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OCCUPANCY PATTERN OF CARIBOU IN THE PRAIRIE CREEK MINE ROAD AND SURROUNDING AREA

Parks Canada Agency; Nahanni National Park Reserve, NT

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REPORT

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Executive Summary

The Prairie Creek Mine (the Mine) is a proposed underground lead-zinc-silver mine located in the Northwest Territories of Canada. The Mine and related infrastructure are surrounded by the Nahanni National Park Reserve (NNPR). The Mine is not part of NNPR; however, approximately 83 km of the winter road used to access the Mine crosses through the Park Reserve. Previous wildlife surveys conducted as part of the Prairie Creek Mine permitting process indicate that woodland caribou (*Rangifer tarandus caribou*) inhabit the lands surrounding the Mine and winter road alignment; however, little information exists on the extent of caribou distribution and area of occupancy, particularly during the proposed road operational period (December 1 to March 31). Using aerial surveys and hierarchical spatial modeling, this study determined caribou distribution and occurrence probabilities in a 9,300 km^2 area surrounding the Mine and winter road alignment (the study area). In February-March 2014, 93 100 km^2 sample units were surveyed for caribou using a fixed-wing aircraft and a crew of three observers. Caribou were detected in 14 of the 93 sample units (15%) during six survey days in 2014. To provide as much detail as possible on baseline caribou range occupancy in the study area, occurrence data collected in 2014 were compared with data collected in winter 2010-11 as part of the Prairie Creek Mine permitting process. Restricted spatial regression was used to model occupancy probabilities of caribou in 2010-11 and 2014 with respect to habitat factors and visibility along survey flight paths, accounting for imperfect detection and lack of independence of sampling units. Of the sample unit covariates examined, elevation was a significant covariate in both survey years. The mean probability of occupancy for a sampling unit was 38% in 2010-11 and 17% in 2014, with 24% of sample units in 2010-11 and 17% of sample units in 2014 having strong probabilities of occupancy by caribou (>0.80). In comparing occupancy estimates for each sample unit in the two survey years, 41 of 93 sample units showed a decline of more than 5% in the estimate of occupancy between 2011 and 2014, primarily due to increased sampling effort in 2014 compared to 2010-11 and a greater level of certainty associated with the 2014 estimates. Golder recommends that repeat surveys be conducted at sufficient intervals (i.e., every two to three years) to inform caribou mitigation and monitoring measures for the Mine and winter road.

Statement of Limitations

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The inferences concerning conditions of the Project area are based on information obtained from PCA, published primary manuscripts and documents, grey literature, and source materials from web-based data repositories. In developing this report, Golder has relied in good faith on information provided by others as noted. We accept no responsibility for any deficiency or inaccuracy contained in this report as a result of our reliance on the aforementioned information.

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1.0 INTRODUCTION

The Prairie Creek Mine (the Mine) is a proposed lead-zinc-silver mine owned by the Canadian Zinc Corporation (CZN) and located in the Mackenzie Mountains in southwest corner of the Northwest Territories (NT; Figure 1). In the early 1980s a 180 km winter road was constructed connecting the mine to southern markets via the Liard Highway (CZN 2010), though the Mine has never been fully operational. In June 2009, the Nahanni National Park Reserve (NNPR) was officially expanded to completely surround the Mine. The Mine is not part of NNPR; however, approximately 83 km of the winter road crosses through the NNPR (CZN 2010).

The Mine contains significant infrastructure, including a processing plant, office buildings, workshops and accommodations, all constructed in the early 1980s by Cadillac Explorations Ltd. CZN has all necessary permits for full mine operation (CZN 2014). The winter road was used extensively to haul construction materials to the existing mine site from January to the end of March in 1981 and 1982, but it has not been used since (CZN 2010). As part of mine operation, CZN has proposed to re-open the winter haul road, with some realignment to avoid difficult ground conditions and sensitive environmental areas (CZN 2010). The re-opening of this road may have direct and indirect impacts on wildlife and wildlife habitat in NNPR and the Greater Nahanni Ecosystem, particularly woodland caribou (*Rangifer tarandus caribou*). Impacts may include increased cumulative disturbance and loss of habitat within caribou range(s), habitat changes and fragmentation, increased sensory disturbance, and direct or indirect mortality.

