section

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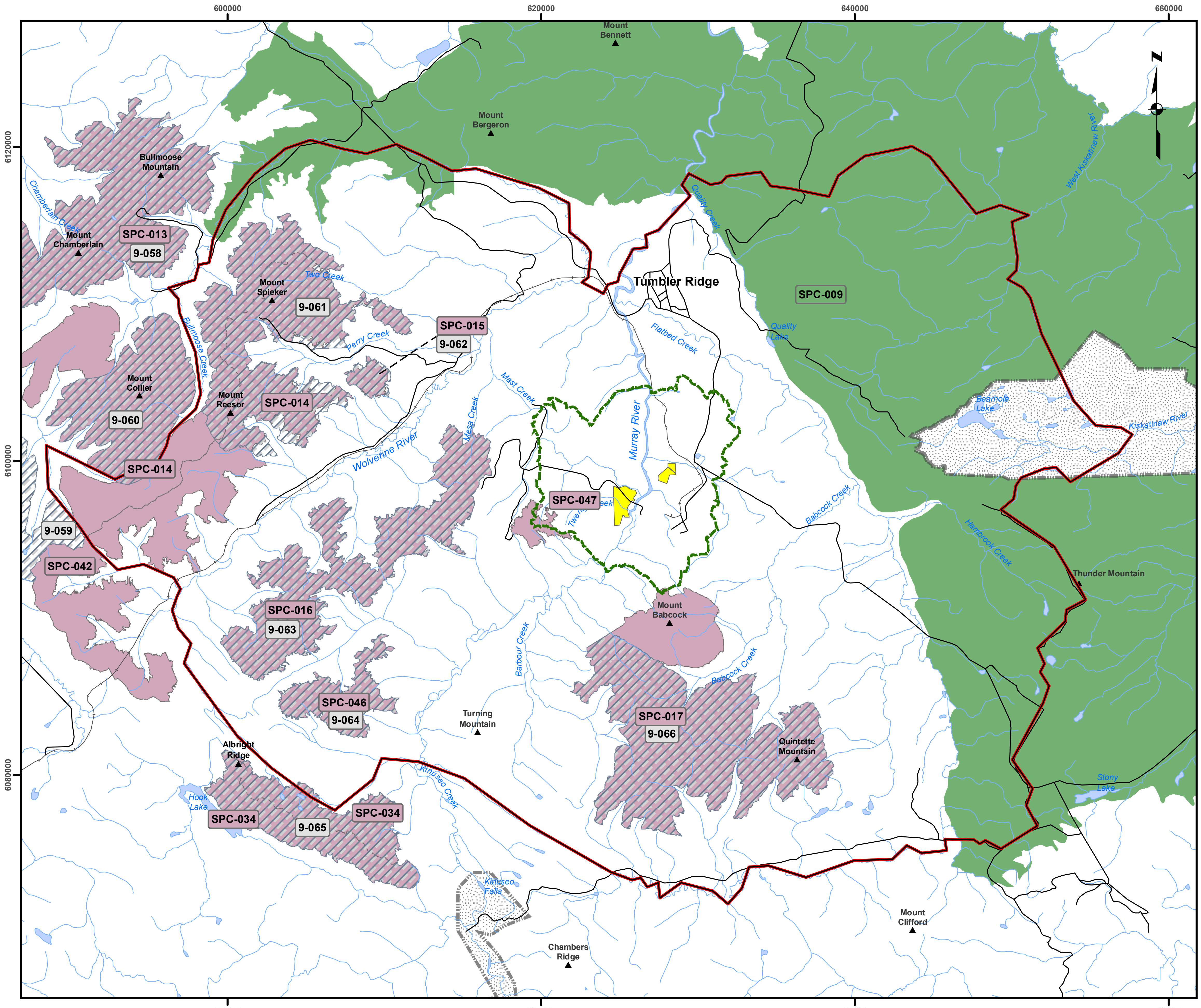

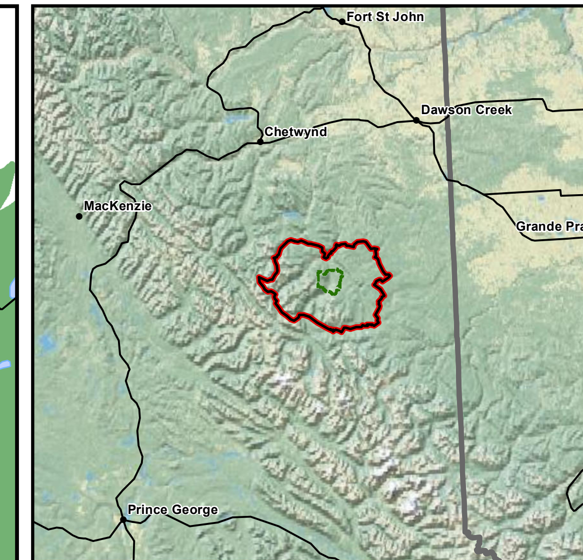

LEGEND

- Regional Study Area
- Local Study Area
- Potential Mine Surface Development Areas
- Parks and Protected Areas

Ungulate Winter Range

- Northern Caribou/Mountain Goat
- Northern Caribou

Wildlife Habitat Area

- Northern Caribou

UWR/WHA Labels

- SPC-015 Northern Caribou/Mountain Goat UWR
- SPC-009 Northern Caribou UWR
- 9-066 Northern Caribou WHA

250K National Topographic Database Data

- Mountains
- Railway
- Road
- Stream
- Waterbody

0 2.5 5 10 Kilometers

Scale: 1:250,000

Original Map Size 11x17in

Murray River Project

Map 2. UWRs and WHAs within and near Project RSA

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 13-P-0108
Date: 07/01/2014	Data Sources: Refer to References Section

EDI

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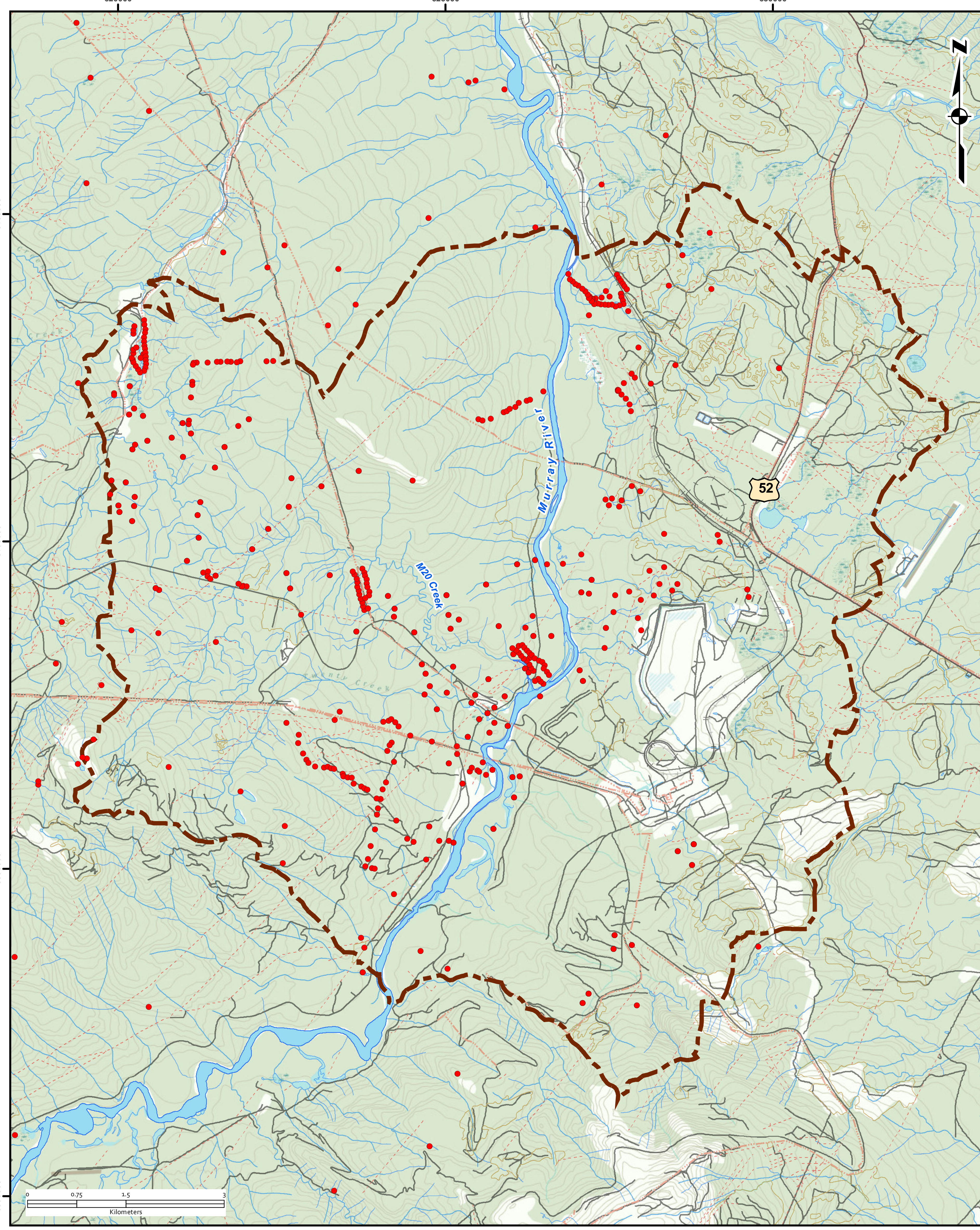


LEGEND

- Field Plots Completed Within the Regional and Local Study Areas (EDI, Rescan)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes
- Murray River
- Local Study Area

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

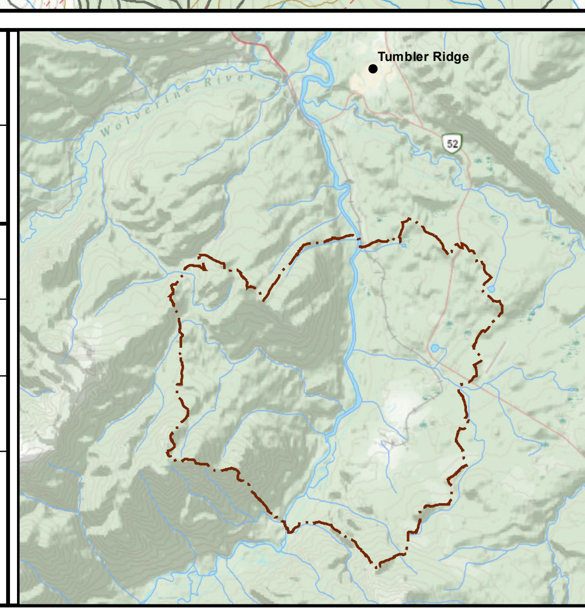
Scale: 1:60,000

Murray River Project

Map 3. Ecology and Wildlife Field Plots: 2010 to 2012

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 13-P-0108
Date: 11/12/2013	Data Sources: Refer to References Section

EDI



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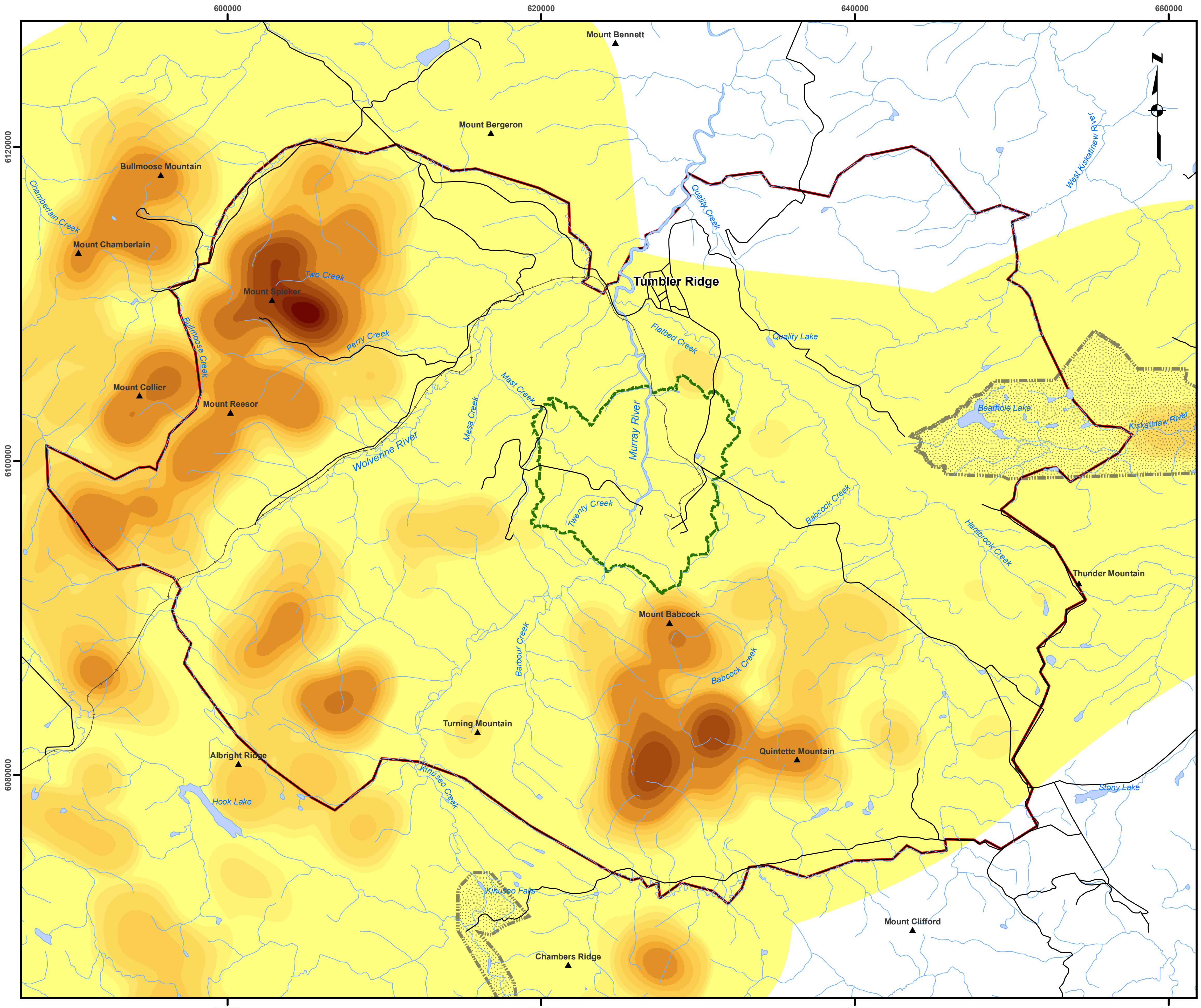

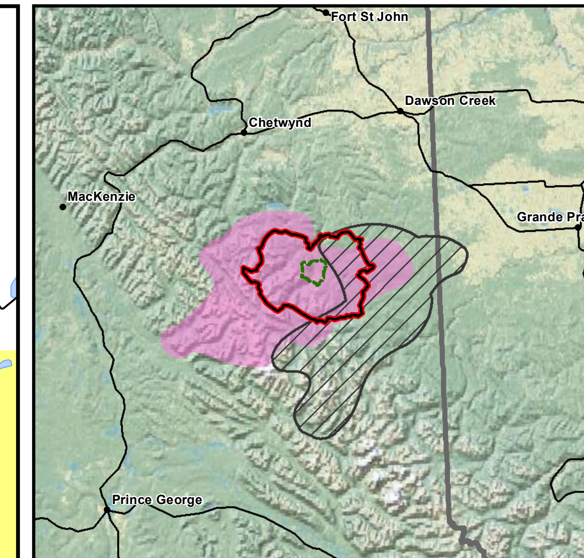

LEGEND

- Regional Study Area
- Local Study Area

Estimated Caribou Density

- Low
- High

250K National Topographic Database Data

- Mountains
- Railway
- Road
- Stream
- Waterbody

INSET LEGEND

- Estimated Quintette Caribou Herd Range
- Estimated Bearhole/Redwillow Caribou Herd Range

Note: Minimum convex polygons were created using ET GeoWizards (Build Convex Hull tool), a third party GIS extension for ArcGIS®, using Quintette and Bearhole/Redwillow telemetry data (2002-2011 and 2006-2010 respectively, South Peace Caribou Research Program) provided by the Ministry of Environment. Polygons were generalized (smoothed) for presentation. Density raster datasets were created using ArcGIS® extension, Spatial Analyst (Kernel Density Tool). The data was clipped by their respective minimum convex polygon.

0 2.5 5 10 Kilometers

Scale: 1:250,000

Original Map Size 11x17in

Murray River Project

Map 4. Estimated Quintette Caribou Herd Range and Density within the Regional Study Area

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 13-P-0108
Date: 11/12/2013	Data Sources: Refer to References Section

EDI

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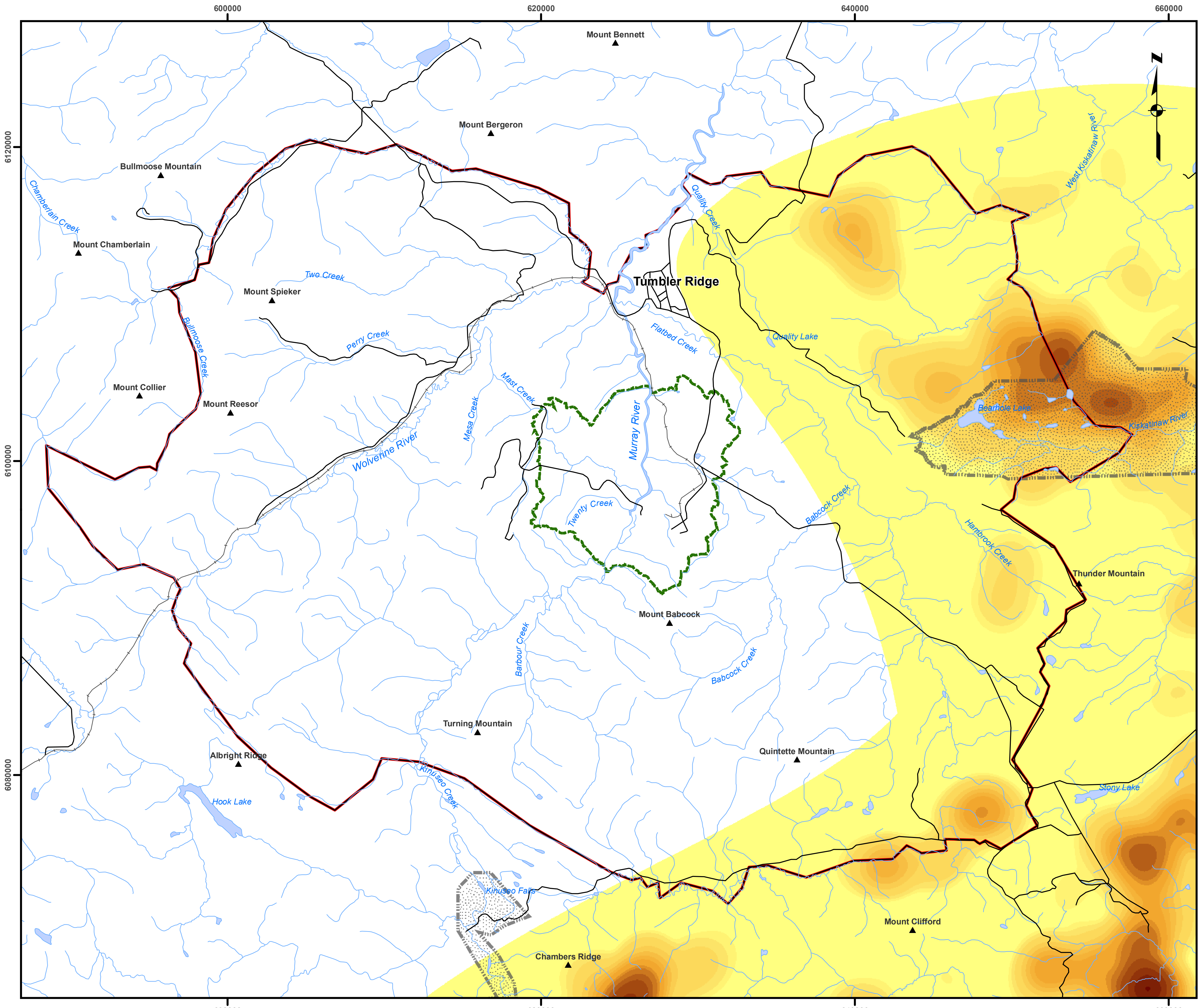

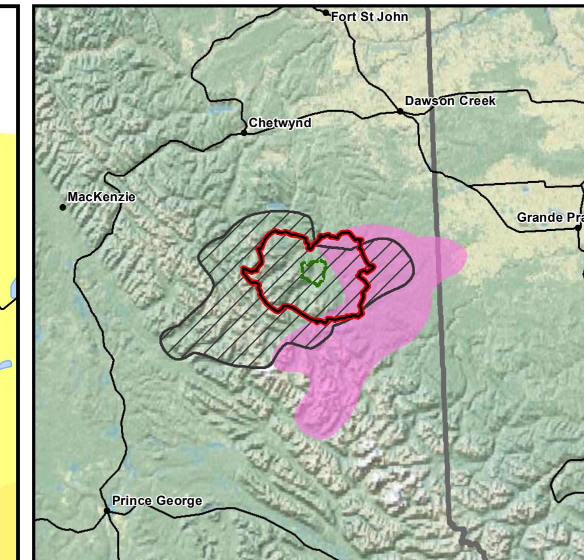

LEGEND

Regional Study Area
Local Study Area

Estimated Caribou Density
Low
High

250K National Topographic Database Data
Mountains
Railway
Road
Stream
Waterbody

INSET LEGEND

Estimated Bearhole/Redwillow Caribou Herd Range
Estimated Quintette Caribou Herd Range

Note: Minimum convex polygons were created using ET GeoWizards (Build Convex Hull tool), a third party GIS extension for ArcGIS®, using Quintette and Bearhole/Redwillow telemetry data (2002-2011 and 2006-2010 respectively, South Peace Caribou Research Program) provided by the Ministry of Environment. Polygons were generalized (smoothed) for presentation. Density raster datasets were created using ArcGIS® extension, Spatial Analyst (Kernel Density Tool). The data was clipped by their respective minimum convex polygon.