Woodland caribou inhabiting Greater Nahanni Ecosystem include both the Northern Mountain and Boreal ecotypes. Northern Mountain caribou are listed as Secure in the Northwest Territories (GNWT 2014), have been designated as Special Concern by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 2014), and are listed as Special Concern on Schedule 1 of the *Species at Risk Act* (SARA) (SRPR 2014). Northern Mountain caribou inhabit the Mackenzie Mountains and have distinct seasonal migrations from summer to winter ranges. Boreal caribou are listed as Sensitive in the Northwest Territories (GNWT 2014), have been designated as Threatened by COSEWIC, and are listed as Threatened on Schedule 1 of the SARA (SRPR 2014). Boreal caribou do not occur in discrete herds but live in small, dispersed, and relatively sedentary bands east of the Mackenzie Mountains (Gullickson and Manseau 2000, Larter and Allaire 2010).

In 2010, as part of the Mine permitting process, CZN contracted Golder Associated Ltd. (Golder) to conduct aerial surveys of caribou occupancy patterns in the vicinity of the Mine and winter road. Survey flights were timed to occur during the proposed operational period of the Mine winter road (December 1 to March 31) and were completed on: December 10, 11, and 17, 2010; and February 8, 9, 18, and 24, 2011, The 2010-11 aerial surveys were planned and performed by Golder, in consultation with Parks Canada Agency (PCA) biologists, and NT Environment and Natural Resources (ENR) biologists. Results of the 2010-11 surveys were used to create an occupancy model that indicated that caribou occupy areas along the Mine winter road and surrounding areas during the winter period, particularly in the upper Prairie Creek drainage and Sundog Creek area (Golder 2010, 2011a, 2011b). However, no final report and model output was completed for the 2010-11 surveys.

In January 2014, PCA contracted Golder to conduct aerial surveys and occupancy modeling to evaluate the 2014 area of occupancy surrounding the Mine winter road, prior to construction of road up-grades and operational periods. Data used to construct the 2010-11 occupancy model were reanalyzed under this contract. Collectively, the results will be used by PCA to determine appropriate mitigation and contingency planning to reduce any potential impacts on caribou as a result of road construction and operation.

2.0 OBJECTIVES

The specific objectives of this study were:

- To identify sampling unit attributes correlated with caribou observations in the study area;
- To determine the importance of open areas along survey flight paths on detection of caribou;
- To model the probability of occupancy of caribou in each geographic sampling unit in each of two time periods: 2010-11 and 2014. The occupancy models are based on sampling unit attributes, flight-path openness, visual observations of caribou and their sign, and spatial autocorrelation with nearby sampling units;
- To produce a map of caribou occupancy probabilities in the study area for each time period; and
- To determine change in the probability of occupancy between 2010-11 and 2014 for each sampling unit and produce a corresponding map.

These aerial surveys were conducted under the terms and conditions outlined in PCA Research and Collection permit NAH-2014-15454 and NT ENR Wildlife Research permit WL500211 obtained by PCA.

3.0 METHODS

3.1 Study Area

The study area encompasses 9,300 km^2 of western NT, including 7,717 km^2 of NNPR (Figure 1). It is primarily located in the Boreal Cordillera-High Boreal ecological region, but also includes a small portion of the Taiga Plains-High Boreal ecological region east of the Nahanni Range. The Boreal Cordillera-High Boreal ecoregion is characterized by broad valleys and lowlands, deeply dissected plateaus, long ridges, and rugged limestone peaks (ECG 2010). Lowland coniferous and mixed forests dominate, with sedge wetlands at lower elevations and in the valleys and a variety of wetlands and alpine communities at higher elevations (ECG 2010). East of the Nahanni Range, the Taiga Plains-High Boreal ecoregion is characterized by black spruce (*Picea mariana*) dominated wetlands interspersed with mixed coniferous and deciduous stands on level to gently undulating terrain (ECG 2007). Precipitation is higher in the Boreal Cordillera because moisture-bearing Pacific systems approaching from the west are forced upward by high mountain ranges, resulting in higher amounts of rainfall and snowfall (ECG 2010).

3.2 Sample Unit Delineation

In 2010 Golder delineated standard survey sample units for caribou in the study area in consultation with PCA and NT ENR staff as part of the Mine permitting process (Golder 2010, 2011a). The same sample units and survey methods as those used previously were applied to the 2014 surveys for consistency in survey design and statistical methodology. The study area was partitioned into a tessellation of 93 100 km^2 hexagonal sample units (Figure 1). The size and configuration of the survey sample units was a trade-off between biological relevance, cost-effectiveness and resolution, and is consistent with other probability of occurrence studies completed for large mammals in northern Canada, notably in Ontario (Magoun et al. 2007, Bowman et al. 2010; Poley et al. 2014).

3.3 Aerial Surveys

The 2010-11 aerial survey methodology is described in detail in Golder (2010, 2011a). In 2014, aerial surveys were conducted by Golder biologists (Daniel Guertin, Liam Doyle) with assistance from PCA staff biologists, and skilled community observers, when possible. Members of the survey team were experienced at locating caribou and their sign from the air. Survey flights followed a standardized protocol to keep flight patterns, parameters, and observation methods as similar as possible among different survey crews. All flights originated in Fort Simpson, NT and were conducted in a fixed-wing aircraft equipped with wheel skis (Cessna 185). Flight routes were planned to pass through each sample unit at least once in each of the three survey periods. Sample units were surveyed in an order that made the most efficient use of flying time; however, the length and direction of a flight route depended on local weather conditions on the day of the flight, day length, and the location of fuel. Where possible, the aircraft entered a hexagonal sample unit at the midpoint of one of the sides, flew through the centroid, and exited at the midpoint of a different side (Magoun et al 2007). Occasionally, the aircraft deviated from that approach due to extreme topographic relief and adverse localized weather conditions (i.e., high wind, turbulence, cloud). Repeat visits were conducted for each sample unit to estimate and account for imperfect detection; however, the number of repeat visits per unit varied.

Survey flights in 2014 were conducted in three two-day blocks, on sunny days or days with bright overcast skies, and with wind speeds favorable for safely manoeuvring the aircraft at low altitudes (February 5-6, 20-21, 2014; March 13-14, 2014). Flights were delayed 24 hours following a snowfall event of 2 cm or more or for a high wind event. There was no upper limit for the number of days following a snowfall event and all observed caribou tracks were considered evidence of occurrence regardless of track age or condition. Daily flights took between 3 and 6 hours to complete traveling at a groundspeed of 100 to 200 km/hr, when safe to do so. Survey altitude varied between 100 to 300 m above ground level depending on terrain.

Survey crews consisted of a navigator and two additional observers who recorded observations of caribou and caribou tracks. Caribou tracks were verified by circling and following the trail to observe track size, shape, and pattern, including the presence of cratering sites. A waypoint of each observation of caribou or tracks was recorded with a Trimble Nomad Global Positioning System (GPS) unit or Garmin GPSmap unit. After investigating a track, the aircraft returned to the pre-planned survey route heading. To avoid false positives, tracks that could not be verified as caribou tracks with full confidence were noted and sample units containing only these tracks were recorded as unoccupied (n = 11). When possible (in 6 of 11 instances), a helicopter was used following the fixed-wing survey to land and inspect these potential caribou tracks from the ground. Helicopter flights were planned to occur on the days immediately following the completion of the fixed-wing survey. Of the six instances where ground observations were used for follow-up, records for three sample units were revised to occupied status and three remained coded as unoccupied.

A GPS flight path track file was logged for each survey flight in 2010-11 and 2014 and waypoints were recorded for each observation of caribou or caribou sign. The track files were later used to determine the degree of openness along each survey flight path in each sample unit.

Observations of other wildlife species of management concern were also recorded during flights when possible, though they were not included in any analyses.