0 2.5 5 10 Kilometers

Scale: 1:250,000

Original Map Size 11x17in

Murray River Project

Map 5. Estimated Bearhole/Redwillow Caribou Herd Range and Density within the Regional Study Area

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 13-P-0108
Date: 11/12/2013	Data Sources: Refer to References Section

EDI

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APPENDIX B BACKGROUND INFORMATION

BACKGROUND

BIOPHYSICAL SETTING

The LSA is located within the Sub-boreal Interior Ecoprovince, in the Central Canadian Rocky Mountains Ecoregion and the Hart Foothills Ecosection, as defined in the British Columbia Ecoregion Classification System (Demarchi 1996). Table 21 summarizes the ecoprovince, ecoregion, ecosection, biogeoclimatic units and administrative areas comprising the LSA. The ecoregion and biogeoclimatic ecosystem classification units are shown in context with the project location in Maps 1 and 2.

Table 21. Ecoregion delineation and administrative areas of the Murray River Project LSA.

	ECOREGION CLASSIFICATION UNITS
Ecoprovince	Sub-boreal Interior (SBI)
Ecoregion	Central Canadian Rocky Mountains (CRM)
Ecosection	Hart Foothills (HAF)
	BIOGEOCLIMATIC ECOSYSTEM CLASSIFICATION UNITS
ESSFmv2	Bullmoose Moist Very Cold ESSF
BWBSmw	Moist Warm Boreal White and Black Spruce
BWBSwk1	Murray Wet Cool BWBS
SBSwk2	Finlay-Peace Wet Cool Sub-Boreal Spruce
	ADMINISTRATIVE AREAS
MOE Region	9 - Peace
Wildlife Management Unit	7-21
Forest District	Peace

CLIMATE AND TOPOGRAPHY

The LSA is located in the foothills on the eastern side of the Rocky Mountains, which is generally drier than the western side due to losses of moisture from Pacific air while crossing a number of mountain ranges (Demarchi 1996). The Hart Foothills Ecosection generally gains elevation from north to south. Within the LSA, the elevation ranges from 760 m in the lowest river valleys to approximately 1380 m. The LSA is situated in the transitional area from the mountain weather to the west and the continental weather to the northeast. To the west, convective showers in the summer and winter frontal systems create even precipitation throughout the year. To the northeast, the climate is continental, where precipitation is convective, rather than a result of Pacific air flow. Uninhibited inflow of Arctic air results in cold winters (Demarchi 1996).

BIOGEOCLIMATIC CLASSIFICATIONS

Based on the Biogeoclimatic Ecosystem Classification (BEC) system, three biogeoclimatic zones occur in the LSA, including the Sub-Boreal Spruce (SBS; plateaus, lowlands, valleys, and the Northern Rocky Mountain trench), the Boreal White and Black Spruce (BWBS; foothill valleys and northern Omineca Mountains) and the Engelmann Spruce-Subalpine Fir (ESSF; middle to upper elevation mountain slopes). The biogeoclimatic zones are further defined by four variants: SBSwk2 (Finlay-Peace Wet Cool), BWBSwk1 (Murray Wet Cool), BWBSmw (Moist Warm) and ESSFmv2 (Bullmoose Moist Very Cold).

The only variant of the SBS in the LSA, SBSwk2, occurs in valley bottoms to 1100 m and is dominated by white spruce (*Picea glauca*) and subalpine fir (*Abies lasiocarpa*), with infrequent lodgepole pine (*Pinus contorta*) in dry areas, and black spruce (*Picea mariana*) in wet areas (Meidinger and Pojar 1991). The BWBS is more commonly found in colder, drier regions than the SBS, on the eastern side of the Rockies between elevations of 650 m and 1050 m (Jones et al. 2007). In this zone, white and black spruce and lodgepole pine are dominant and fires are common; therefore, early seral stands of trembling aspen (*Populus tremuloides*) and cottonwood (*Populus balsamifera*) are correspondingly common (Meidinger and Pojar 1991). BWBSmw generally encompasses rolling terrain and is warmer and of intermediate moisture to other BWBS subzones, whereas BWBSwk1 is wetter and cooler with a shorter growing season and is distributed on low to mid elevation slopes (DeLong et al. 1990). Above the BWBS zone, the ESSF extends to approximately 1700 m. The ESSF is dominated by Engelmann spruce (*Picea engelmannii*) and subalpine fir. As elevation increases and the landscape becomes more open and interspersed with alpine meadows, subalpine fir becomes more prominent and these trees are often stunted (Meidinger and Pojar 1991). The ESSFmv2 is east of the Rocky Mountain divide and above the SBSwk2 and BWBSwk1 (DeLong et al. 1994).

REGULATORY CONTEXT

There are a number of regulations and management strategies applicable to wildlife that are referred to in this report. A brief description of each follows.

- *Species at Risk Act* (SARA)/COSEWIC
  - The *Species at Risk Act* is federal legislation aimed at preventing species, subspecies and populations from becoming extirpated or extinct in Canada. It protects and enables the recovery of endangered and threatened species through the establishment of prohibitions to protect them and their critical habitat. The Act requires that long and short-term objectives are identified in a recovery strategy and action plan (Environment Canada 2009).
  - Schedule 1 under the Act lists those species at risk under categories of extirpated, endangered, threatened or special concern. Only once a species is listed on this schedule do conservation and protection measures apply. Note that prohibitions do not apply to species listed as a Special Concern. Schedules 2 and 3 do not offer protection to the species listed on them; however, these species must be assessed by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) within a specified time (Environment Canada 2009).
  - One of the selected species referred to in this report is listed on Schedule 1 of *SARA* as Threatened, the Southern Mountain population of woodland caribou.
  - The Act also establishes the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This group is responsible for identifying species at risk through species assessments (Environment Canada 2009).

- Red-, blue- and yellow-lists/*Wildlife Act*
  - Red-listed species, subspecies or ecological communities are those that are extirpated, endangered or threatened in British Columbia. Red-listed species, as well as those assessed by COSEWIC as extirpated, endangered, threatened or special concern may be considered for legal designation as Extirpated, Endangered or Threatened under British Columbia's *Wildlife Act*. This designation enables habitat protection in the form of Wildlife Management Areas and increases penalties for harming the species. None of the selected species for this study are currently red-listed or designated under the *Wildlife Act*.[19]
  - Blue-listed species, subspecies or ecological communities are those that are considered of special concern in British Columbia. They are not considered Extirpated, Endangered or Threatened, but are vulnerable to population declines caused by human or natural events. Along with red-listed species, blue-listed species are highlighted as those that could be considered for formal designation as Endangered or Threatened under the *Wildlife Act* or by

[19] Four species are legally designated: the Vancouver Island Marmot (*Marmota vancouverensis*), American White Pelican (*Pelecanus erythrorhynchus*), and Burrowing Owl (*Athene cunicularia*) as Endangered and the Sea Otter (*Enhydra lutris*) as Threatened.

COSEWIC. Most of the species selected for this study are blue-listed (i.e. caribou, Black-throated Green Warbler, fisher and grizzly bear).

  - Yellow-listed species, subspecies or ecological communities are those that are secure and not at risk in British Columbia. Mountain goat, moose and elk are yellow-listed.
  - The British Columbia *Wildlife Act* protects all wildlife species and their critical habitat or nesting structures. Section 4 of the *Wildlife Act* identifies provisions for the Minister to designate Wildlife Management Areas, Critical Habitat Areas or Wildlife Sanctuaries for the protection of wildlife. Section 5 of the *Wildlife Act* protects designated habitat except as permitted under other regulations or permits. There are no Wildlife Management Areas, Critical Habitat Areas or Wildlife Sanctuaries as designated by the B.C. *Wildlife Act* within the LSA.

- Identified Wildlife Management Strategy, Ungulate Winter Ranges/*Forest and Range Practices Act*

  - This strategy enables the Minister of the Ministry of Environment under the *Forest and Range Practices Act* (*FRPA*) to designate species as "Identified Wildlife (IW)" from within Species at Risk and Regionally Important Wildlife categories. The species must not be adequately protected by other legislation and be potentially negatively affected by forest and range activities to be designated as IW. Ungulate Winter Ranges (UWRs), Wildlife Habitat Areas (WHAs), General Wildlife Measures (GWMs) and wildlife habitat area objectives are implemented under *FRPA*. Management practices may also be provided in strategic or landscape level plans.
  - Four of the selected species are Identified Wildlife including caribou, Black-throated Green Warbler, fisher and grizzly bear.
  - A portion of UWR #U-9-002, SPC-047 (designated for caribou and mountain goats) is located above the 1300 m contour in the southwest corner of the newly revised LSA. However, none of the WHAs or UWRs lie within the proposed project footprint as identified in current mine planning (Map 2).

- Core Caribou Habitat Area /Peace Northern Caribou Plan

  - The draft Peace Northern Caribou Plan (PNCP) prepared by Ministry of Forests, Lands and Natural Resource Operations used a resource selection function (RSF) habitat model to gauge the suitability of high elevation winter habitat for northern caribou. The Peace Northern Caribou Habitat Model classified areas into four different suitability categories (ranging from low to very high) (MFLNRO 2012). Draft guidelines for the mining industry apply if the Project is expected to impact Core Caribou Habitat.
  - There are no Core Caribou Habitat areas within the LSA.
  - In October 2012, the Government of B.C. made a commitment to increase the population of South Peace Northern Caribou to $\geq$ 1200 animals within 21 years across their range. To do this, the following additional commitments were made:

1. "Protect 90% of identified high elevation winter habitat across the range of South Peace Northern Caribou:
    - Protect ≥ 90% of identified high elevation winter habitat in the Graham, Moberly, Burnt Pine, Scott, Kennedy Siding, and Narraway herd ranges; and
    - Protect ≥ 80% of identified high elevation winter habitat in the Quintette herd range.
2. Conduct South Peace Northern Caribou population management to address non-habitat related threats (e.g. predation) to certain South Peace Northern Caribou herds.
3. In all ranges, manage the industrial footprint in identified high and low elevation habitats by requiring standardized industry management practices across all industry sectors to reduce or prohibit surface disturbance and habitat alteration, and support long-term sustainable caribou habitat conditions.
4. In all ranges, monitor the compliance and effectiveness of management actions and modify actions accordingly to ensure the population and distribution goal is being achieved (MOE 2013)."

- B.C. Conservation Framework
    - A method designed by the B.C. government to guide and coordinate conservation actions for species and ecosystems at risk across the province among government and non-government sectors. The goals of the framework are:
        1. "to contribute to global efforts for species and ecosystem conservation;
        2. to prevent species and ecosystems from becoming at risk; and
        3. to maintain the diversity of native species and ecosystems." (MOE 2011)
    - The framework helps determine priorities for species and ecosystems at risk and outlines the corresponding most appropriate management actions using two tools: the Prioritization and Action Sorting Tools. Prioritization is based on five criteria: global and provincial status, trends, threats, stewardship responsibility and feasibility of recovery. Management Actions follow using a transparent decision-making process for high-ranked species, and fall into one of the following groups: *assessing, planning & listing,* and *acting (MOE 2011).*
    - The approach is used by Ministry of Environment and Ministry of Forests, Lands and Natural Resource Operations to prioritize conservation works during annual planning (MOE 2011).
    - Although not regulation, it can be used by non-government organizations to prioritize species and corresponding conservation efforts. In this way, the Conservation Framework facilitates conservation works across sectors.

APPLYING A BAYESIAN BELIEF NETWORK

Decision models were made to describe the "ecological causal web" for each species' selected life requisite. Our process was consistent with recommendations provided in Marcot et al. (2006). We used Netica® (version 5.12, Norsys Systems Corporation, Vancouver, B.C.) as the framework to develop and process the models. Terminologies used in Marcot et al. (2006) and within Netica® are used to describe the models.

Bayesian Belief Network modeling is based on nodes; nodes are the variables or habitat predictors that form the ecological web to predict habitat suitability. Nodes are:

1. Parent nodes — input nodes that originate from existing raw GIS data or from pre-processed existing GIS data. Examples of existing raw GIS data are roads, slope and aspect. Examples of pre-processed GIS data are: distance to roads, steep and rugged "escape" terrain and riparian area that were created by applying a buffer around water;
2. Child nodes — formed by combinations of parent nodes and are intermediate between the inputs and the eventual output node; or
3. Output nodes — in this study the output node for each model was habitat suitability.

Figure 19 illustrates the decision model structure.

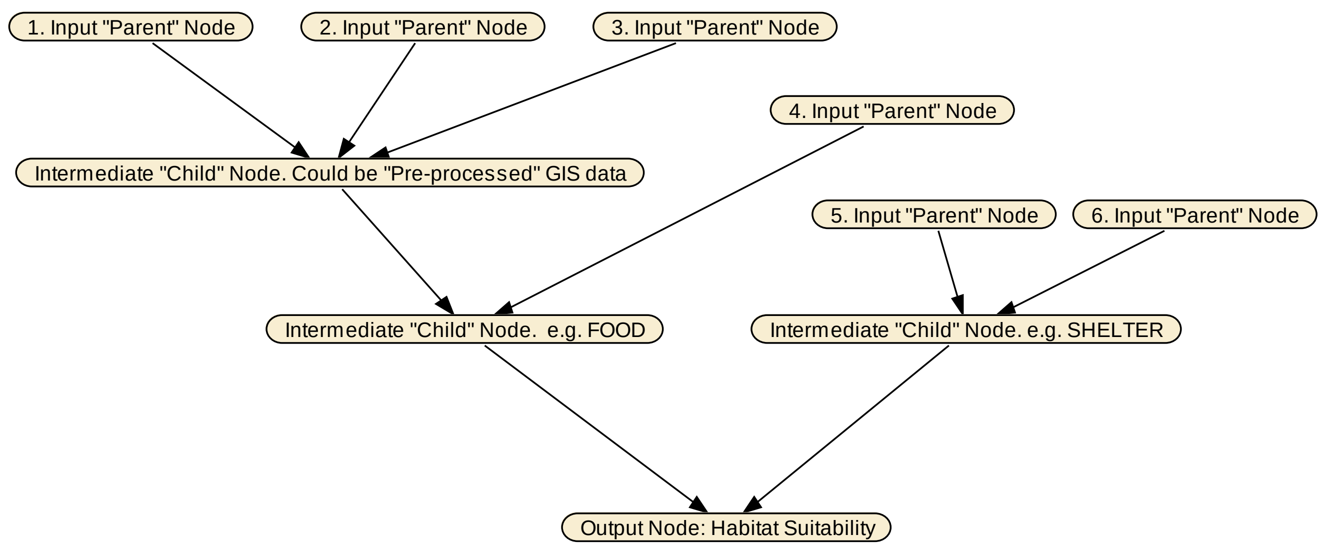


Figure 19. **Framework of a decision model using "Node" terminologies.**

A single decision model was created for each life requisite of the selected species, for a total of 16 models. Two key data processing steps, using GIS and data management, were integral to the completion of the study. GIS data was gathered and managed to consistent raster formats. These rasters were then output to input files for Netica®. The raster cell size was 5 m square. ESRI ArcGIS® (Version 10.1) was used to manage and manipulate all raster and vector data. ArcGIS® was also used to review and display model outputs in map form.

Species model development occurred within an iterative process in which the models were developed, reviewed and revised according to internal review and with the opinion of external experts. Once nodes for each species and life requisite were conceptualized and created, the first versions of the models were created in Netica®. We ensured that the models logically functioned as intended, then graphical outputs of each were produced. These outputs were reviewed internally and by an external senior ecologist, Maureen Ketcheson, MSc, RPBio. Revisions were analyzed within Netica and suggested edits were incorporated. Graphical outputs were produced again to ensure that the revisions had the expected outcomes. This process continued until revisions produced an output that best matched the species accounts, expert opinion and review comments.

5.2.1 Common Nodes

Any node that was used by multiple models is referred to as a common node. Common nodes were derived from variables identified to be important and many were based on data directly available from GIS layers (e.g. elevation, slope, aspect and riparian areas). One new piece of GIS-derived data called Generalized Stand Structure mapping was used among many of the models. Nodes that could not be derived directly from GIS required the use of surrogate variables. For example, snow load was a variable important to multiple species habitat requirements and was described by two common nodes, elevation and aspect, as surrogate variables.

5.2.2 BEC-derived Nodes

The BEC-derived nodes were based on the data contained within the field guides to ecosystem identification (e.g. *A Field Guide to Ecosystem Identification for the Boreal White and Black Spruce Zone of British Columbia*, DeLong et al. 2011). These guides provide tables that summarize site series within each BEC subzone by the relative values of occurrence and abundance of a number of vegetation species common to the subzone. The comparative tables are based on empirical data collected to create the classifications within the guides; generally, the data is based on thousands of plots (e.g. DeLong et al. 2011 is based on 1590 plots).

As the tables comparing vegetation values are coded using an indicator of frequency of occurrence (i.e. plant A is present 50 – 74.9% of the time), the relative value could not be used straight across, instead we used a system to assign a value to each vegetation species based on frequency of occurrence and abundance for the BWBS zone and based on prominence class for the SBS and ESSF zones. A comparison exercise was used between the two systems (i.e. frequency of occurrence and abundance versus prominence class) such that the systems were roughly comparable. Values for the number of species that met a criterion for a species (e.g. shrub species for moose) were added for each site series. Values of each site series were compared to each other and each assigned a relative ranking of high, moderate, low or nil for the criterion.

5.2.3 Surrogate Variable-derived Nodes

Surrogate variable-derived nodes are child nodes that are predicted from GIS data based on a relationship found between the field data we collected and existing GIS layers. The surrogate variable-derived nodes were not based directly on empirical data, but rather indirectly as their information must be predicted from other available GIS data. A couple of the surrogate variable-derived nodes, arboreal lichen potential and CWD abundance, were determined based on relationships found between collected field data and existing GIS layers. Other surrogate variable-derived nodes were based on logical process and expert opinion (e.g. snow load) on how two or more available GIS layers could be used to predict an important variable to wildlife habitat.

Relationships between field data and existing GIS layers were investigated by intersecting the locations of EDI 2012 field plots with the GIS layers (namely the TEM and TIN). This created a complete dataset which could be used to examine potential relationships between variables. A high level analysis was conducted to examine trends between field data and mapped variables. Although statistical tests were used, the relationships found should be taken as trends only.

5.2.4 Other Nodes

Other nodes created in the models functioned simply to combine two or more parent nodes thereby moving the model closer to the final habitat suitability rating. For example, in the Black-throated Green Warbler model, the child node "Warbler Stand Structure Value" combined parent nodes Generalized Stand Structure and Structural Stage. These nodes usually combined parent nodes that were related in some sense; in this example, Generalized Stand Structure and Structural Stage, both characterize the structure of the forest stand. Therefore these nodes reflect a combined value to the species of concern.

APPENDIX C FIELD WORK

FIELD WORK

The purpose of field work was to collect data that could help predict wildlife habitat value in association with available GIS data for the LSA. Post-field analysis of possible relationships between this data and existing GIS data was completed to aid in developing wildlife habitat models. In order to provide the most meaningful data, our goal was to complete a high number of field plots over a diversity of habitat types within the LSA. This was done by completing rapid assessment plots. Geographical, biophysical and wildlife habitat data were collected at each plot. Transect lines were positioned across the LSA to meet the criteria of being accessible and representing the LSA. Plot locations were randomly selected from points positioned at 50 m intervals along the transect lines. Each plot was a minimum distance of 50 m from any other plot.

Pre-field planning occurred in summer 2012. One of the goals of pre-field planning was to develop conceptual models for each species in which ecological variables important to each life requisite were identified. These variables would predict the value of habitat to the species and life requisite of concern, but also needed to be measurable either by derivation from GIS or collection in the field. Available GIS data was investigated and is identified as described in the Section 2.3. Variables that were identified as being important but were not available from GIS were examined for potential to be collected in the field and related back to a surrogate or set of surrogate GIS variables. Therefore, the preliminary models guided what variables or habitat predictors should be investigated through field work.