3.4 Covariates

3.4.1 Detection Covariate (Flight Path Openness)

As flight paths often passed over several different habitat types that may have affected animal sightability, a detection covariate for flight path land cover openness was included in the detection model (Poley et al. 2014). Openness was calculated by creating a 250 m buffer on either side of each flight path recorded during the surveys. The 250 m buffer is the approximate limit of detection while in the aircraft. The percentage of open land cover within the buffer in each sample unit was calculated based on 13 ‘open’ land cover classes from the Land Cover of Canada Classification. The classification was derived by The Government of Canada from Moderate-Resolution Imaging Spectroradiometer (MODIS) spatial imagery, 2000-2011, and classified into 25 vegetated and non-vegetated land cover types at 250 m resolution. Openness was classified according to the amount of cover associated with each land class description. Habitats with less than 25% cover were classified as open, habitats with 25 to 60% cover were classified as semi-open, and habitats with greater than 60% cover were classified as closed. The amount of each habitat class surveyed varied depending on the survey and the sample unit. The openness covariates were unique for each individual survey of each sample unit.

3.4.2 Sample Unit Covariates

Three sample unit covariates were identified that were thought to have potential to influence caribou distribution and for which the necessary data were available. The inclusion of covariates for each sample unit increases the predictive ability of the models. For this study, covariates included in the models were elevation, terrain ruggedness, and a caribou habitat value based on a resource selection function (RSF) model for caribou in the lower Mackenzie River Valley, NT during the mid-winter period (Nagy et al. 2006). Sample unit covariates are attributes of geographic units and remain consistent across years; hence they are the same for 2010-11 and 2014 analyses.

3.4.2.1 Caribou Habitat Value (Resource Selection Function) Covariate

A RSF model produces a value for a resource unit (in this study, the 100 km^2 sample units) that represents the relative selection of that resource unit by an animal compared to selection of other resource units; in this study it represents the relative value of each sample unit. The RSF for each sample unit in the study area was determined from a RSF model for caribou in the lower Mackenzie River valley, NT during the mid-winter period (Nagy et al. 2006). Nagy et al. (2006) used Ducks Unlimited Canada’s (DU) land cover classification for the lower Mackenzie River, Peel Plateau, and middle Mackenzie River areas to develop the RSF (DU 2002; 2003; 2006). Therefore, to apply the RSF to the study area, the 25 land cover classes included in Land Cover of Canada Classification were reclassified by Golder vegetation ecologists according to the DU land cover classification scheme. The percentage of each land cover type within each 100 km^2 hexagonal sample unit was then determined and the weighted average of the selection coefficient estimates for those land cover classes was calculated, resulting in a single value for each sample unit in the study area.

3.4.2.2 Elevation and Terrain Ruggedness Covariates

A digital elevation model (DEM) obtained from GeoBase® was available for the study area. The mean elevation of the set of 10 m pixels in each 100 km^2 hexagonal sample unit was used to represent sample unit elevation. The standard deviation of the set of 10 m pixels for each sample unit was used as an index of terrain ruggedness.

3.5 Occupancy Analyses

Data were analyzed using the R programming statistical environment (R Core Team 2012).

3.5.1 Covariate Screening

As an initial step, logistic regression was used to examine relationships between covariates and observations. Separate regressions were run for each of the two survey years; a full model with all covariates and all interactions and then a separate model for each covariate. Covariates with significant relationships with survey observation data were retained for use in the occupancy analyses.

3.5.2 Occupancy Estimation

For occupancy analyses, restricted spatial regression was conducted using the 'stocc' package for R (Johnson et al. 2013). The restricted spatial regression approach accounts for spatial autocorrelation. The probability of occupancy of a sampling unit is based on observations made in that unit, on the detection covariate, on sample unit covariates, and on observations and covariates of nearby sampling units. The process includes a detection model based on sample unit observation histories and detection covariates, an occupancy model that incorporates sample unit covariates, and concludes with fitting a spatial model incorporating information from other sample units. Models in analyses for this project specified a threshold of 12,000 m to account for all immediate neighbouring sample units, flat prior distributions for detection and occupancy, and a Gamma (0.5, 0.0005) distribution for spatial modelling. The Gibbs sampler was run for a burn-in period of 10,000 iterations and then for an additional 50,000 iterations (Johnson et al. 2013).

Data were analysed independently for each of the two survey years (2010-11 and 2014) and the same covariates were used for each of the survey years. The sample unit-wise posterior occupancy estimates for each period were compared to determine changes in the estimated occupancy for each sample unit between 2010-11 and 2014.

4.0 RESULTS

4.1 Aerial Surveys

Results from the 2010-11 aerial survey flights are described in detail in Golder (2010, 2011a) and are summarized with 2014 survey results below.

Local weather data for the survey time periods were retrieved from the nearest available weather recording station in Fort Simpson, NT, which is located approximately 100 km east of the study area. Temperature, snowfall, and wind speed measured in December, January, and February 2010-11, and February and March 2014 are included in Table 1. Overall, weather conditions in the study area in winter 2010-11 were less favorable for aerial surveys than those encountered in 2014, which resulted in delays between survey flights in 2010-11 and some sample units being missed.

Table 1: Weather Conditions Recorded at Fort Simpson, NT during the 2010-11 and 2014 Aerial Caribou Occupancy Survey Time Periods

Month	Average Daily Temp (°C)	Average snowfall per day (cm)	Number of days with snowfall	Number of days with ≥ 2 cm snow	Range of snow on ground (cm)	Days with wind gust > 31 km/hr
December 2010	–24	1.5	13	9	33-65	6
January 2011	–24	0.9	13	7	57-65	3
February 2011	–18	1.7	10	5	57-79	3
February 2014	–23	0.4	13	2	55-59	2
March 2014	–16	0.6	4	2	57-60	0

Data obtained from Environment Canada's Canadian Daily Climate Data database for weather station Fort Simpson A, NT (Available at: www.climate.weatheroffice.ec.gc.ca).

A total of 93 sample units were included in the study area. During 2010-11 flights, 6 (6%) sample units were surveyed once, and 75 (81%) between two and six times over seven survey days (3 days in December 2010 and 4 days in February 2011). Twelve sample units were not visited during the 2010-11 surveys. During 2014 flights, three (3%) sample units were surveyed twice, 89 (96%) sample units were surveyed three times, and one (1%) sample unit was surveyed four times over six survey days (4 days in February and 2 days in March). All sample units were surveyed during the 2014 flights.

Caribou were detected in 20% (19 of 93) of the sample units in 2010-11 and 15% (14 of 93) in 2014 (Figure 2). Sample units with caribou detections were generally consistent among survey sessions and the majority of detections were located in the western and central portions of the study area, particularly the Vera Creek, Prairie Creek, and Sundog Creek areas (Figure 2). Caribou were also detected in the Tetcela River drainage in 2010-11 and 2014. The approximate geographical coordinates of caribou detections recorded in 2010-11 and 2014 are included in separate digital data files.

4.2 Covariates

4.2.1 Detection Covariate (Flight Path Openness)

In the 2010-11 survey year the mean percent open habitat in the flight path buffer was 37% and the range of values was from 0%-100%. The results were similar in 2014 when the mean percent open habitat in the flight path buffer was 40% and the range of values was from 0% to 100%.

4.2.2 Sample Unit Covariates

4.2.2.1 Caribou RSF Covariate

The RSF selection coefficient values applied to a sample unit ranged from –1.68 to 0.35, with a grand mean value for the study area of –0.45.

4.2.2.2 Elevation and Terrain Ruggedness Covariates

Mean sample unit elevation ranged from 190 to 1,430 m, with a grand mean elevation of 798 m for the entire study area. Sample unit ruggedness values had a mean of 1.71 and ranged from 0.12 to 3.70.

4.3 Occupancy Analyses

4.3.1 Covariate Screening

Of all the logistic regression models examined there were three that showed significant relationships between a covariate and observed occupancy: flight path openness in 2010-11 (p<0.001); sample unit elevation in 2010-11 (p<0.0001); and sample unit elevation in 2014 (p<0.0001). Flight path openness was specified as a covariate for the detection model and sample unit elevation was specified as a covariate for the occupancy model. The two covariates were kept the same for both survey years to facilitate comparisons between years.