Pre-field exercises also included transect planning and preliminary investigation of the LSA using available information and desktop review. This included review of available GIS data and mapping of the LSA. Mapping of the biogeoclimatic zones and TEM information was used in access analysis and transect planning. Finally, maps were prepared and used for field navigation.

Basic information was recorded at each plot including date, time, plot number, UTMs and photographs. Data was collected for the set of habitat predictors selected as a result of preliminary model development. For example, arboreal lichen abundance is known to be important to caribou habitat and does not exist in spatial form for the LSA. It is possible to collect field data from representative habitats within the LSA and relate the data to other available GIS data. The criteria in selecting these field variables were that they had to be quantifiable by standard methodology and preferably they were common to several models. For the arboreal lichen example, it was quantifiable and quick to collect using the methodology outlined by Armleder and colleagues, titled “Estimating the Abundance of Arboreal Forage Lichens” (1992). The remaining field variables followed standards in the Field Manual for Describing Terrestrial Ecosystems (MOF & MOE 2010) for vegetation and wildlife assessments. The variables collected in the field are listed in Table 22.

Table 22. Field variables collected for use in species model development.

Variable	Relevant to Models	Standard Methodology Used
Basic Information		
Date	All	n/a
Start time	All	n/a
Plot number	All	n/a
UTM	All	n/a
Photographs	All	n/a
Trees		
Dominant species	All	Field Manual for Describing Terrestrial Ecosystems (MOF & MOE 2010)
Canopy species	All	MOF & MOE 2010
Subcanopy species	All	MOF & MOE 2010
Canopy cover	All	Densiometer
Shrubs		
Percent cover of select shrubs	Moose: LI-W, LI-G	MOF & MOE 2010
Percent cover of select shrubs	Grizzly LI-F	MOF & MOE 2010
Total percent cover of shrubs	Fisher: LI-A, BI Moose LI-W	MOF & MOE 2010
Herbs		
Percent cover of select herbs	Moose: LI-W, LI-G	MOF & MOE 2010
Percent cover of select herbs	Grizzly: LI-P, LI-S	MOF & MOE 2010
Percent cover of select herbs	Elk: LI-W, LI-G	MOF & MOE 2010
Total percent cover of herbs	Elk: LI-W, LI-G Moose: LI-W, LI-G	MOF & MOE 2010
Lichen		
Percent cover terrestrial lichen (*Cladina spp., Cladonia spp.*)	Caribou: all models	MOF & MOE 2010
Arboreal lichen	Caribou: all models	Armleder et al. 1992
Other		
Presence of trees with potential for fisher natal den	Fisher BI	As outlined by Weir and Almuedo 2010
Coarse woody debris	Fisher: LI-A, BI	Modified from MOF & MOE 2010

Fieldwork occurred from September 19th to 24th, 2012. EDI completed 147 plots of a total 467 ecology and wildlife plots completed within the LSA to date. The other 320 plots were completed in previous years of the study by EDI and by Rescan. Although similar data was collected for those plots, the methodology and field variables collected differed according to the specific purpose of the data for those field programs. For example, during Wildlife Habitat Suitability plots completed by EDI over the RSA in October 2010 and July 2011, sites were classed to ecosystem unit and rated for wildlife habitat value. Details of that data collection can be found in "Murray River Project, Wildlife Habitat Ratings Study, Final Report" (EDI 2012). Rescan completed Ecosystem Mapping Plots over the LSA as well. Locations of all plots within and near the LSA are depicted in Map 3. All EDI field data was entered into Microsoft Excel. Photographs were taken at each plot and are available upon request.

Data entry was subject to Quality Assurance (QA) by revisiting at least 10% of all entered field records. Of the 147 records, fifteen were assessed for errors occurring in data entry of field notes into digital records. In the data, three mistakes were found within three separate records. Each record has 43 variables where mistakes could occur, therefore three mistakes in fifteen records corresponded to an error rate of 0.47%.

Post-field analysis of field data with GIS data was conducted to find any possible relationships between the datasets. Relationships were found between GIS data with arboreal lichen and CWD abundance. Therefore, surrogate-variable derived nodes could be created for arboreal lichen and CWD abundance. The results of the analysis are presented in the Surrogate Variable-derived Nodes section of Appendix D.

APPENDIX D HABITAT PREDICTORS: NODES

INTRODUCTION

Habitat predictors are variables that can be mapped and that predict how suitable an area is for a wildlife species. Habitat predictors are also called nodes. The nodes used in all the habitat models can be summarized in four categories.

1. Common Nodes. Habitat predictors that were used across multiple species models.
2. Biogeoclimatic Ecosystem Classification (BEC) Derived Nodes. Habitat predictors that were based on data obtained from the BEC system. For example, the amount of berry-producing plants expected to occur in each vegetation community can be estimated from BEC data.
3. Surrogate Variable Derived Nodes. Habitat predictors that were not directly available but can be estimated based on other known data. For example, amount of arboreal lichen was not available on any mapped product, but was estimated based on a combination of other vegetation indicators such as structural stage and forest type.
4. Combination Nodes. These habitat predictors were combinations of others, such as the total lichen value was the amount of arboreal lichen and terrestrial lichen combined.

COMMON NODES

Fourteen nodes were directly derived from existing GIS layers. These nodes were used commonly among many of the models. A description of each of these nodes follows:

- Elevation – derived from TIN. A common node used for a number of life requisites. The elevational ranges of interest were modified for each species.
- Slope – derived from TIN.
- Aspect – derived from TIN.
- Forest type – Coniferous (C), Broadleaf (B) or Mixed (M). Available in TEM.
- Structural Stage – available in TEM.
- Canopy Structure – available in TEM. Canopy structure can either be single-storied (s), two-storied (t), multistoried (m) or irregular (i).
- Biogeoclimatic Ecosystem Classification (BEC) Subzone and Map Unit – available in TEM. Often combined to produce site series and thereby used as a parent node to estimate vegetation characteristics such as total shrub cover or herb cover for moose.

- Distance to roads – calculated through GIS. Two sets of polygons were created, one including all those areas within 500 m of a road and one including all those areas outside 500 m of a road. Road linework was filtered to exclude deactivated roads and overgrown trails that often appear within this layer. Those linear features would be identified in other GIS layers as disturbances, but did not meet the definition of actively used roads for this study. Roads were defined as gravel roads, both one and two-lanes, and paved road two-lane.

- Riparian/Low Elevation Stream Modifier – calculated through GIS. A polygon was created using distance to a stream or other waterbody and slope to define the riparian area. Those areas within 50 m of water and under 10% slope were classified as riparian. If slope was greater than 10%, all area within 25 m of water was classified as riparian. In the Elk models, for example, the riparian buffer was only applied at elevations less than 1000 m hence the name "Low Elevation Stream Modifier."

- Distance to escape terrain

  - Escape terrain was calculated through GIS using the TIN. Triangulated polygons of greater than 30° slope were unified and three zones were created proximal to the areas of high slope: 0 – 50 m, 50 – 100 m or 100 – 200 m.

  - Considering the range of suitable slopes reported in various B.C. studies, we used >30^0 to delineate escape terrain. This relatively low slope value was a conservative approach to include all slopes that are suitable as escape terrain. Ecosystem map units classified as rock talus were also categorized as escape terrain.

  - Tailings were excluded as escape terrain because although slopes are steep at some of these sites, they do not provide suitable habitat.

  - Distance to escape terrain of 50 m, 100 m and 200 m was used to represent preferential distances to escape terrain. We tested using a buffer of 400 m from escape terrain but this did not highlight unique habitat, perhaps due to the resolution of the slope mapping. Buffering greater than 200 m did not provide suitable resolution for escape terrain in this project area.

- Structural adjacency – derived from TEM. This is calculated slightly differently between fisher and moose. For moose, this node described whether a polygon contains both a shrubby structural stage for forage and a more mature structural stage for shelter. Specifically, this query asked if Decile 1 was structural stage 3a or 3b at a level greater than 50% and if Decile 2 or 3 was structural stage 5, 6 or 7 at greater than or equal to 30%. For fisher, this node described whether a polygon contains both a shrubby structural stage for foraging opportunities and a more mature structural stage for shelter/resting sites. Specifically, this query asked if Decile 1 was structural stage 3a, 3b or 4 at a level greater than 50% and if Decile 2 or 3 was structural stage 5, 6 or 7 at greater than or equal to 30%.

- Wetland – derived from TEM. This node determined whether any wetland map unit occurred in any decile.
- (Mine) Tailings – derived from TEM. One Map Unit, TZ, is used to describe mine tailings areas. This node categorizes Map Unit into a mine tailings unit and an "other" category.
- Generalized Stand Structure Mapping – derived from satellite imagery classification by Maureen Ketcheson. The LSA was delineated into eight categories as presented in Table 23.
- River Modifier – derived from TRIM and used in the Grizzly spring model. This node evaluated whether an area was situated within or outside of a 150 m buffer on the Murray River and combined this result with aspect to provide an indication of where high value spring forage would appear earlier than surrounding areas. Warm and neutral aspects were given high values within this buffer, while cool aspects were moderately high. If sites were outside of the buffer there was nil effect.

Table 23. Generalized Stand Structure Mapping codes.

Code	Name	Description
0	Wetlands	Open wetlands, could be shrub-dominated type, fen-type or a combination
1	Closed canopy Mature conifer	Closed canopy mature conifer < 1% cover of deciduous
2	Closed canopy Mature deciduous	Closed canopy mature deciduous < 1% cover of conifer
3	Closed canopy Mature mixed	Could be evenly interspersed or clumpy distribution between conifers and deciduous, tree cover >10%
4	Open canopy conifer	Widely spaced conifer, because site is very dry due to being shallow or on coarse textured materials, or selectively harvested
5	Disturbed shrub	Sites where the overstory has been removed either through timber harvest or industrial activities
6	Disturbed barren Industrial	Sites where the terrain materials have been dramatically altered such as mines, tailings ponds, roads
7	Rock talus	Naturally occurring rock and talus, may include a few widely spaced trees or shrubs, tree cover < 10%

BEC-DERIVED NODES

Ten BEC-derived nodes were compiled using vegetation data from the field guides for ecosystem identification in the BWBS, SBS and ESSF (DeLong 2004; DeLong et al. 1990, 1994, and 2011). Not all species consumed by each wildlife species were used in the calculation of vegetation value for each site series. This was limited to the vegetation species listed in the field guides which do not describe all the vegetation species present in each site series. A subset of the preferred forage vegetation that was available in the guides were used as an indicator of the habitat requirement. The preferred forage vegetation was determined based on the review of information with a focus on regional data if available.

Criteria for BEC-derived nodes by species were as follows:

Woodland Caribou

- Terrestrial Lichen Potential
  - Terrestrial lichen for caribou was estimated by adding the values of terrestrial lichen species eaten by caribou within the comparative tables. Not all species eaten by caribou were used; instead, a selection of the best species was chosen. These species included:
    - *Cladina spp.* (reindeer lichens)
    - *Cladonia spp.* (clad lichens)
- Non-lichen Forage for Caribou
  - Non-lichen forage for caribou was estimated by adding the values of species eaten by caribou within the comparative tables. Not all species eaten by caribou were used; instead, a selection of the best species was chosen. These species included:
    - *Salix spp.* (willows)
    - *Vaccinium spp.* (blueberries/huckleberries/lingonberry) in both shrub and dwarf shrub layers
    - *Ledum groenlandicum* (Labrador tea)
    - *Betula papyrifera* (paper birch)
    - *Betula glandulosa* (resin birch)

Black-throated Green Warbler

- None

Mountain Goat

- None

Moose

- Moose Shrub Availability
  - Moose shrub availability was estimated by adding the values of shrubs eaten by moose within the comparative tables. Not all shrub species eaten by moose were used; instead, a selection of the best species was chosen. Note that some of the species are also trees, but they were only tallied if they were listed in the shrub layer. These species included:
    - *Salix spp.* (willows)
    - *Cornus stolonifera* (red-osier dogwood)
    - *Populus balsamifera* (balsam poplar)
    - *Populus trichocarpa* (black cottonwood)
    - *Betula papyrifera* (paper birch)
    - *Populus tremuloides* (trembling aspen)
    - *Viburnum edule* (highbush-cranberry)
    - *Abies balsamea* (balsam fir)
    - *Amelanchier alnifolia* (saskatoon)
- Moose Herb Availability
  - Moose herb availability was estimated by adding the values of herbs eaten by moose within the comparative tables. Not all herb species eaten by moose were used; instead, a selection of the best species was chosen. These species included:
    - *Equisetum spp.*(horsetails)
    - *Leymus innovatus* (fuzzy-spiked wildrye)
    - *Calamagrostis spp.* (reedgrass)
    - *Gymnoarpium dryopteris* (oak fern)

Grizzly Bear

- BEC Zone Berry-producing Potential
  - Berry-producing potential was estimated by adding the values of berry-producing shrubs within the shrubs and dwarf shrubs layers in the comparative tables. Not all berry-producing shrubs were used; instead, a selection of the best species for grizzly bears was chosen. These species included:
    - *Vaccinium spp.* (blueberries/huckleberries/lingonberry) in both shrub and dwarf shrub layers
    - *Shepherdia canadensis* (soopolallie)
- Canopy Closure
  - Canopy closure was estimated by adding the values of all the tree species within the tree layer in the comparative tables; however, this value could only be applied to mature structural stages (i.e. 5, 6, and 7) as the field guides only describe mature ecosystems. Pole sapling stage (structural stage 4) has the highest canopy closure (i.e. a higher rating than mature structural stages). Tall shrub stage (structural stage 3b, shrub height 2 – 10 m), low shrub stage (structural stage 3a, shrub height <2 m) and herb stages (2a and 2b) have nil canopy closure values as a forest canopy has not yet developed.

Fisher

- Canopy Closure
  - See description under grizzly bear
- Shrub Cover
  - Total shrub cover was estimated by adding the values of all shrub species in the comparative tables; however, this value could only be applied to mature structural stages (i.e. 5, 6, and 7) as the field guides only describe mature ecosystems. Pole sapling stage (structural stage 4) was estimated to have low shrub cover values, while shrub stage (structural stage 3) was estimated to have higher shrub cover values. Structural stages 2a and 2b (herb stages) have no shrub cover value.
- Presence of spruce (Sx), trembling aspen (At), balsam poplar (Acb), black cottonwood (Act) in Canopy
  - Presence of Sx, At, Acb, Act in canopy differed from the other BEC-derived nodes in that values were not calculated or added; instead, only the presence or absence of these species within the tree layer of the comparative tables was recorded.

- Trembling aspen (At), balsam poplar (Acb) and black cottonwood (Act) have potential as fisher den trees if over specified the diameter at breast height (DBH). These values are 90 cm for black cottonwood, 50 cm for balsam poplar and 40 cm for trembling aspen.
- Also interpreted the presence of Sx in canopy as an indicator that younger deciduous trees could be in canopy as often is the case in BWBS zone.
- Once this node was combined with forest type, a relative probability was assigned to each scenario to create a Birthing Tree Presence Potential node.

Elk

- Herbs for elk
  - Elk herb availability was estimated by adding the values of herbs eaten by elk within the comparative tables. Not all herb species eaten by elk were used; instead, a selection of the best species was chosen. These species included:
    - *Leymus innovatus* (fuzzy-spiked wildrye)
    - *Calamagrostis spp.* (reedgrass)
  - Note that a refinement occurred on top of the BEC derivation. It was suggested that the SBS and ESSF subzones should be upgraded according to expert opinion of the reviewer. For these two subzones, site series 01, 02 and 04 were upgraded to a ranking of moderate and site series 05 and 06 were upgraded to a ranking of high.
- Shrubs for elk
  - Elk shrub availability was estimated by adding the values of shrubs eaten by elk within the comparative tables. Not all shrub species eaten by elk were used; instead, a selection of the best species was chosen. These species included:
    - *Salix spp.* (willows)
    - *Viburnum edule* (highbush-cranberry)
    - *Rosa acicularis* (prickly rose)
    - *Amelanchier alnifolia* (saskatoon)

SURROGATE VARIABLE-DERIVED NODES

Seven unique surrogate variable-derived nodes were predicted from other available GIS data based on logical process and expert opinion. Five of the surrogate variables were modeled based on expert opinion and existing information that is summarized in species accounts. For example, forage availabilities for certain seasons and species are based on the type and age of the forest. Aspect and elevation influence habitat suitability and these two variables also weigh into forage where needed. For instance, looking to aspect and elevation is useful within mountain goat winter habitat, where high value habitat centers around rock talus that is not variable in forest type and age. The final two surrogate variables, arboreal lichen and coarse woody debris, are two important habitat influencers that are not mapped in existing base data. These variables showed trends that made it possible to strengthen caribou and fisher models by developing surrogates that best predicted their relative level of occurrence.

Due to the complex nature and interrelatedness of ecosystem attributes in the field, a very substantial sample size would be required to statistically confirm trends. However, the goal in this project was to predict the relative suitability of each ecosystem unit using specific habitat attributes and trend analysis served this goal. Surrogate variable models were based on the most evident trend found between collected field data and existing GIS layers in combination with expert opinion.

All seven surrogate variables are summarized as follows:

Woodland Caribou

- Arboreal Lichen Potential
  - Predicted from three variables: Structural Stage, Forest Type and BEC Subzone.
  - A trend was found between Arboreal Lichen Potential and Structural Stage. Relationships were not found in the field data between Arboreal Lichen Potential and Forest Type or BEC Subzone. Expert opinion was used to incorporate these variables and strengthen a model to predict the likelihood of an ecosystem unit providing suitable forage habitat for caribou.

Black-throated Green Warbler

- None

Mountain Goat

- Forage Availability (growing season)
  - Generated from Generalized Stand Structure Mapping and Structural Stage
- Forage Availability (winter season)
  - Generated from Aspect, Elevation and Structural Stage

Moose

- Snow Load
    - Generated from Elevation and Aspect
- Moose Winter Thermal
    - Generated from Forest Type and Structural Stage

Grizzly Bear

- None

Fisher

- CWD Abundance
    - Predicted from three variables: Canopy Closure, Forest Type and Elevation.
    - Relationships were not found in the field data between CWD Abundance and Forest Type. Expert opinion was used to incorporate this variable.

Elk

- Snow Load
    - Generated from Elevation and Aspect
- Elk Winter Thermal
    - Generated from Forest Type, Structural Stage and Canopy Closure

Trends were found between GIS data and the field data variables for arboreal lichen and CWD abundance. These variables were partly predicted based on these trends for the applicable species models. The relationships that were found are detailed below:

- Arboreal Lichen Potential (used in the caribou models)
    - It is known that "abundance of arboreal lichen is significantly related to the amount of spruce and to the age of the forest (Szkorupa 2002 in Goddard 2005)."
    - A trend was found between Arboreal Lichen Potential and Structural Stage. Arboreal Lichen class is rated in a five category system from 1 to 5 (1 being low to 5 being high; Armleder et al. 1992).

- Mature and old structural stages (5, 6 and 7) were the only structural stages to have trees with higher abundance classes (i.e. 3, 4 and 5) of arboreal lichen (Figure 20). Note that structural stage 3.5 represents 3b (tall shrubs).
- No significant difference was found in the number of higher abundance classes (i.e. 3, 4 and 5) between Structural Stages 5, 6 and 7 (p=0.758). Class 2 arboreal lichen abundance occurred only in structural stage 4 and greater and Class 1 occurred only in 3b and greater (Figure 21).

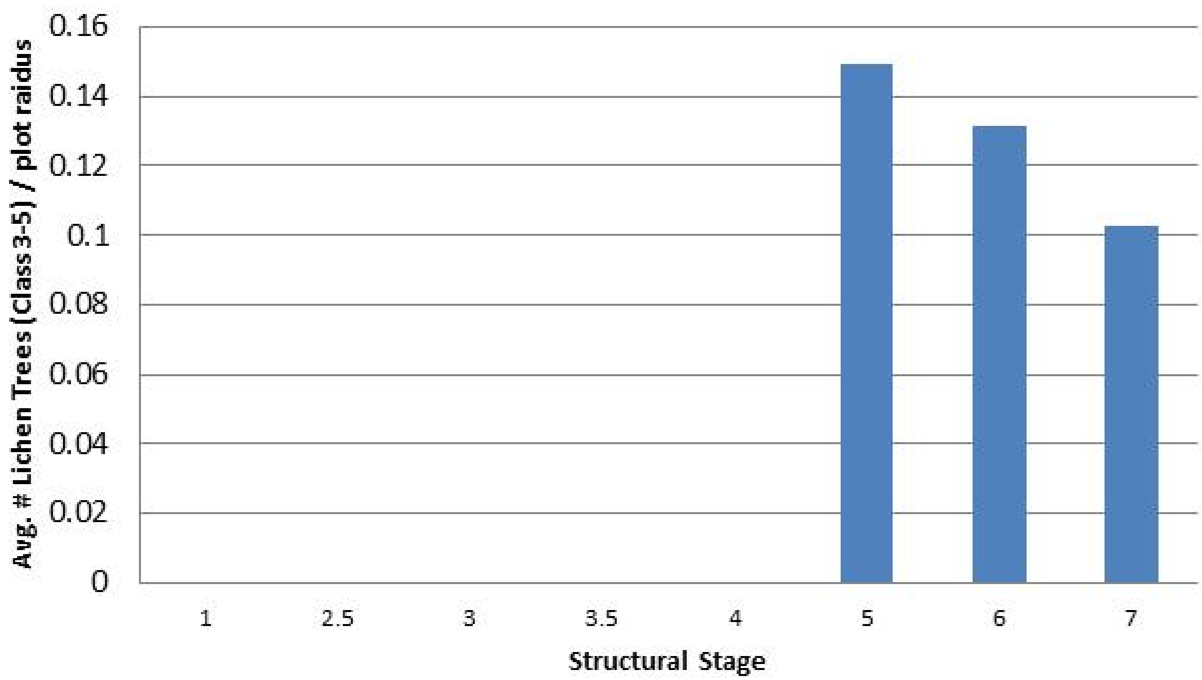


Figure 20. **Average arboreal lichen tree (class 3 – 5) abundance by structural stage.**

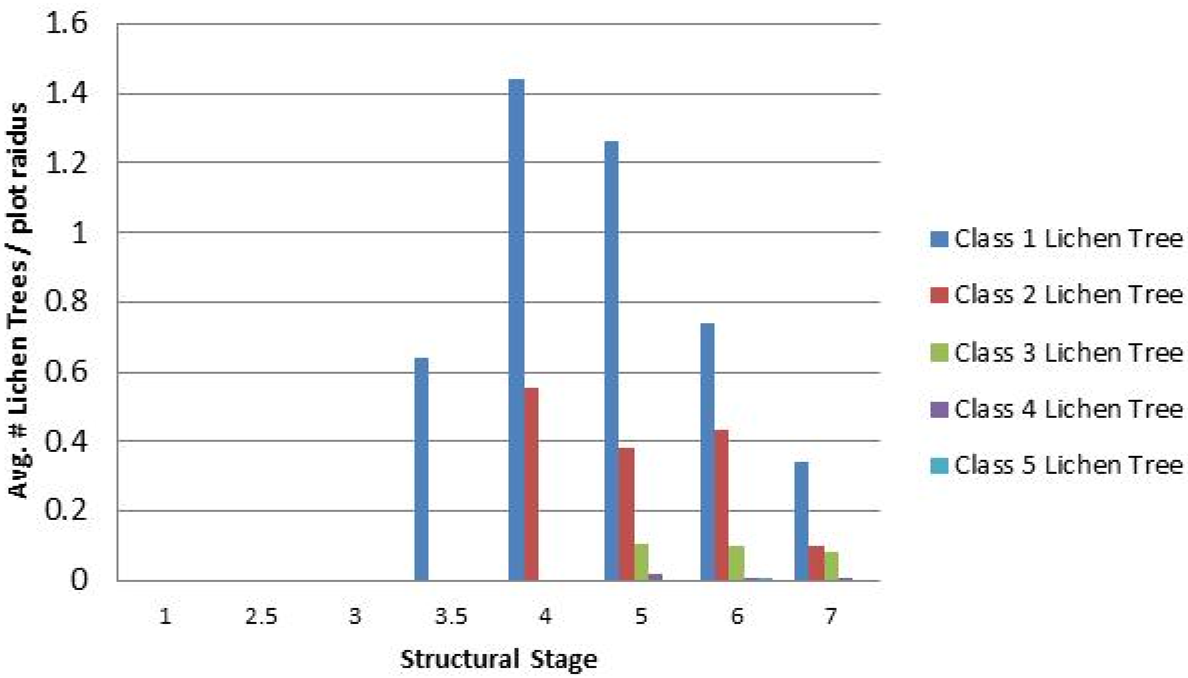


Figure 21. **Average arboreal lichen tree abundance by structural stage.**

- CWD Abundance (used in the fisher models)
  - Trends were found between CWD Abundance and two variables: Canopy Closure and Elevation.
  - Higher abundance of CWD was associated with higher canopy closure when cutblocks and power lines were removed from the dataset (Figure 22). These disturbed areas were found to confound results due to slash contributing higher numbers of CWD pieces than non-disturbed areas. That fact is a result alone, and separating those areas from the analysis made it possible to find additional results.
  - Coarse woody debris abundance decreased with increased elevation. Cutblocks and power lines were removed from the dataset (Figure 23).

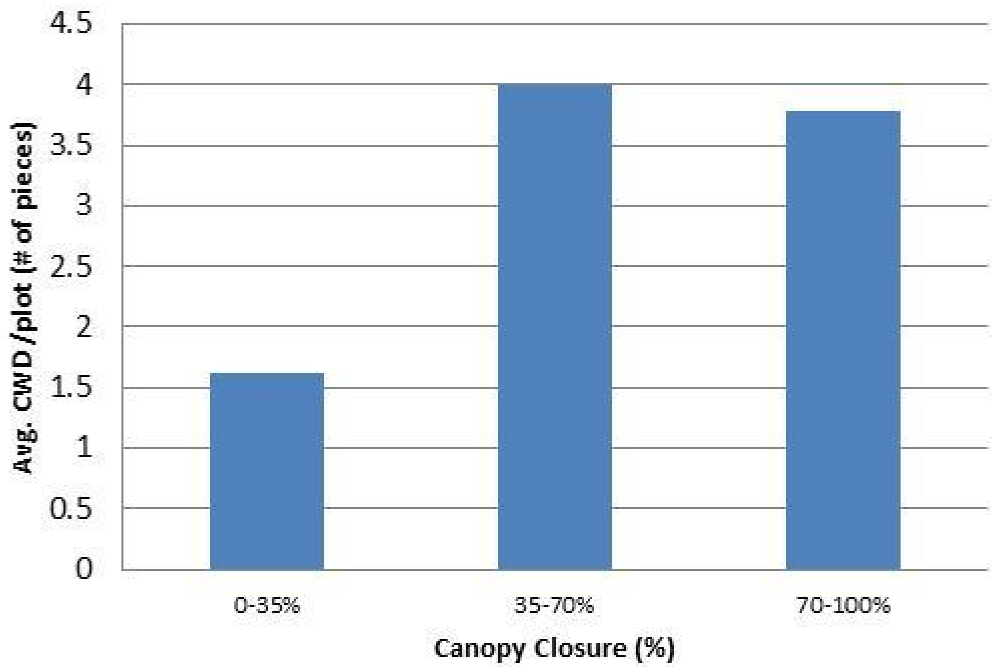


Figure 22. **Average number of CWD (all categories) by canopy closure.**

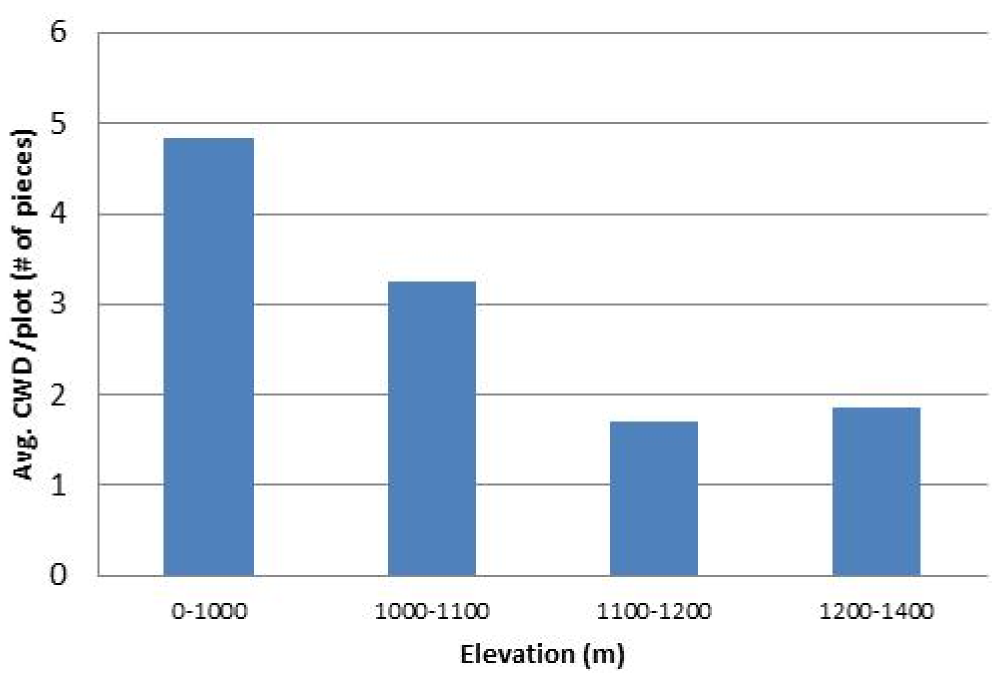


Figure 23. **Average number of CWD (all categories) by elevation.**

COMBINED NODES

A large number of other nodes were used in the models to combine two or more parent nodes. These nodes are described here, with the child node listed first and followed by the parent nodes that have been combined to create the child node.

Woodland Caribou

- Lichen Value – Terrestrial Lichen Potential and Arboreal Lichen Potential
- Caribou Forage Potential (for Bearhole/Redwillow Caribou Herd Growing Season, Quintette Caribou Herd Growing Season) – Non-lichen Forage for Caribou and Lichen Value
- Caribou Forage Potential (for Bearhole/Redwillow Caribou Herd Winter Season, Quintette Caribou Herd Winter) - Terrestrial Lichen Potential and Arboreal Lichen Potential
- Bearhole Redwillow Caribou Herd Growing Season Living Habitat Suitability - Caribou Forage Potential and Structural Stage
- Bearhole Redwillow Caribou Herd Winter Living Habitat Suitability - Caribou Forage Potential and Structural Stage
- Quintette Caribou Herd Growing Season Living Habitat Suitability - Caribou Forage Potential and Elevation
- Quintette Caribou Herd Winter Living Habitat Suitability - Caribou Forage Potential and Elevation
- Caribou Winter Living Habitat Suitability – Bearhole Redwillow Winter Habitat Suitability and Quintette Winter Habitat Suitability
- Caribou Growing Season Living Habitat Suitability – Bearhole Redwillow Growing Season Habitat Suitability and Quintette Growing Season Habitat Suitability

Black-throated Green Warbler

- Warbler Topographic Value – Elevation and Slope
- Warbler Stand Structure Value – Generalized Stand Structure and Structural Stage
- Warbler Reproducing Habitat Suitability - Warbler Topographic Value and Warbler Stand Structure Value

Mountain Goat

- Distance to Escape Terrain – Distance to Escape Terrain 0 – 50 m, Distance to Escape Terrain 50 – 100 m, Distance to Escape Terrain 100 – 200 m, Tailings and Generalized Stand Structure Mapping
- Goat Growing Season Habitat Suitability – Elevation, Distance to Escape Terrain and Forage Availability
- Goat Winter Habitat Suitability - Distance to Escape Terrain and Forage Availability

Moose

- Moose Growing Season Food Availability – Generalized Stand Structure, Moose Shrub Availability and Moose Herb Availability
- Moose Habitat Potential (growing season) – Slope and Moose Growing Season Food Availability
- Moose Habitat Potential (winter) – Slope, Moose Access to Food and Moose Access to Thermal
- Moose High Quality Habitat Modifier – Structural Adjacency, Wetland and Riparian
- Moose Growing Season Habitat Suitability - Moose Habitat Potential and Moose High Quality Habitat Modifier
- Moose Access to Thermal - Moose Winter Thermal and Snow Load
- Moose Access to Food – Moose Shrub Availability and Snow Load
- Moose Winter Habitat Suitability – Generalized Stand Structure, Moose Habitat Potential (winter season) and Moose High Quality Habitat Modifier

Grizzly Bear

- Grizzly Topographic Value for Fall – Elevation and Structural Stage
- Grizzly Fall Forage Potential - Grizzly Topographic Value for Fall and BEC Zone Berry-producing Potential
- Grizzly Fall Habitat Suitability - Grizzly Fall Forage Potential and Distance to Roads
- Grizzly Topographic Value for Summer – Elevation and Aspect
- Grizzly Fall Forage Potential - Grizzly Topographic Value for Summer and Structural Stage
- Grizzly Summer Habitat Suitability - Grizzly Fall Forage Potential and Distance to Roads

- Grizzly Topographic Value – Elevation and Aspect
- Grizzly Spring Forage Potential – Generalized Stand Structure, Grizzly Topographic Value and Canopy Closure
- Grizzly Spring Habitat Suitability - Grizzly Spring Forage Potential and Distance to Roads

Fisher

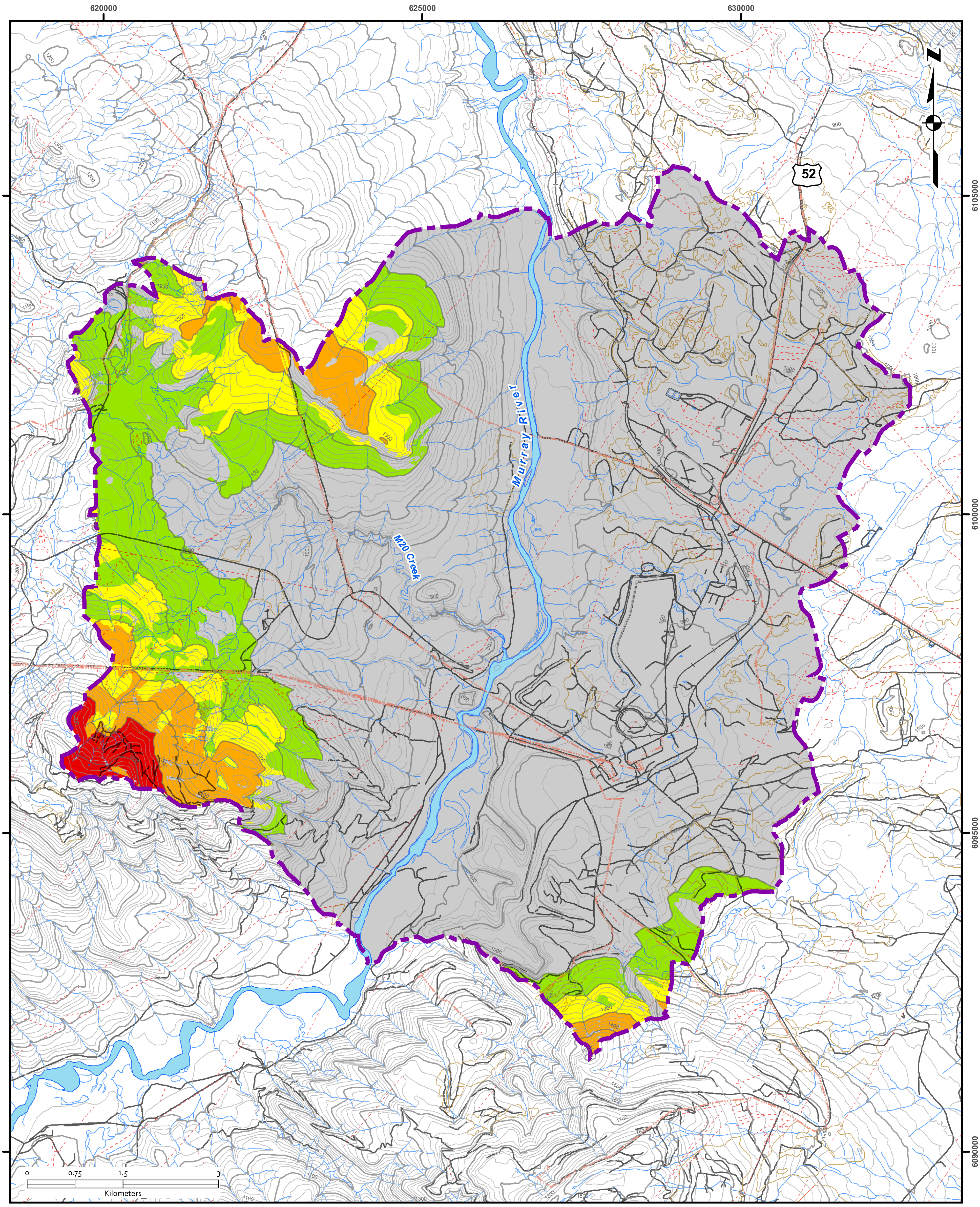
- Stand Structure Value – Forest Type and Structural Stage
- Canopy Structure Value – Canopy Closure and Canopy Structure
- Canopy and Stand Structure Value – Canopy Structure Value and Stand Structure Value
- Fisher Foraging Value – CWD Abundance and Shrub Cover
- Fisher Birthing Potential – Birthing Tree Presence Potential and Structural Stage
- Fisher Habitat Potential – Fisher Foraging Value and Canopy and Stand Structure Value
- Fisher High Quality Habitat Modifier – Structural Adjacency and Riparian
- Topographic Value – Aspect and Slope
- Fisher Birthing Habitat Suitability - Fisher Birthing Potential, Fisher Habitat Potential, Elevation and Fisher High Quality Habitat Modifier
- Fisher All Seasons Habitat Suitability - Fisher Habitat Potential, Elevation and Fisher High Quality Habitat Modifier

Elk

- Elk Winter Feeding – Shrubs for Elk, Herbs for Elk and Structural Stage
- Elk Access to Food – Elk Winter Feeding and Snow Load
- Elk Access to Thermal – Elk Winter Thermal and Snow Load
- Elk Habitat Potential (winter) – Elk Access to Food and Elk Access to Thermal
- Elk Habitat Potential (growing season) - Elk Topographic Value for Growing Season and Herbs for Elk
- Elk Topographic Value for Growing Season – Structural Stage, Elevation and Aspect

- Elk Winter Habitat Suitability - Elk Habitat Potential (winter) and Riparian High Quality Habitat Modifier
- Elk Growing Season Habitat Suitability – Elk Habitat Potential (growing season) and Riparian High Quality Habitat Modifier

APPENDIX E HABITAT SUITABILITY RATINGS



LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

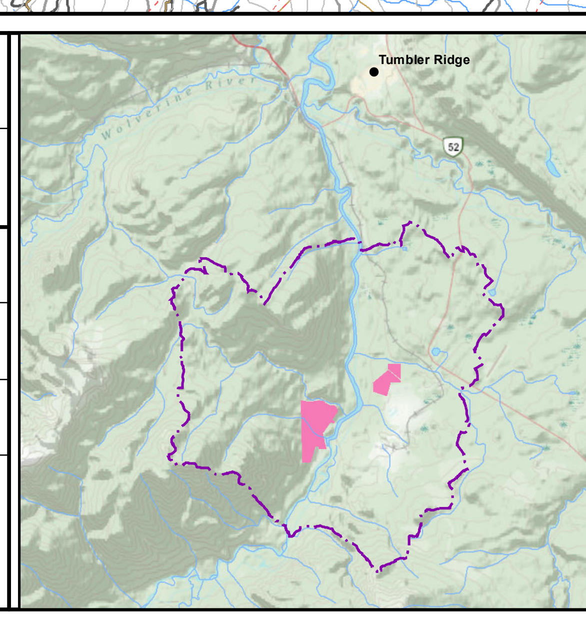
Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Woodland Caribou, Quintette Herd
Winter Season Living Habitat Suitability

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	12-V-0073
Date:	Data Sources:
10/01/2014	Refer to References Section