4.3.2 Occupancy Estimation

The mean probability of occupancy for a sampling unit in 2010-11 was 38% (SE = 19%; Table 2), with 22 sample units having an occupancy estimate of 80% or higher, 15 sample units with an occupancy estimate of between 50% and 80%, and 56 sample units with an occupancy estimate below 50%. In 2014 the mean probability of occupancy was 17% (SE = 11%; Table 2) with 14 sample units with occupancy estimates of 100% (i.e., actual observations during surveys) and all 79 other sample units with occupancy estimates of <20%. The spatial distributions of occupancy estimates for each of the two survey years appear in Figures 3 and 4. In comparing occupancy estimates for each sample unit in the two survey years, 41 of 93 sample units showed a decline in the estimate of occupancy between 2011 and 2014 of more than 5%, 37 sample units showed a difference of between 5% decrease and 5% increase, and four showed an increase of more than 5% (Figure 5). There were nine sample units where caribou or caribou sign was observed in 2010-11, but not in 2014; 10 sample units had caribou or caribou sign observed in both survey years.

Table 2: Mean posterior probability of occupancy estimates and mean standard error from caribou surveys in the Prairie Creek Mine Road area, Nahanni National Park Reserve

Year	Occupancy (%)	Occupancy SE (%)	Sampling units with Observations
2010-11	38	19	19 (20%)
2014	17	11	14 (15%)

4.4 Incidental Observations

Other species of management concern observed during survey flights include Dall's sheep (*Ovis dalli*), grey wolf (*Canis lupus*), moose (*Alces alces*), and wood bison (*Bison bison athabascae*). Figure 6 shows the location of wildlife species incidentally observed during survey flights in 2010-11 and 2014. The geographical coordinates of incidental observations of these species are included in a separate digital data file.

5.0 CONCLUSIONS

Previous wildlife surveys conducted as part of the Mine permitting process indicate that woodland caribou inhabit the lands surrounding the Mine and winter road alignment (CZN 2010); however, little information exists on the extent of caribou distribution and area of occupancy, particularly during the proposed road operational period (December 1 to March 31). An occupancy survey was therefore designed to collect caribou occurrence data over a large area in a relatively short period of time. This survey technique identified not only the extent of caribou distribution in the study area but also core areas of occupation, in addition to providing a probability of occurrence for each sampling unit. Based on the results of the 2010-11 and 2014 surveys, it may be expected that the areas with the highest likelihood of caribou-vehicle conflict during the winter period is the Sundog Creek drainage and in Mackenzie Mountains near the Mine site.

The realized occupancy from the two survey years revealed a greater level of certainty (i.e., smaller standard errors) in 2014 than in 2010-11. There may have been more than one contributing factor:

- the 2014 survey design resulted in each sample unit being surveyed multiple times; 89 of 93 sample units were surveyed at least three times while in 2010-11 six sample units were surveyed only once and 12 were not surveyed at all; and
- survey flight path openness and occupancy were highly correlated in 2010--11 while the strong correlation was absent in 2014.

Consequently, in 2014 the sample units with caribou or caribou sign observed during surveys were the only sample units in which realized probability of occupancy was >20%. In 2010-11 there were a number of sample units that were not surveyed and there was also a significant relationship between flight path openness and caribou observations. The result was a number of sample units where caribou were not observed where the probability of occupancy for 2010-11 was estimated at >80% (n=3) or between 50% and 80% (n=15). The uncertainty in 2010-11 is reflected in the larger standard errors associated with the probability of occupancy for each sample unit.

Of the sample unit covariates examined, elevation was a significant covariate in both survey years. Generally, caribou distribution was associated with the higher elevations of the Mackenzie Mountains in both survey years.

There were not strong correlations between occupancy and either caribou RSF value (i.e., habitat based covariate) or terrain ruggedness. It is possible that the caribou RSF value does not relate to caribou distribution at this scale or in this season, but it is also possible that the lower Mackenzie River valley caribou RSF model employed was not appropriate for caribou in the study area. Similarly, the absence of a relationship between terrain ruggedness and occupancy caribou distribution may indicate a lack of importance of terrain ruggedness to caribou distribution or that the method of analysing terrain ruggedness was ineffective for this study area.