EDI



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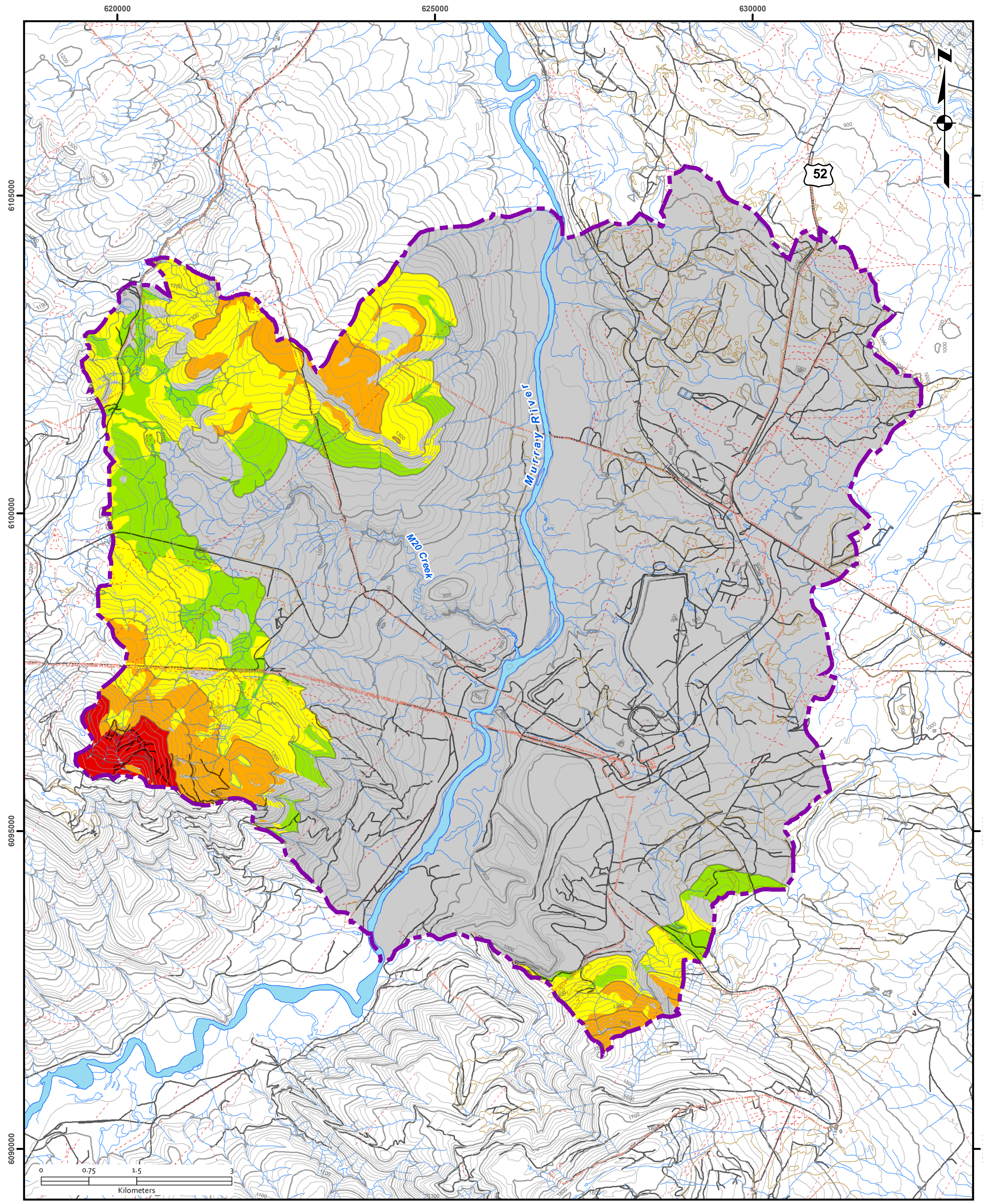


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

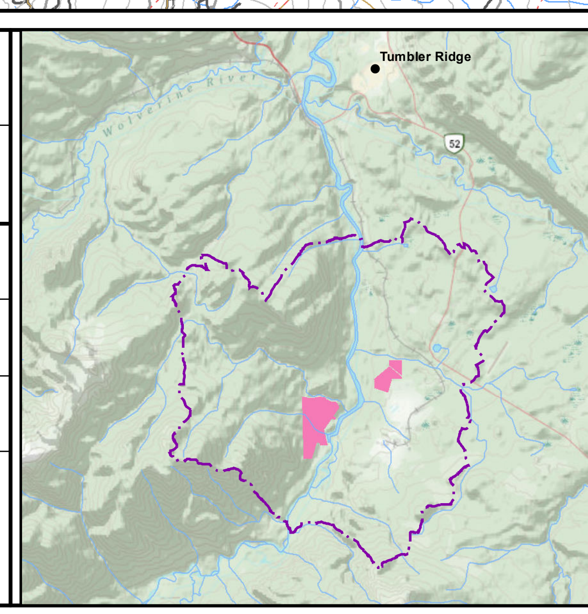
Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Woodland Caribou, Quintette Herd
Growing Season Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section



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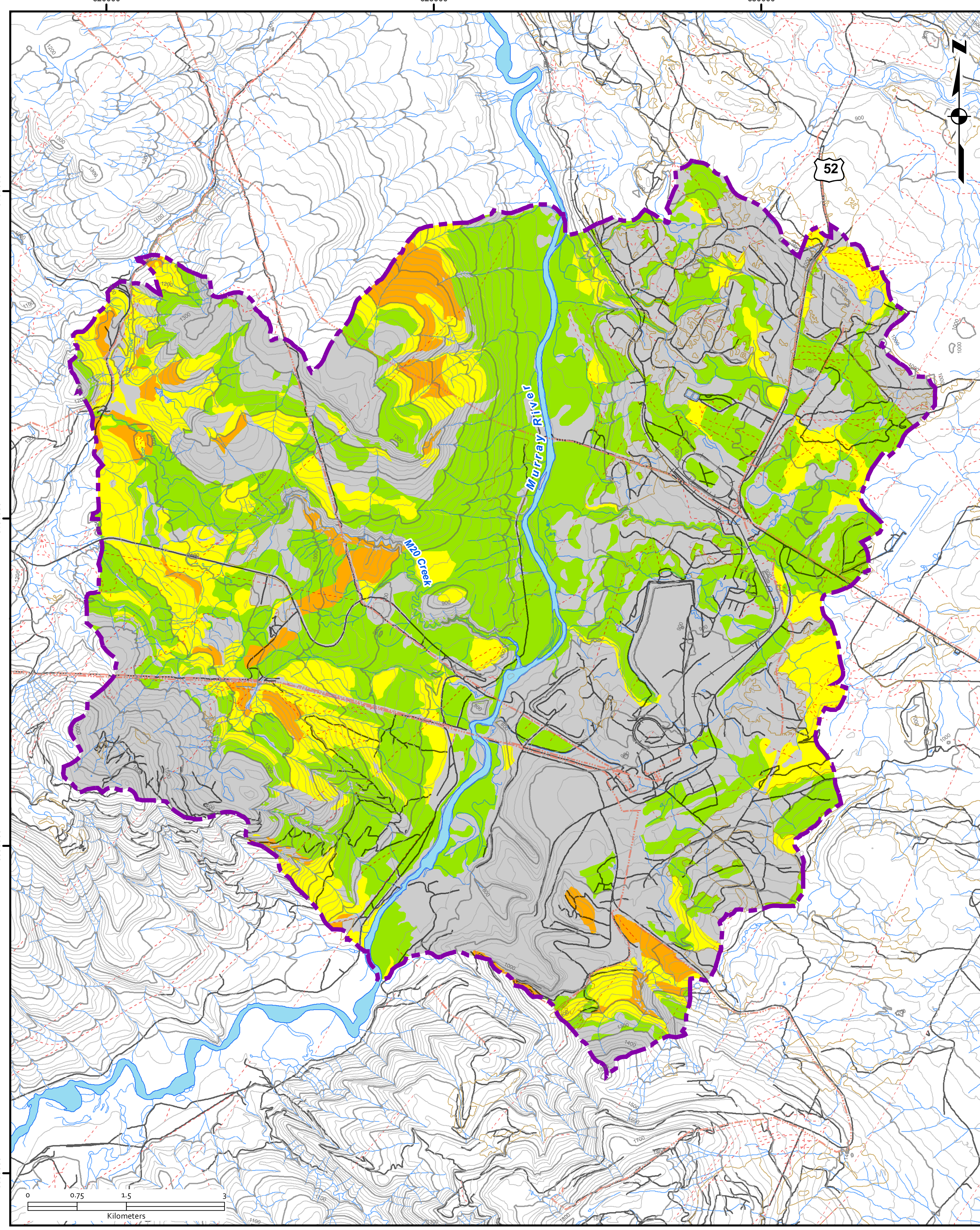


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

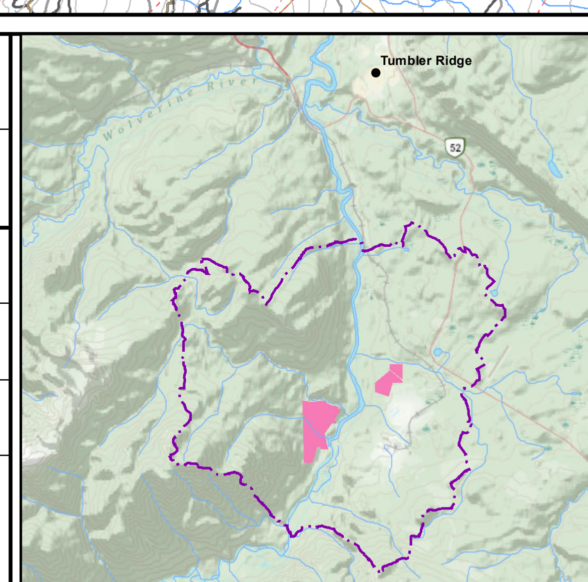
Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Woodland Caribou, Bearhole/Redwillow Herd Winter Season Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

EDI



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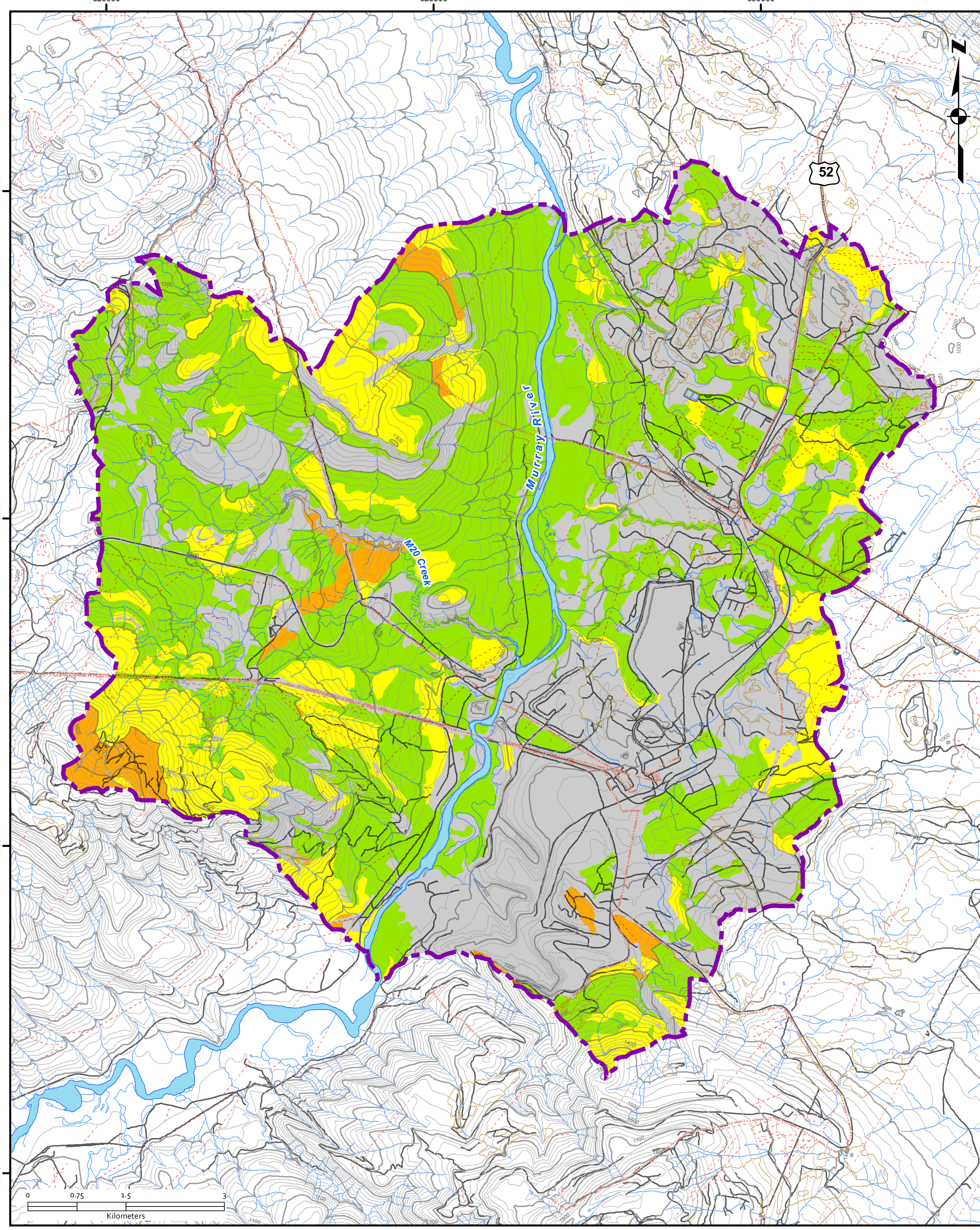

LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Woodland Caribou, Bearhole/Redwillow Herd Growing Season Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

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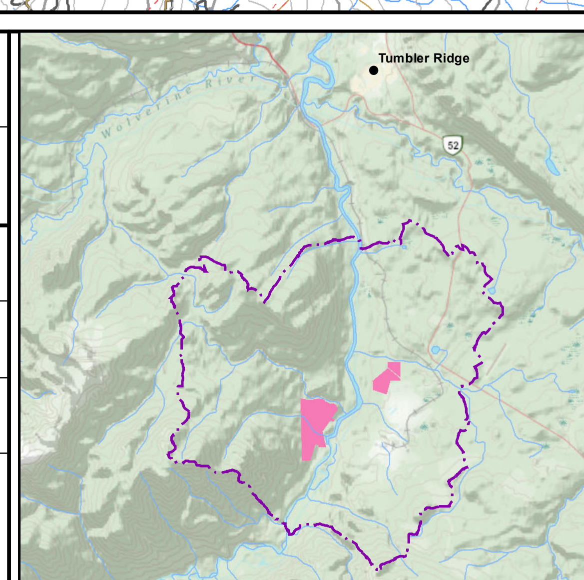

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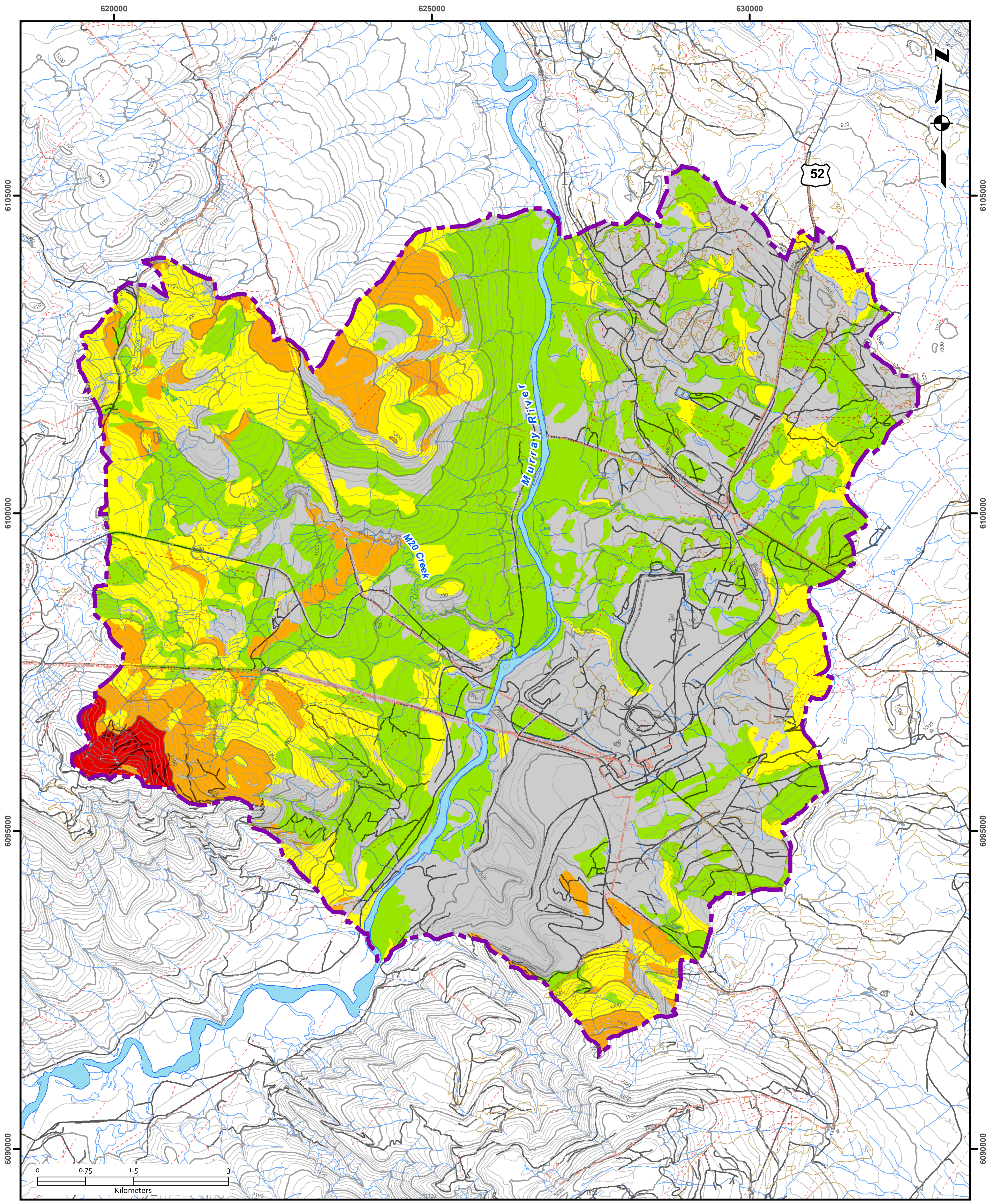


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Original Map Size 11x17in

Scale: 1:60,000

INSET LEGEND

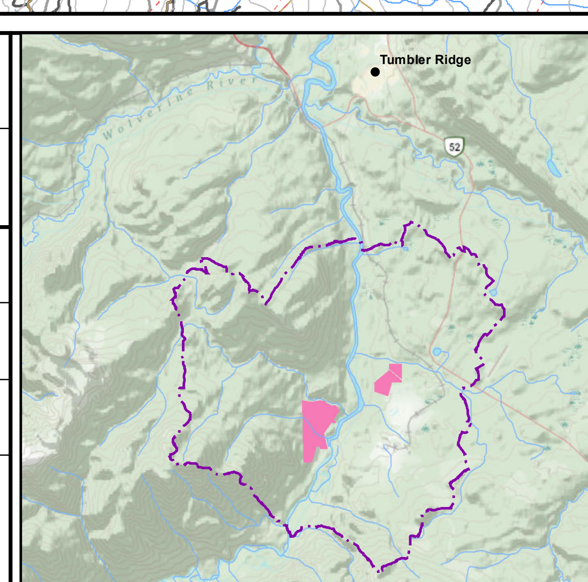
- Local Study Area
- Potential Mine Surface Development Area

Murray River Project
Wildlife Habitat Ratings

Woodland Caribou Winter Living Habitat Suitability

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	14-P-0025
Date:	Data Sources:
04/04/2014	Refer to References Section

EDI



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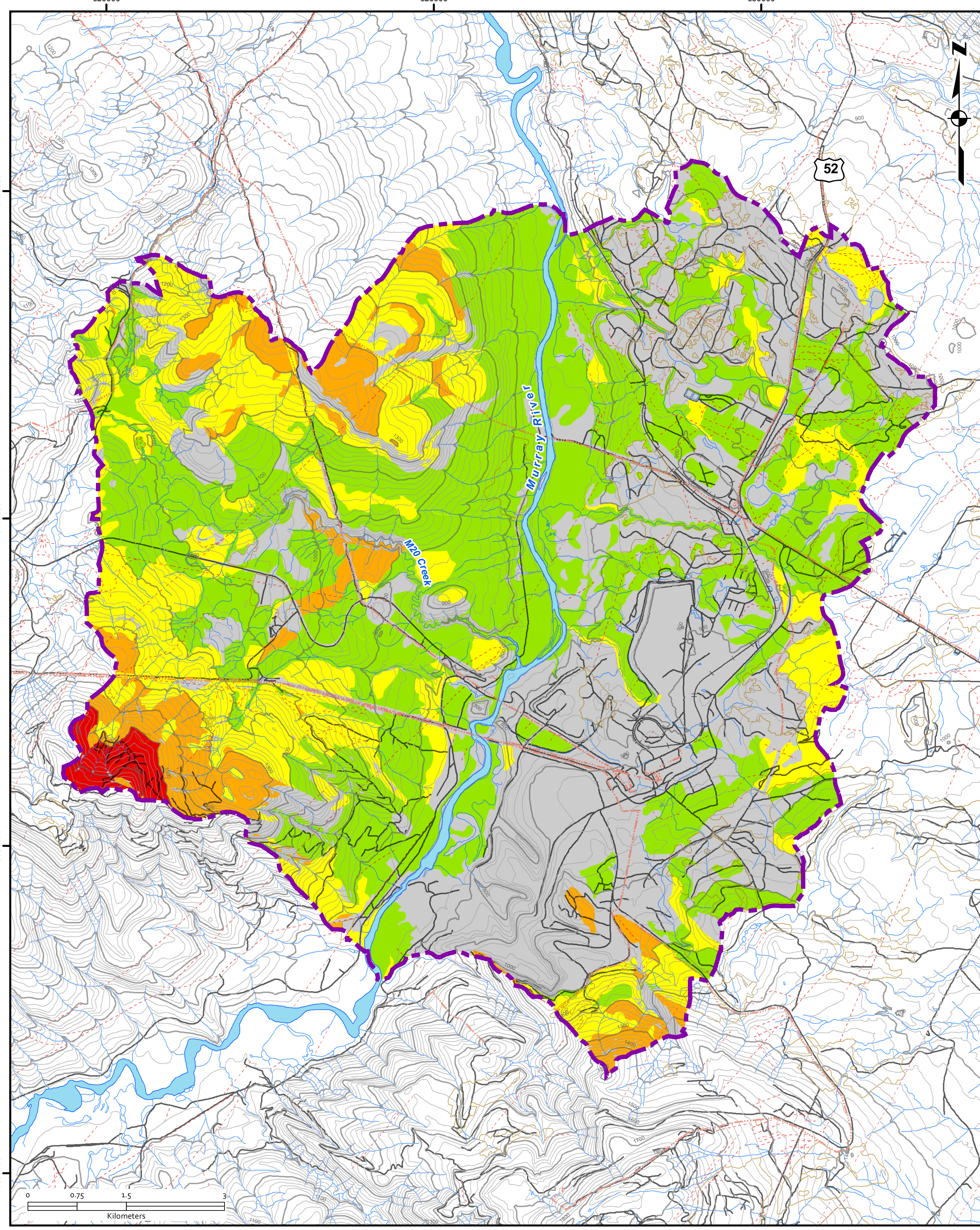

LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Woodland Caribou Growing Season Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 14-P-0025
Date: 03/04/2014	Data Sources: Refer to References Section

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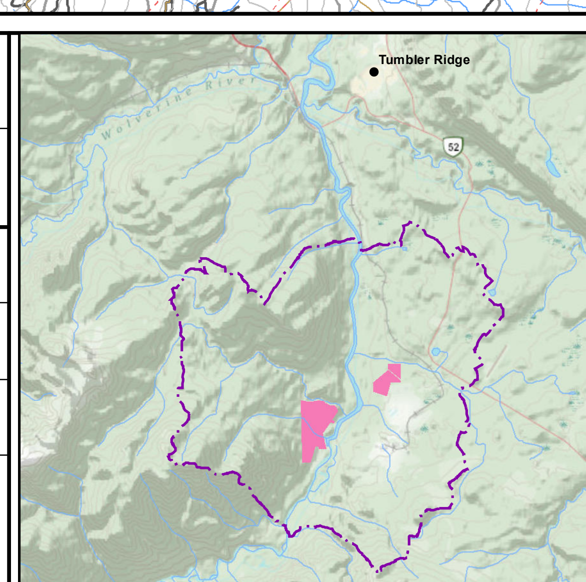

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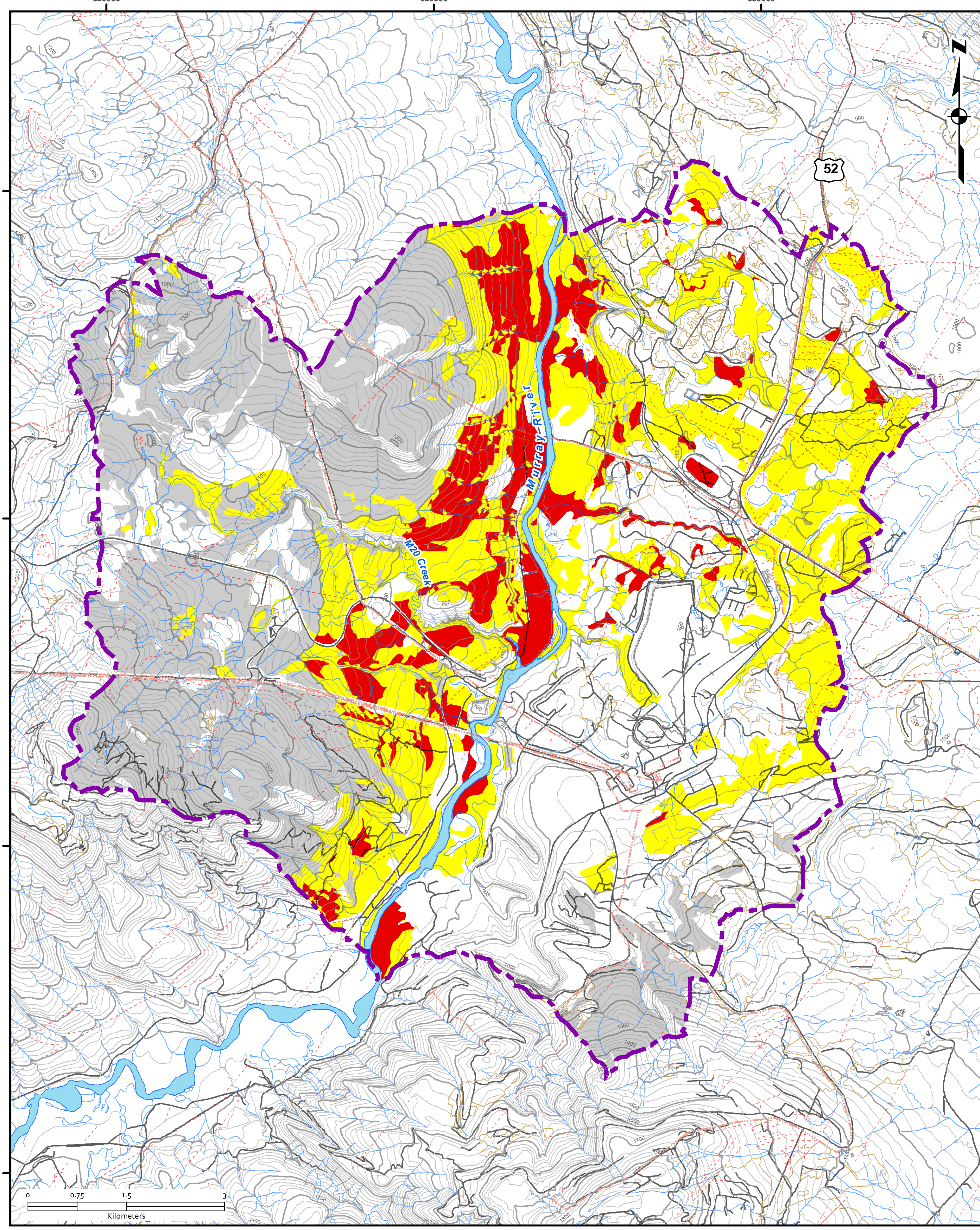


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderate
- Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

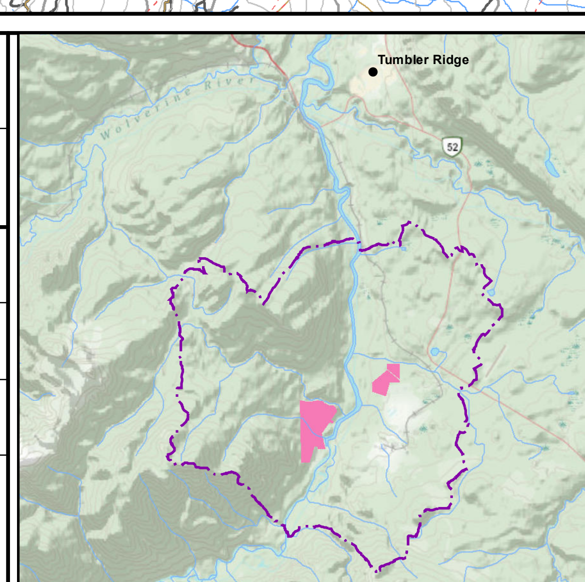
Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Black-throated Green Warbler
Reproducing Habitat Suitability

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	12-V-0073
Date:	Data Sources:
10/01/2014	Refer to References Section

EDI



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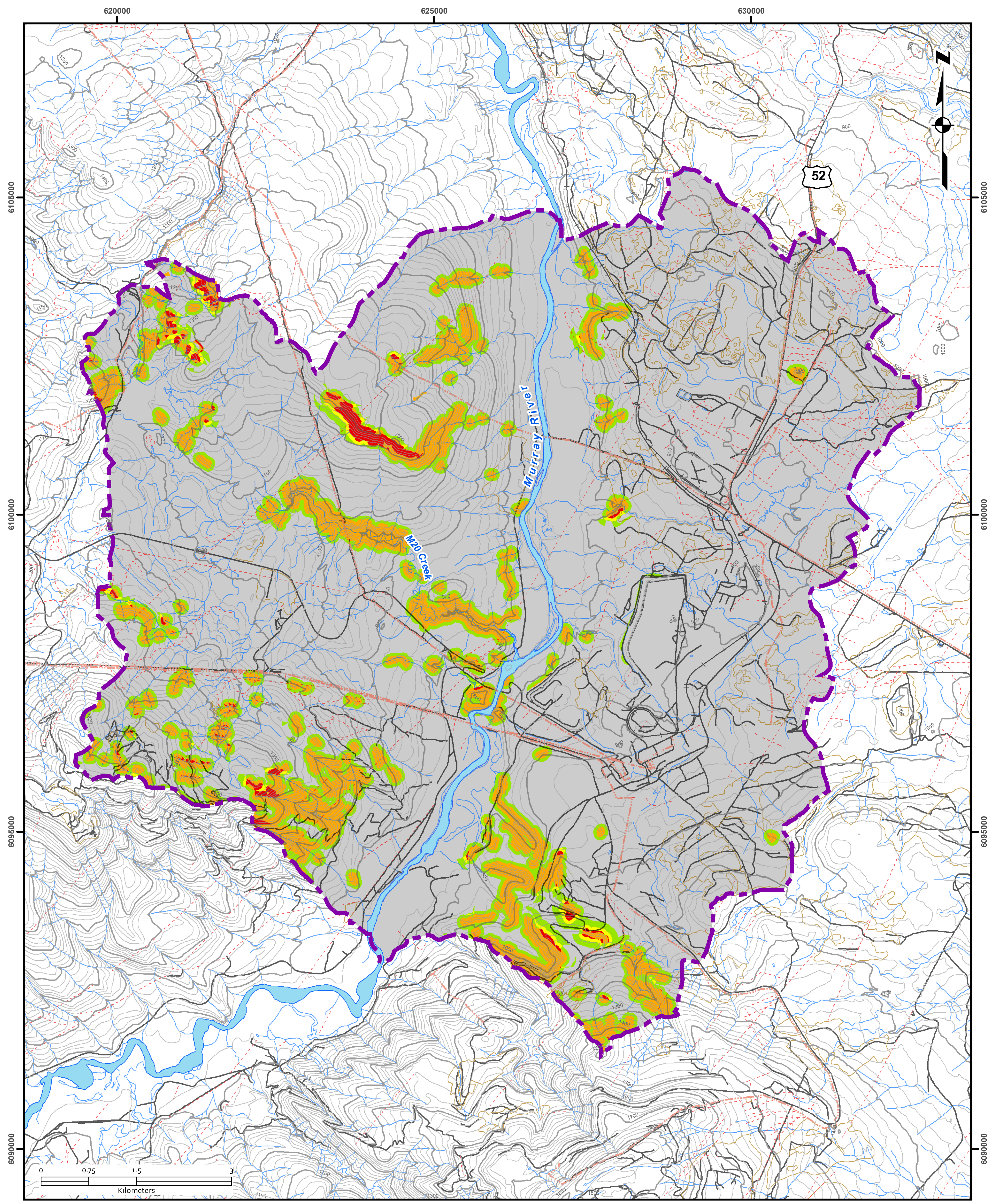


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

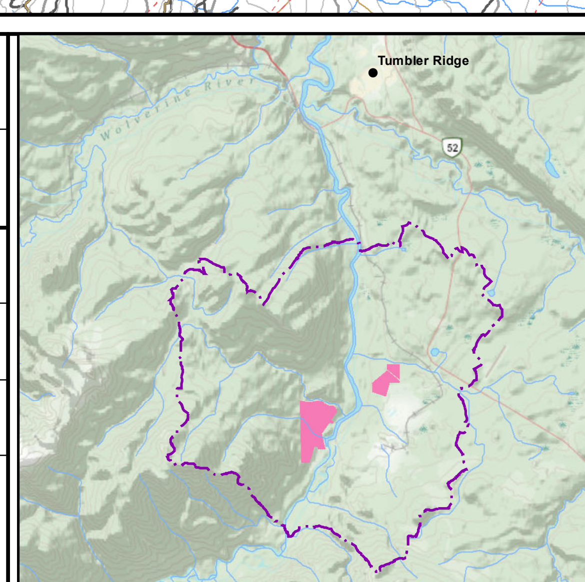
Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Mountain Goat Winter Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section



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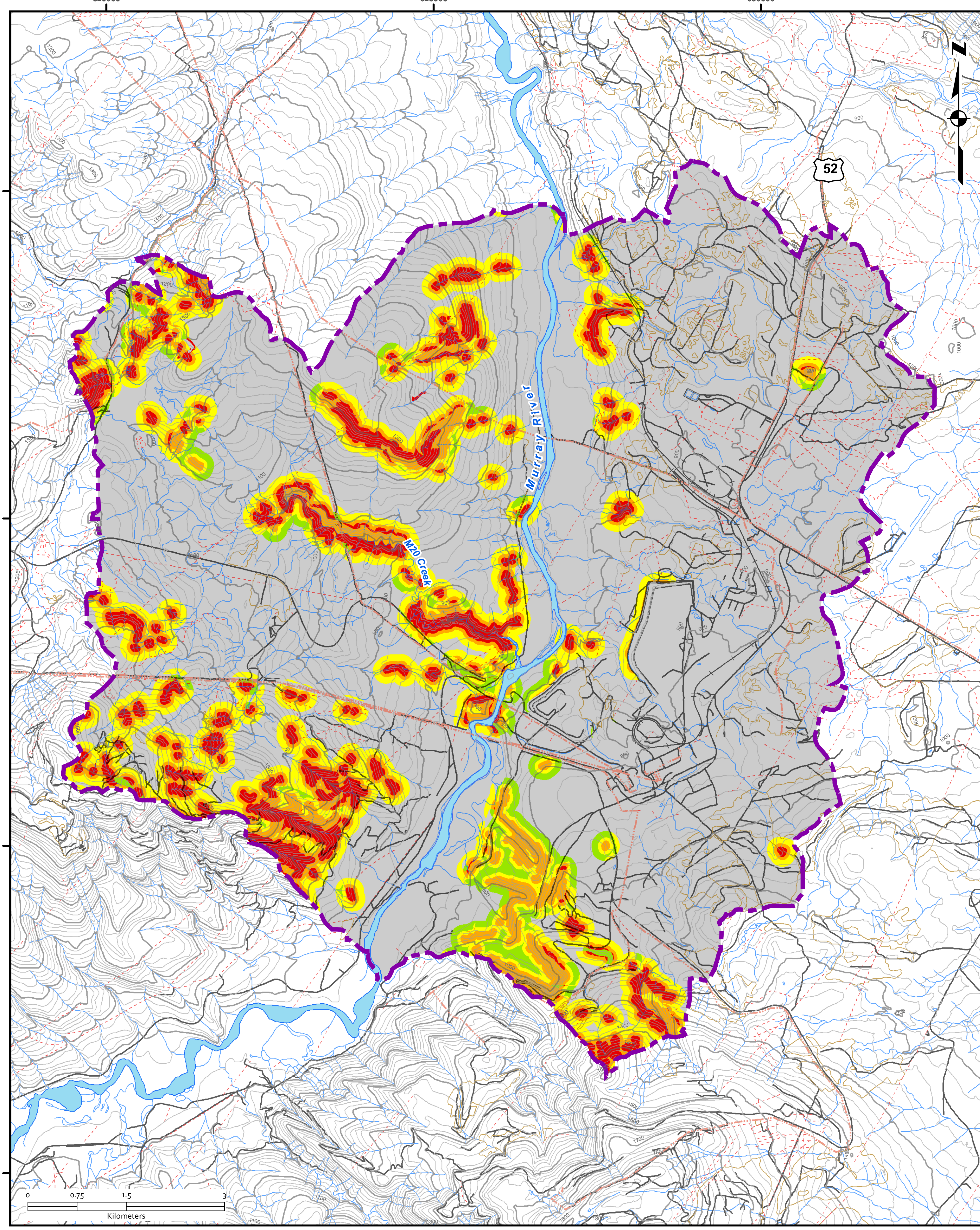


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

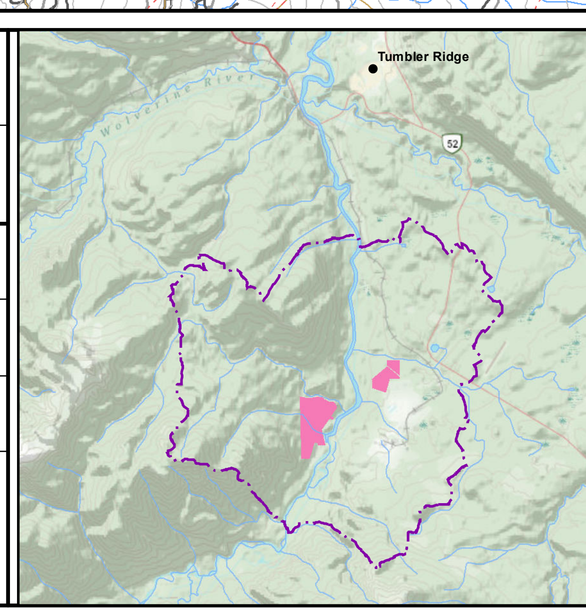
Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Mountain Goat Growing Season
Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section



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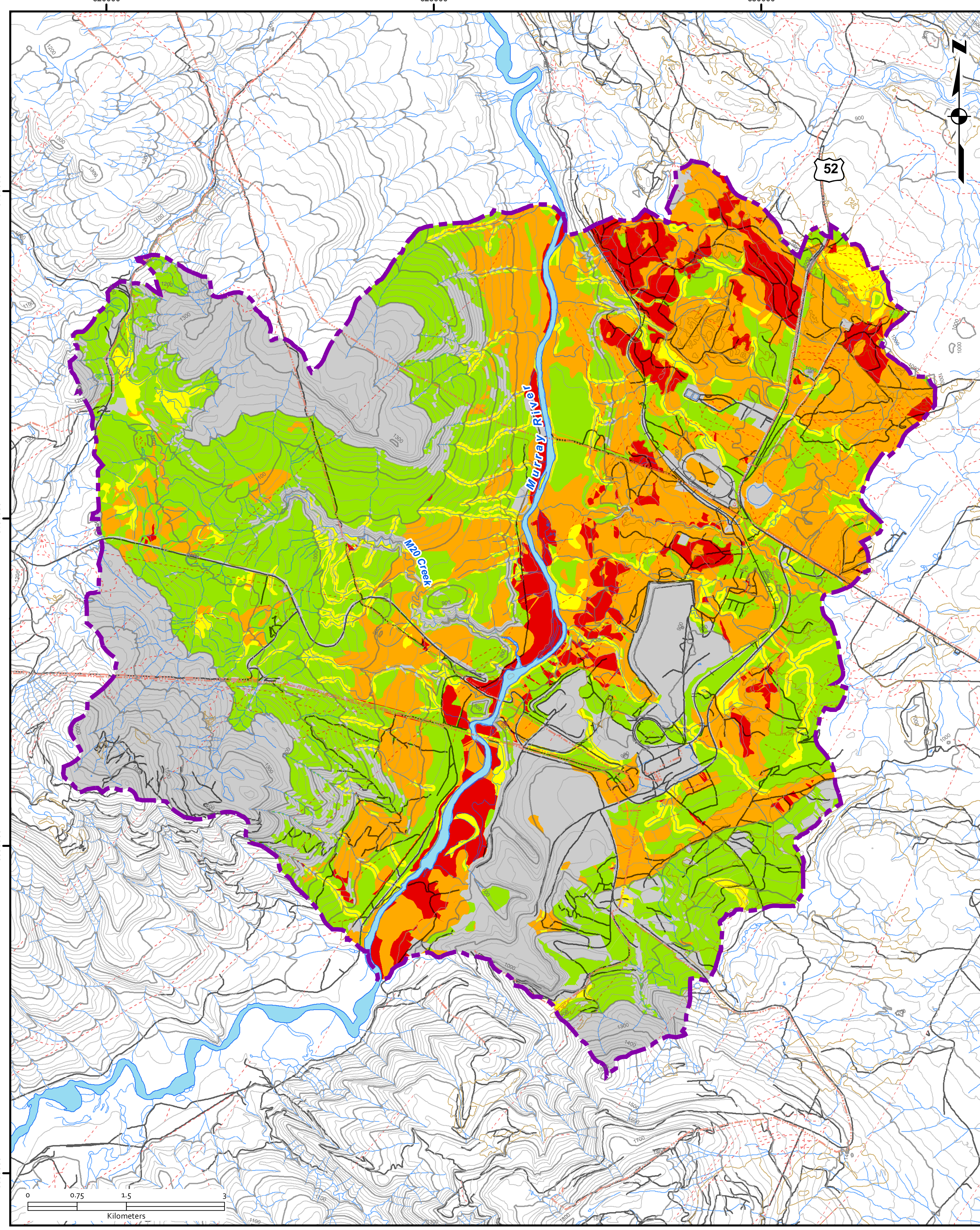

LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Moose Winter Living
Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