In selecting an analytical model for these data, it was decided to employ a model that accounted for spatial autocorrelation. In so doing, models that employ data from multiple years to evaluate detectability were excluded; there are currently no analytical approaches that allow for both multi-year detection models and spatial autocorrelation (D. Johnson, pers. comm.). Golder recommends that these data be reanalysed when such models are developed. This will permit detectability models to make use of data from all survey years while allowing observations made in each year to inform the estimate of occupancy in nearby sample units.

All populations of woodland caribou have complex movement patterns, and the ability to move between seasonal ranges (e.g., calving, rutting, wintering) is vitally important. A key objective of the *Management Plan for the Northern Mountain Population of Woodland Caribou* (EC 2012a) and the *Recovery Strategy for the Boreal Population of Woodland Caribou* (EC 2012b) is to maintain the ecological integrity of key habitats and ecosystems through habitat management. With an understanding of how caribou distribution changes with changing habitat conditions in the area surrounding the Mine and winter road, PCA and CZN can cooperate in the development of mitigation measures targeted at maintaining caribou on the landscape as resource development activities increase in the study area. The occupancy estimation and modeling approach provides a robust framework for such long-term monitoring, and changes in caribou distribution and occurrence can be tracked by comparing future surveys with the 2010-11 and 2014 baseline surveys. Golder recommends that repeat surveys be conducted at sufficient intervals (i.e., every two to three years) to inform caribou mitigation and monitoring measures for the Mine and winter road.

6.0 CLOSURE

We trust that this report and the attachments are sufficient for your present requirements. If you have any questions, please do not hesitate to contact the undersigned at 604-296-4200.

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Poley, L.G., B.A. Pond, J.A. Schaefer, G.S. Brown, J.C. Ray, and D.S. Johnson. 2014. Occupancy patterns of large mammals in the far north of Ontario under imperfect detection and spatial autocorrelation. Journal of Biogeography 41:122-132.

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Personal Communications

Johnson, D.S., Author and Maintainer of R Package ‘stocc’. Personal Communication with James Rettie (Golder Associates Ltd.), April 18, 2014.

LEGEND

- Prairie Creek Mine
- City/Town
- Prairie Creek Mine Road Alignment
- Road
- Park Boundary
- Watercourse
- Waterbody
- Survey Unit (100 km^2 Hexagon)

REFERENCE

PROJECT FEATURES OBTAINED FROM CANADIAN ZINC CORPORATION. BASE FEATURES OBTAINED FROM GEOBASE. PARK BOUNDARY OBTAINED FROM PARKS CANADA AGENCY, NAHANNI NATIONAL PARK RESERVE. OTHER DATA OBTAINED FROM CANVEC.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
PARKS CANADA AGENCY