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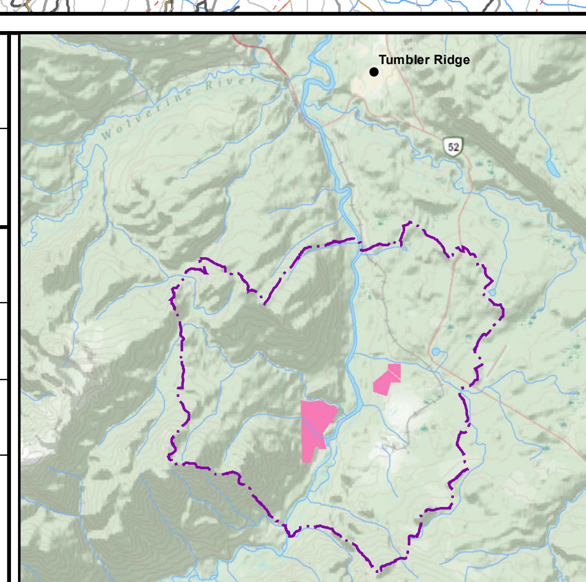

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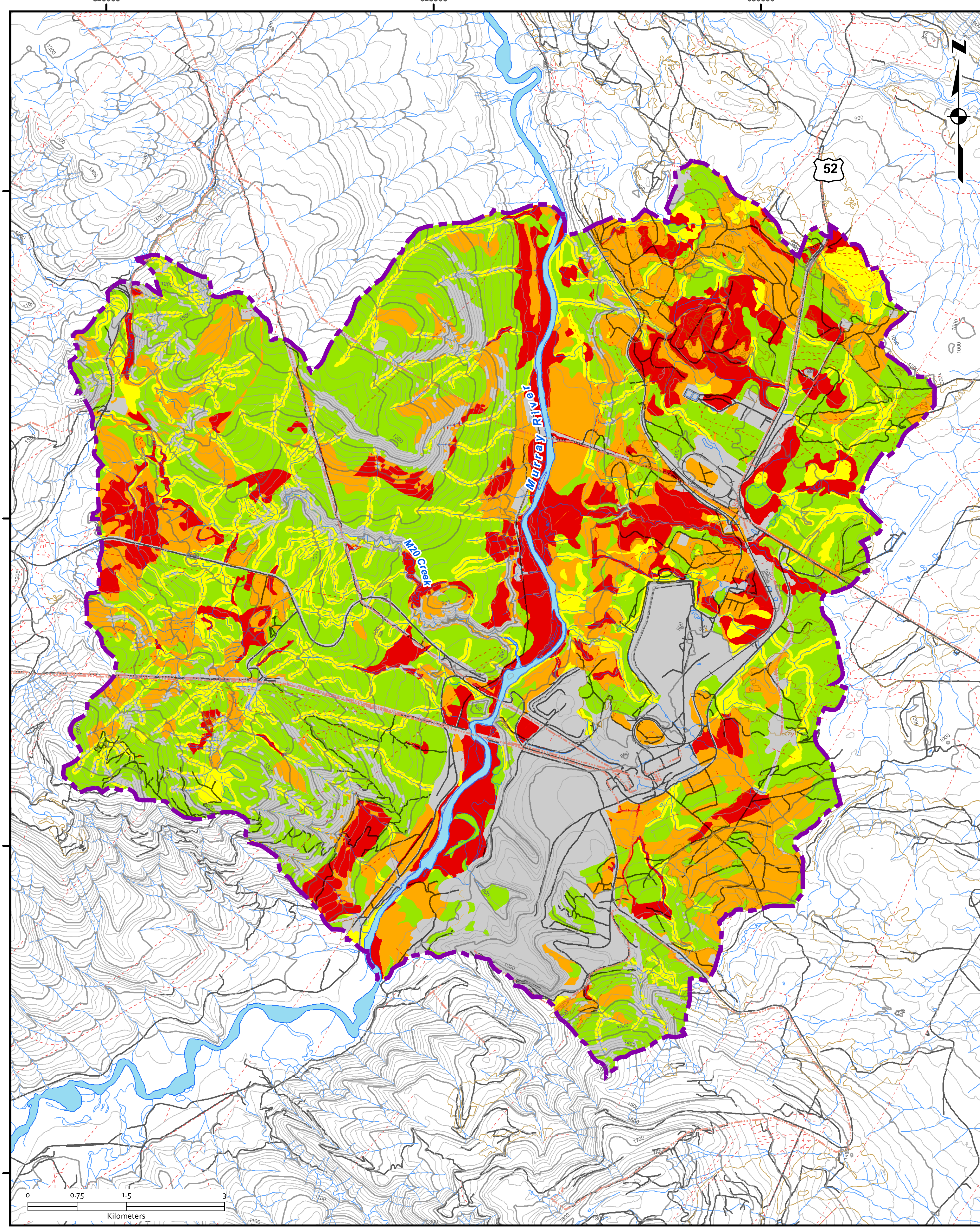

LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Moose Growing Season Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

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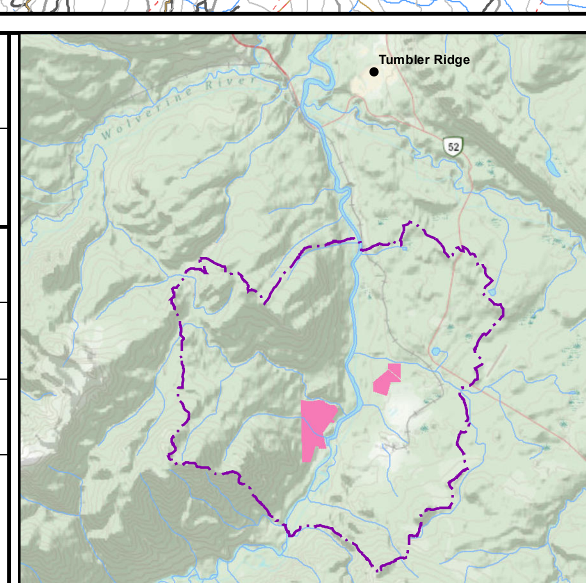

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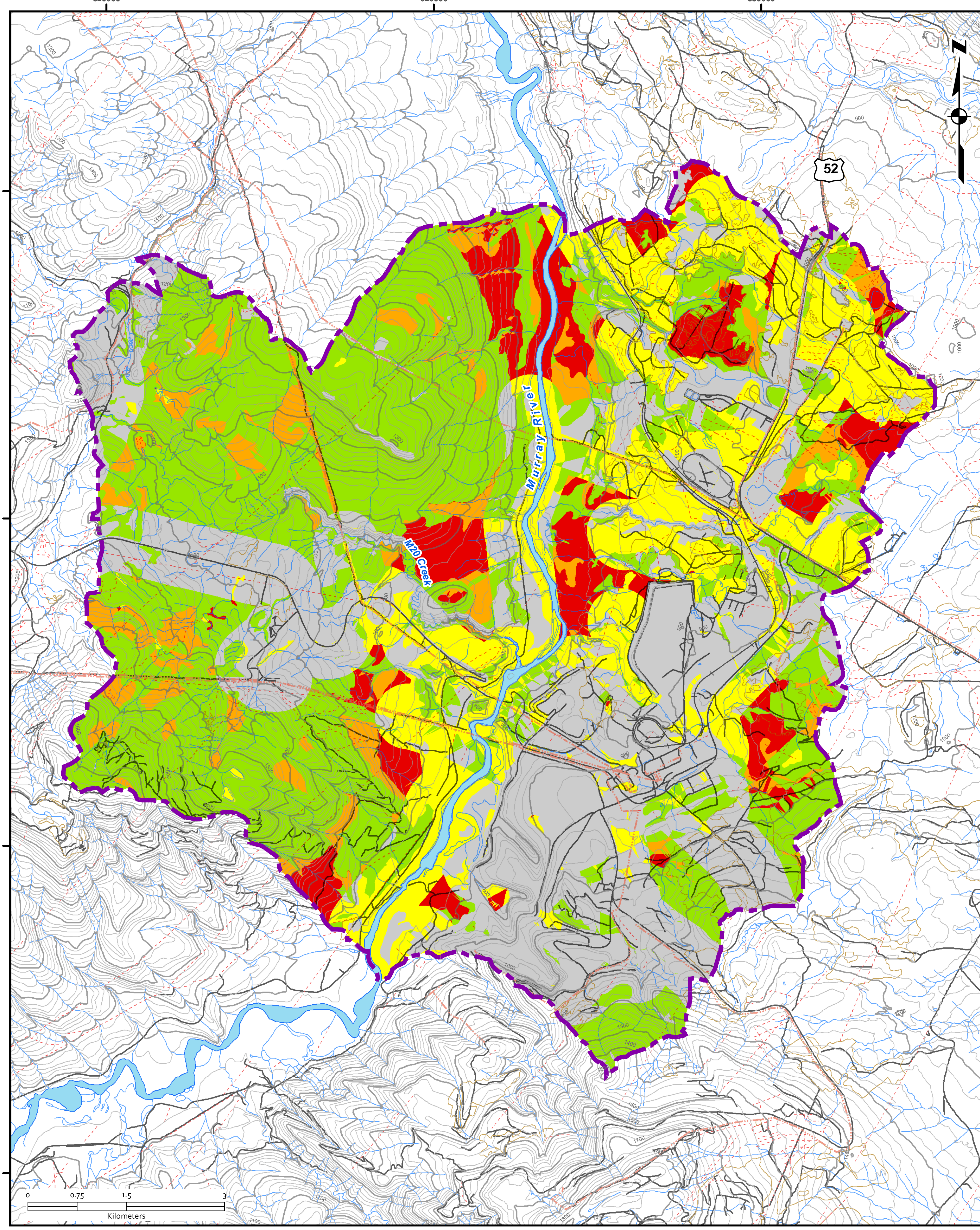


LEGEND

Local Study Area
Intermediate Contour (20m Interval)
Index Contour (100m Interval)
Transmission Line; Pipeline; Linear Disturbance
Cutline; Seismic Line; Trail
Cut Block; Burn
Railways
Road
Streams/Lakes

Habitat Suitability Class

High
Moderately High
Moderate
Low
Very Low
Nil

INSET LEGEND

Local Study Area
Potential Mine Surface Development Area

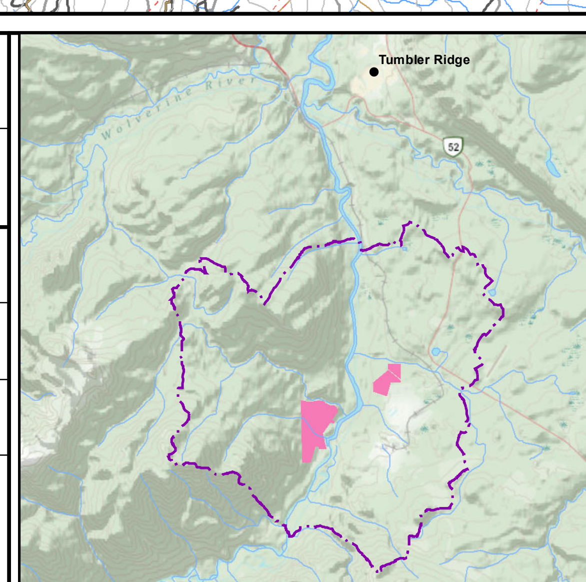
Original Map Size 11x17in

Scale: 1:60,000

Murray River Project Wildlife Habitat Ratings

Grizzly Bear Spring Living Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section



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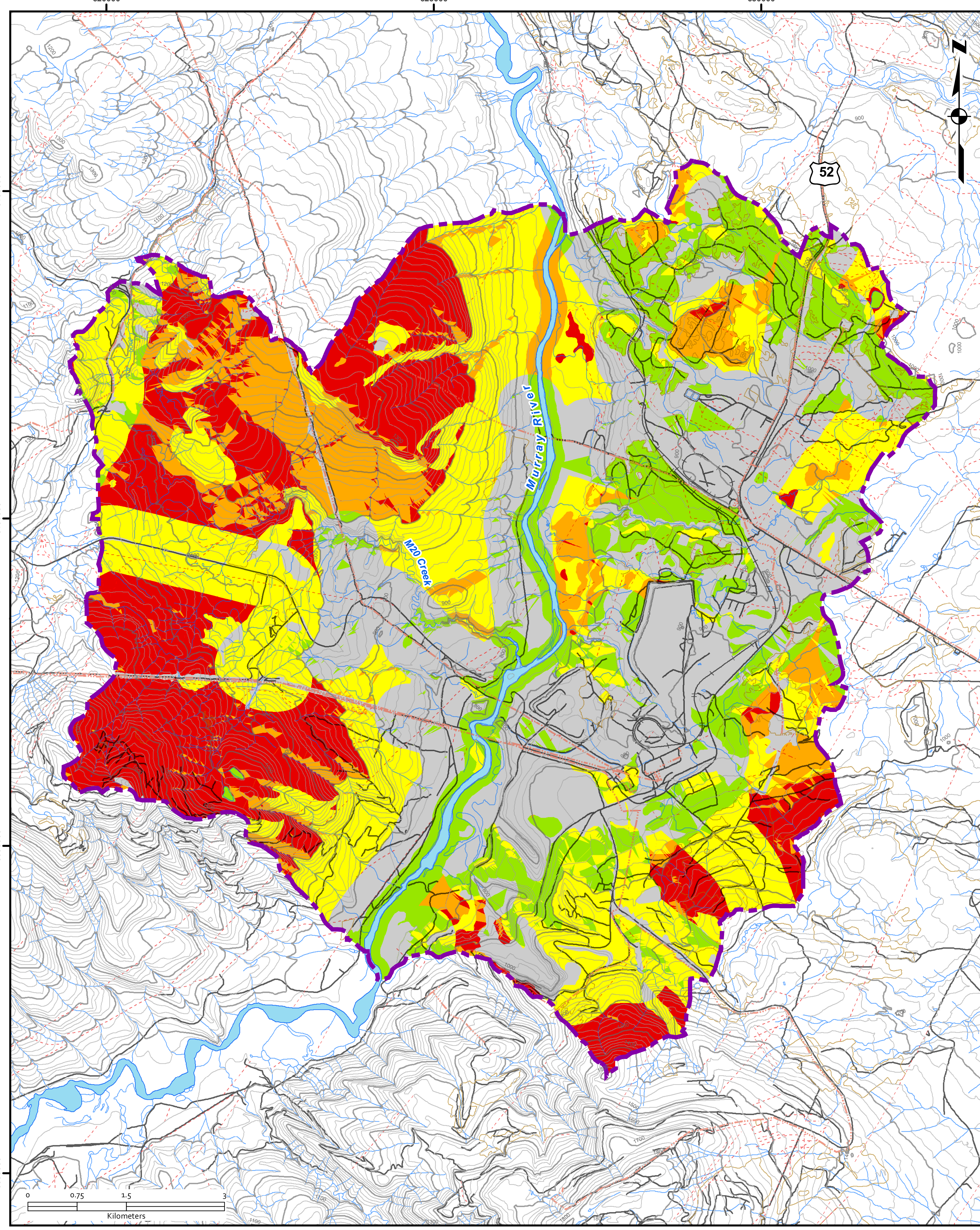


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

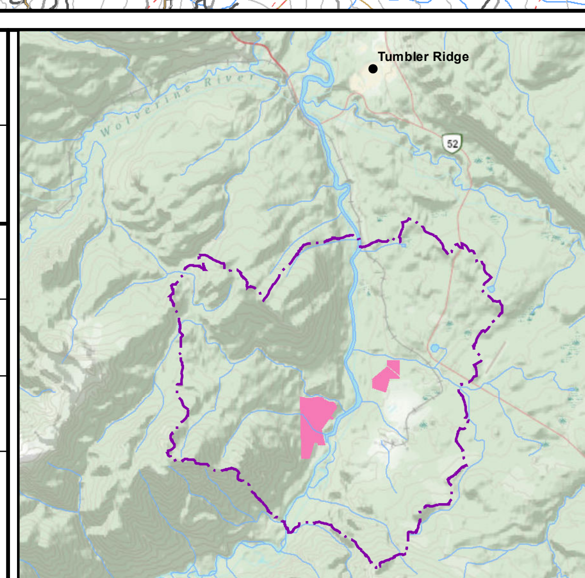
Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Grizzly Bear Summer Living Habitat Suitability

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	12-V-0073
Date:	Data Sources:
10/01/2014	Refer to References Section

EDI



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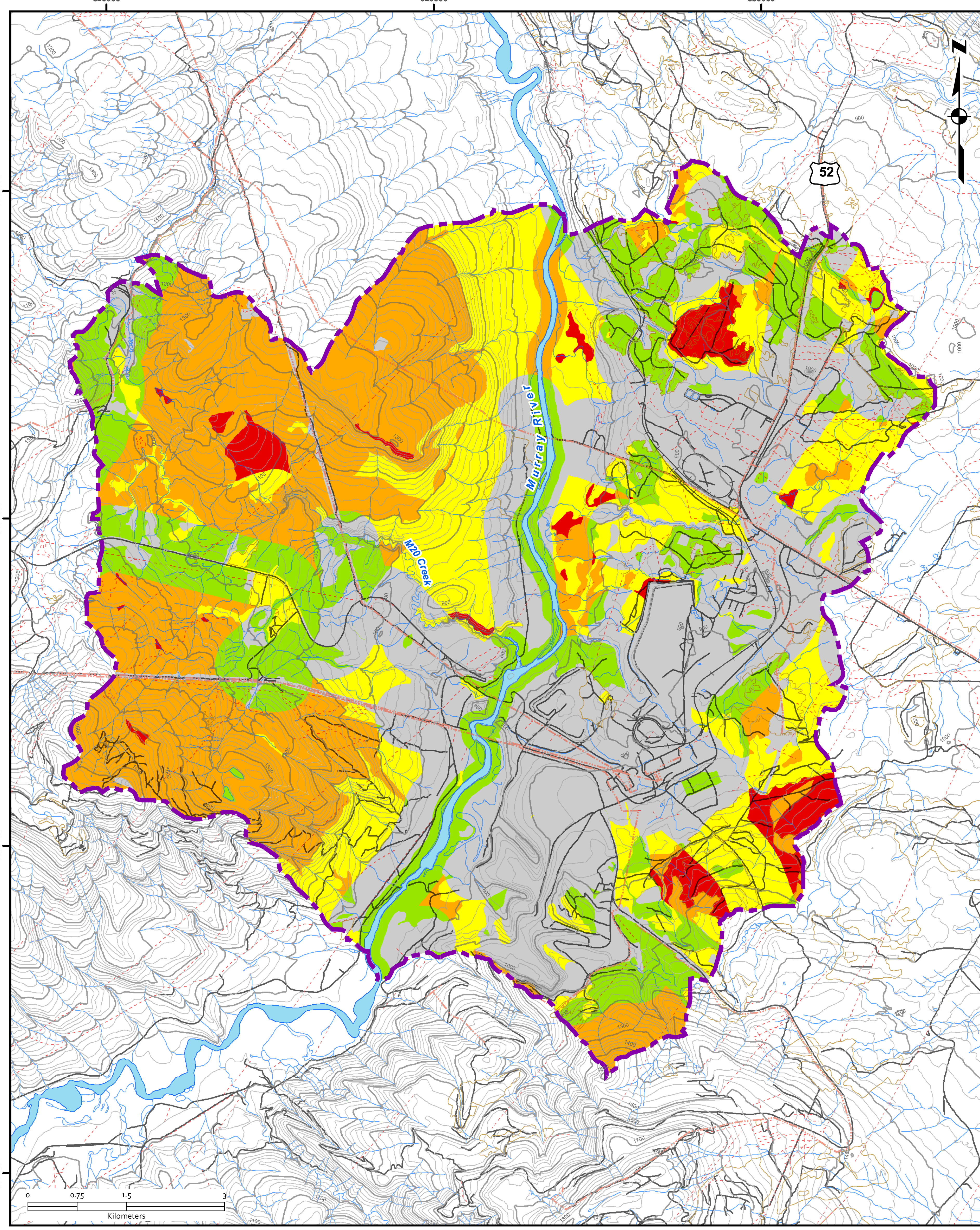

LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Grizzly Bear Fall Living
Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

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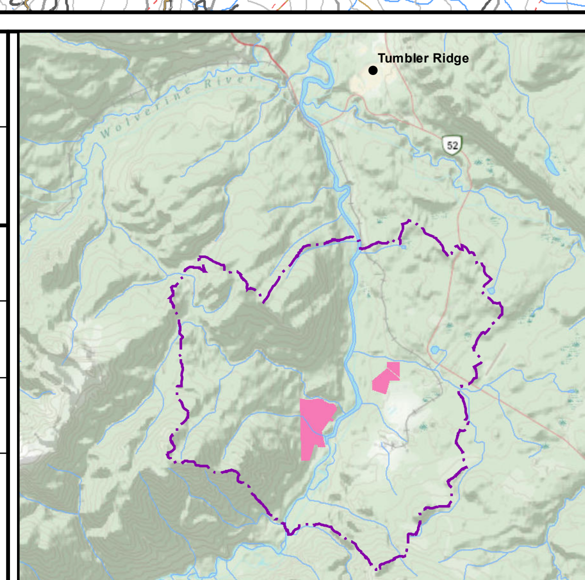

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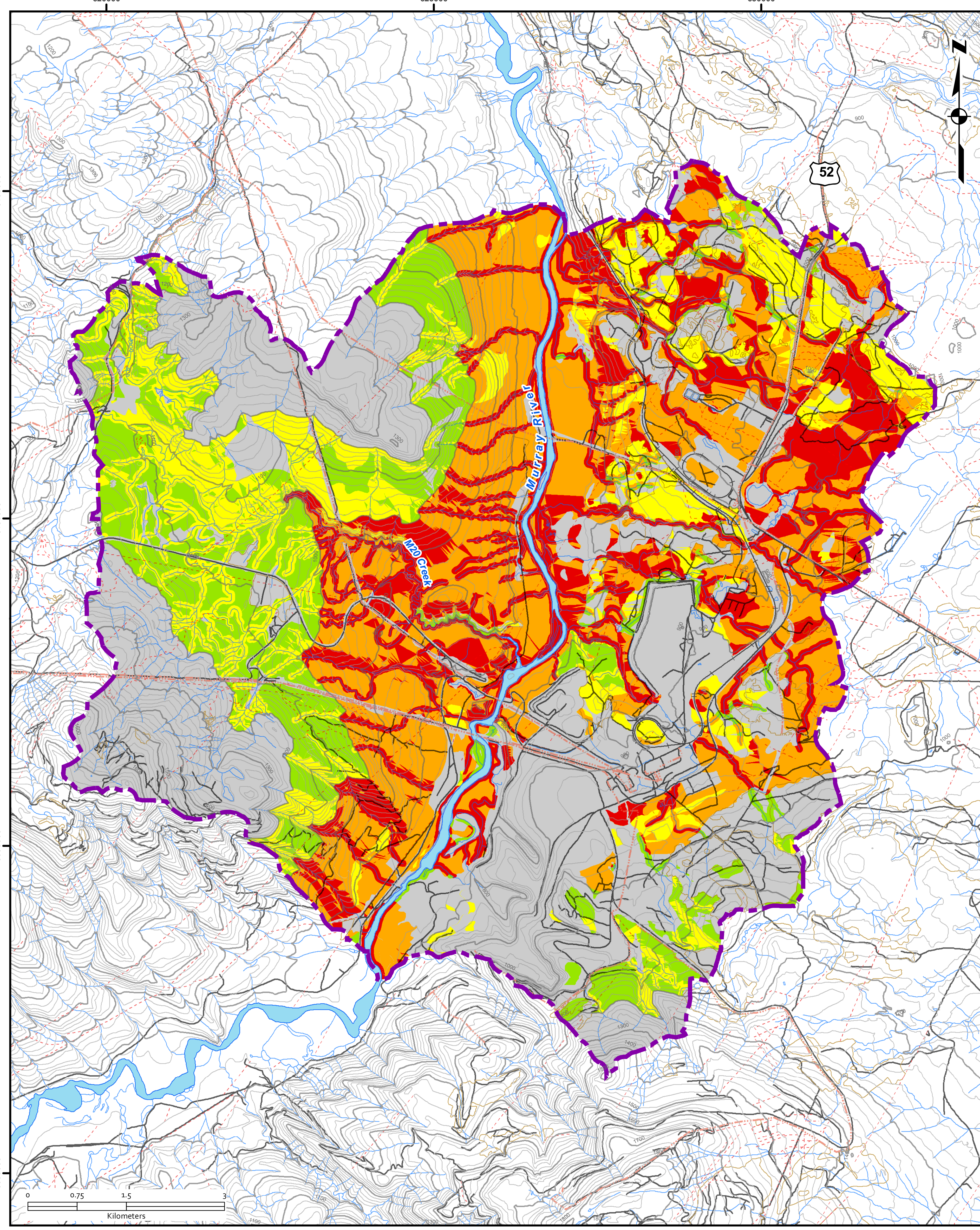


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

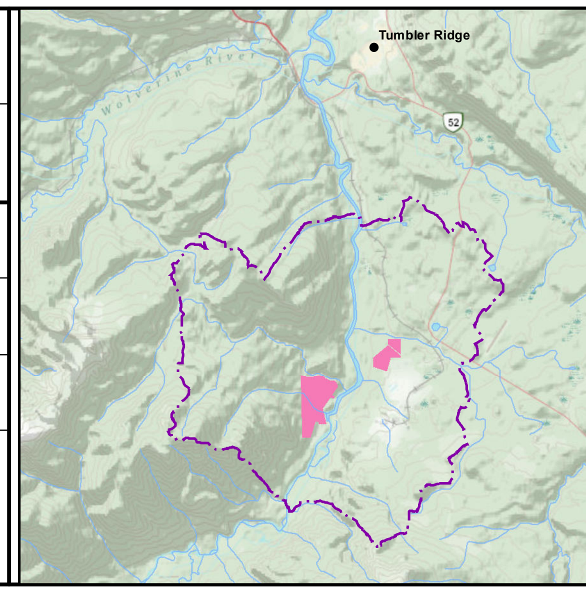
Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Fisher All Seasons Living Habitat Suitability

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	12-V-0073
Date:	Data Sources:
10/01/2014	Refer to References Section

EDI



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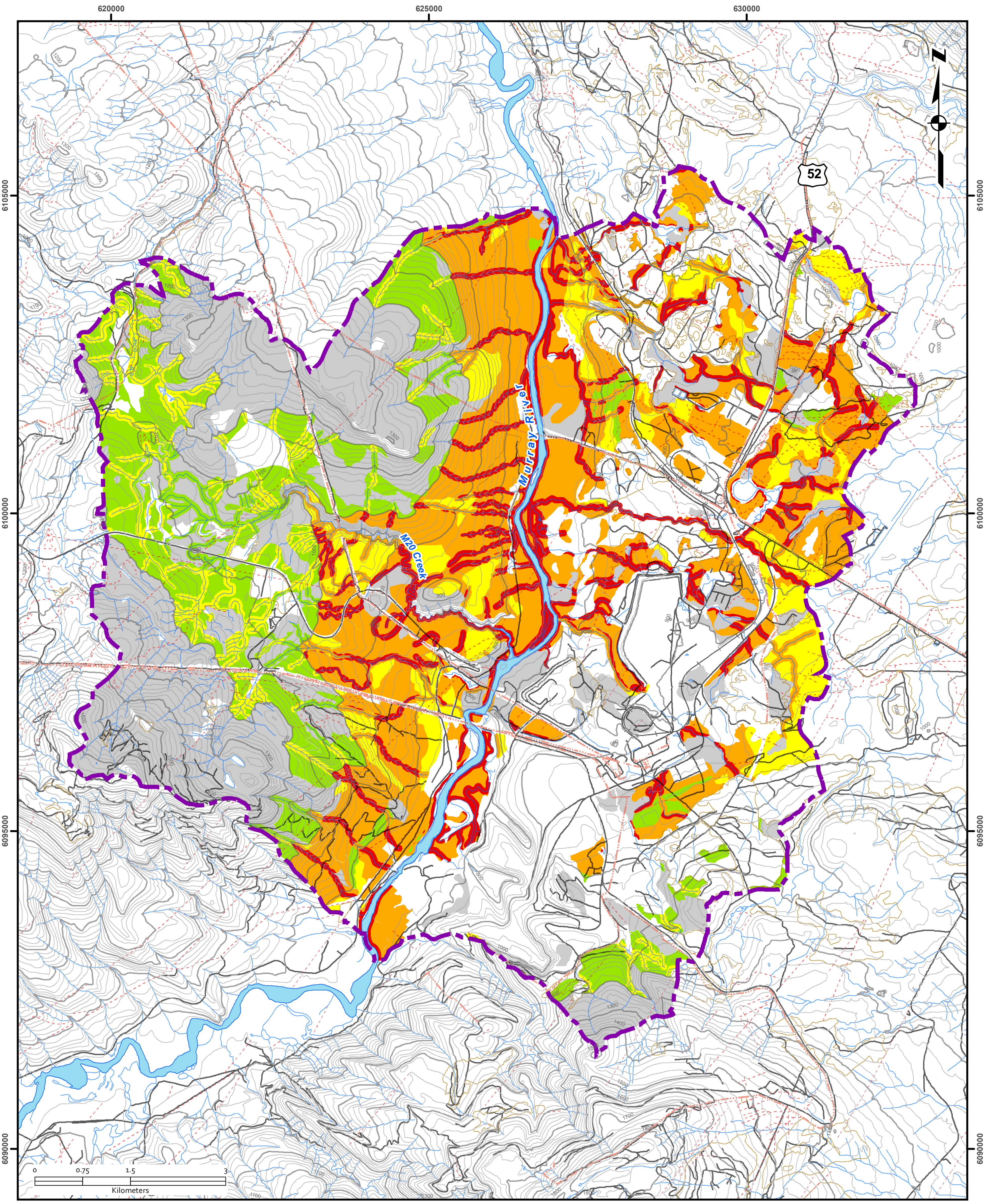


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

Original Map Size 11x17in

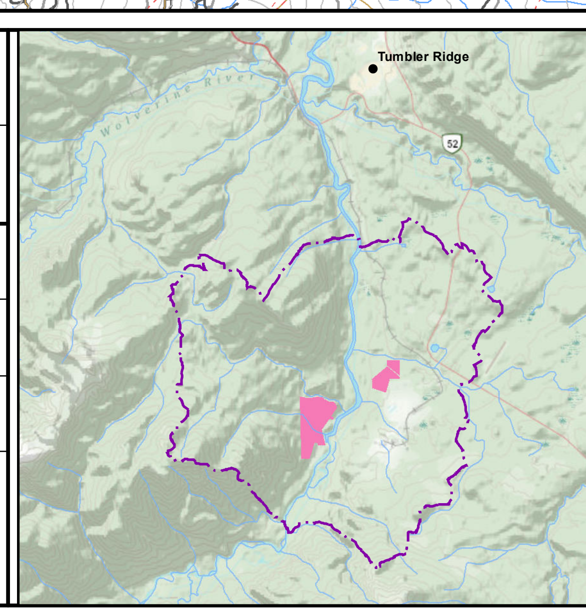
Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Fisher Birthing
Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

EDI



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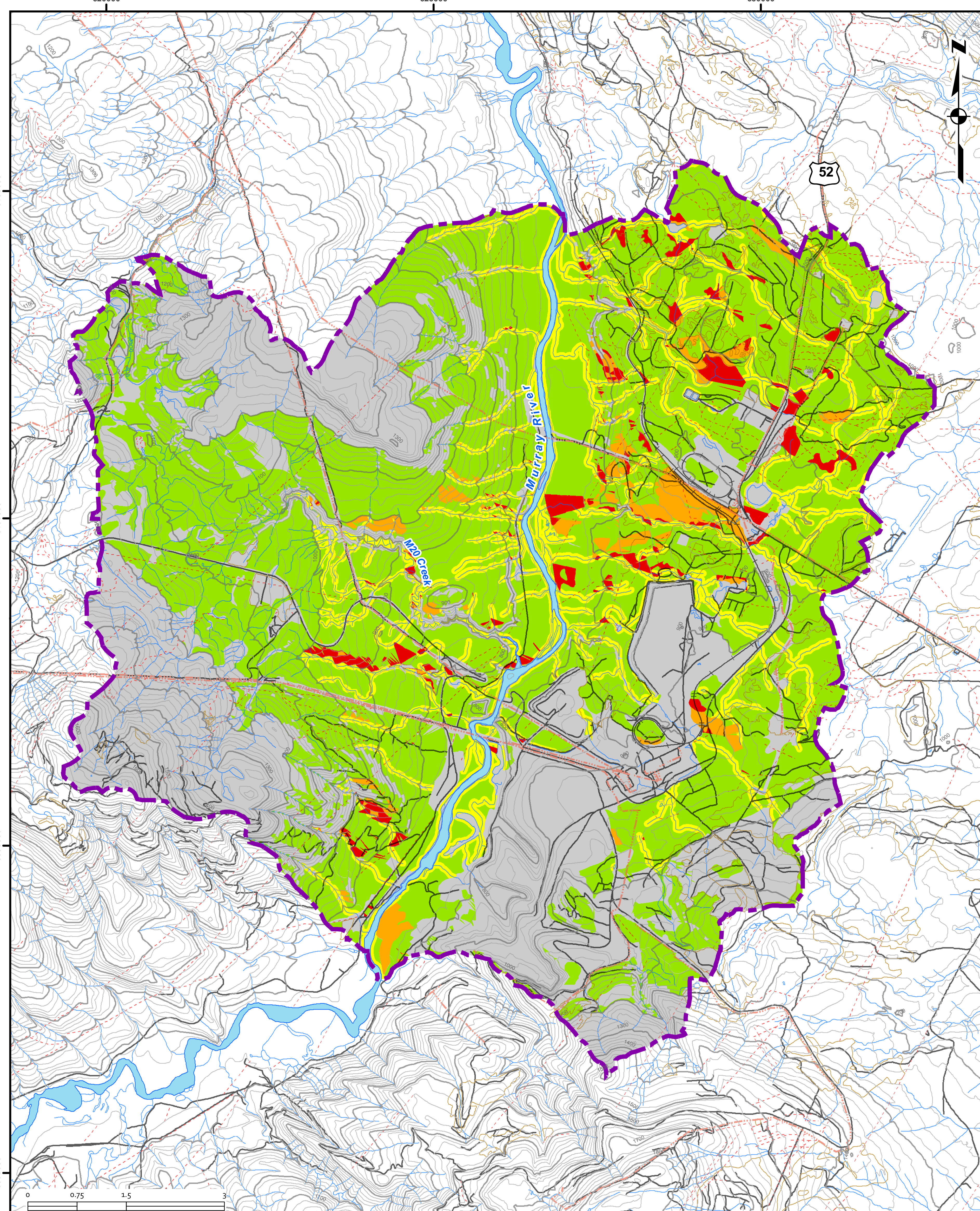


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

Original Map Size 11x17in

Scale: 1:60,000

INSET LEGEND

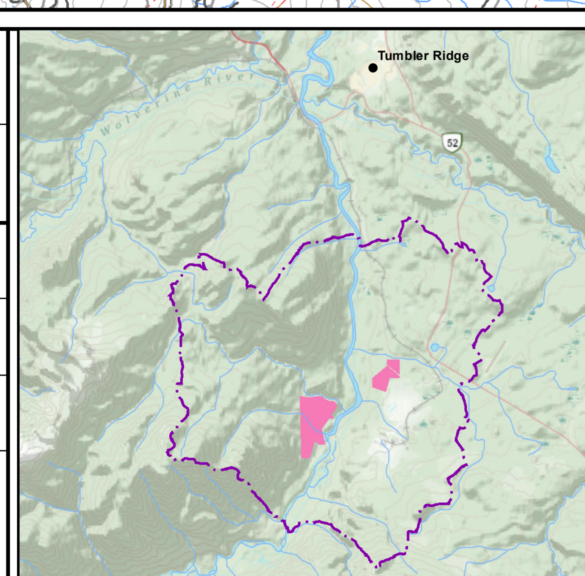
- Local Study Area
- Potential Mine Surface Development Area

Murray River Project
Wildlife Habitat Ratings

Elk Winter Living
Habitat Suitability

Drawn: D. Wiens	Datum/Projection: NAD 1983 UTM Zone 10N
Checked: S. Racicot	EDI Project No.: 12-V-0073
Date: 10/01/2014	Data Sources: Refer to References Section

EDI



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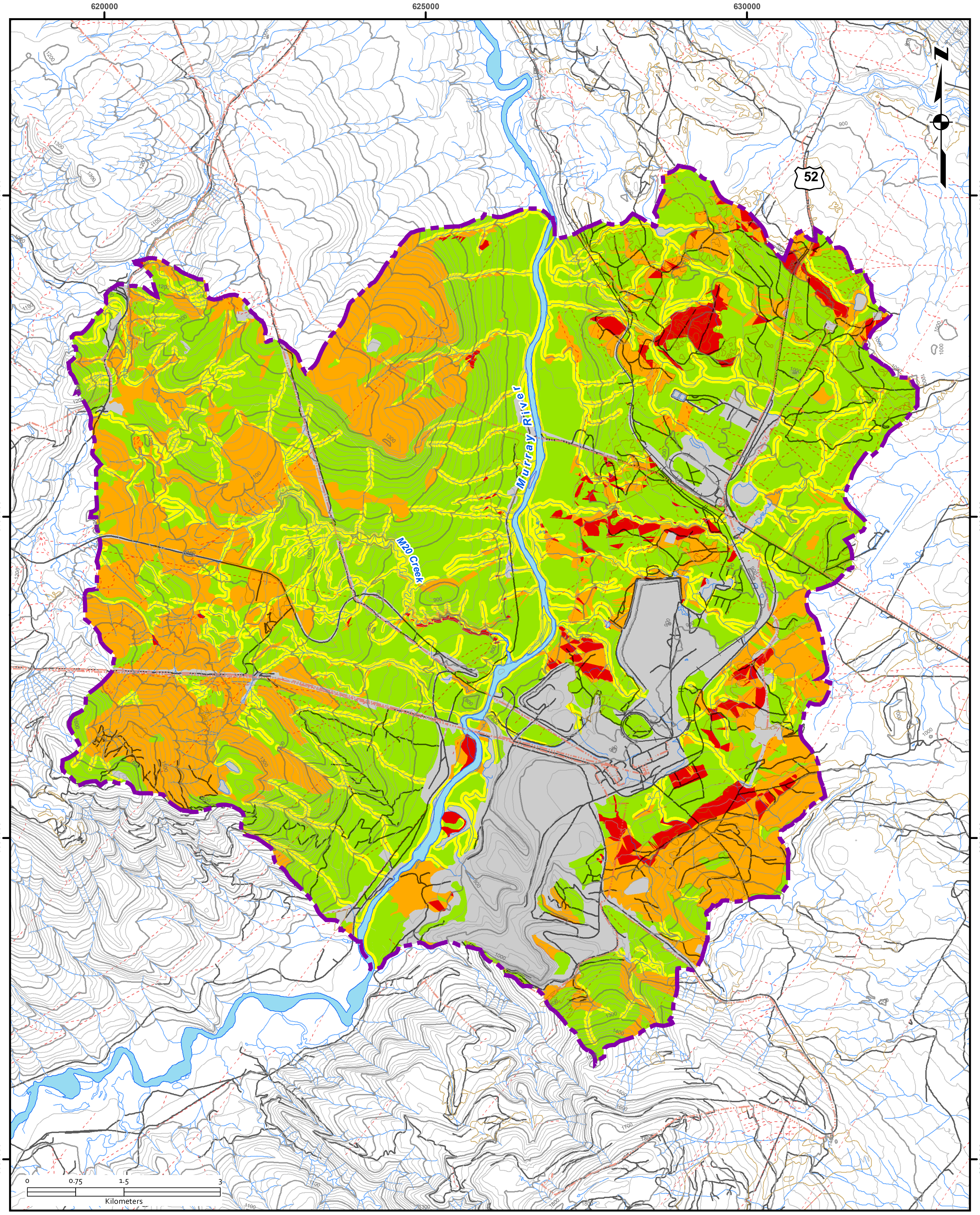


LEGEND

- Local Study Area
- Intermediate Contour (20m Interval)
- Index Contour (100m Interval)
- Transmission Line; Pipeline; Linear Disturbance
- Cutline; Seismic Line; Trail
- Cut Block; Burn
- Railways
- Road
- Streams/Lakes

Habitat Suitability Class

- High
- Moderately High
- Moderate
- Low
- Very Low
- Nil

INSET LEGEND

- Local Study Area
- Potential Mine Surface Development Area

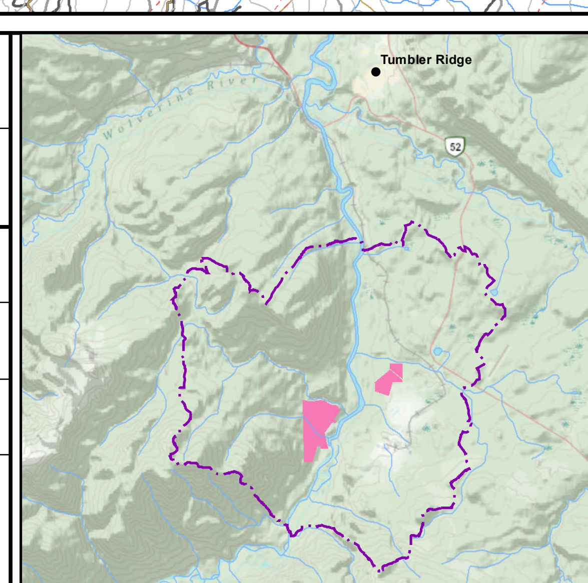
Original Map Size 11x17in

Scale: 1:60,000

Murray River Project
Wildlife Habitat Ratings

Elk Growing Season Living Habitat Suitability

Drawn:	Datum/Projection:
D. Wiens	NAD 1983 UTM Zone 10N
Checked:	EDI Project No.:
S. Racicot	12-V-0073
Date:	Data Sources:
10/01/2014	Refer to References Section



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