PROJECT
AERIAL CARIBOU OCCUPANCY SURVEY OF THE PRAIRIE CREEK MINE ROAD AND SURROUNDINGS

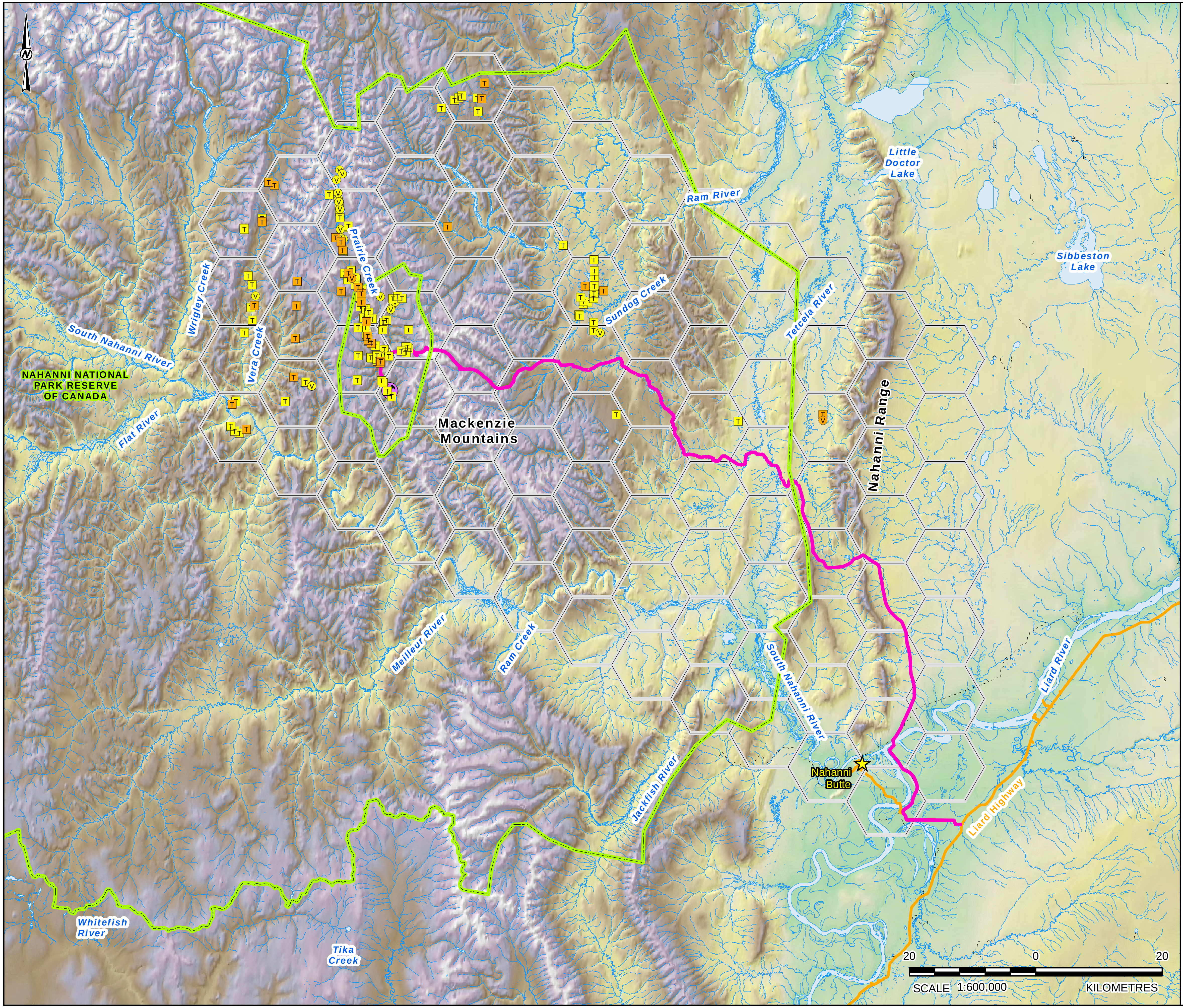
TITLE
THE PROJECT STUDY AREA IN THE NORTHWEST TERRITORIES

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-06-24
PREPARED	JP
DESIGN	DG
REVIEW	DAG
APPROVED	MGJ

PROJECT No.	CONTROL	Rev.	FIGURE
13-1433-0002	00	00	01

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET HAS BEEN MODIFIED FROM ANSI B



LEGEND

Caribou Obseravtion

2014 Observation

- Track
- Visual

2010-2011 Observation

- Track
- Visual
- Prairie Creek Mine
- City/Town
- Prairie Creek Mine Road Alignment
- Road
- Park Boundary
- Watercourse
- Waterbody
- Survey Unit (100 km^2 Hexagon)

REFERENCE

PROJECT FEATURES OBTAINED FROM CANADIAN ZINC CORPORATION. BASE FEATURES OBTAINED FROM GEOBASE. PARK BOUNDARY OBTAINED FROM PARKS CANADA AGENCY, NAHANNI NATIONAL PARK RESERVE. OTHER DATA OBTAINED FROM CANVEC.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT

PARKS CANADA AGENCY

PROJECT

AERIAL CARIBOU OCCUPANCY SURVEY OF THE PRAIRIE CREEK MINE ROAD AND SURROUNDINGS

TITLE

CARIBOU OBSERVATIONS DURING OCCUPANCY SURVEYS IN 2010-11 AND 2014

CONSULTANT

Golder Associates

YYYY-MM-DD	2014-06-24
PREPARED	JP
DESIGN	DG
REVIEW	DAG
APPROVED	MGJ

PROJECT No.	CONTROL	Rev.	FIGURE
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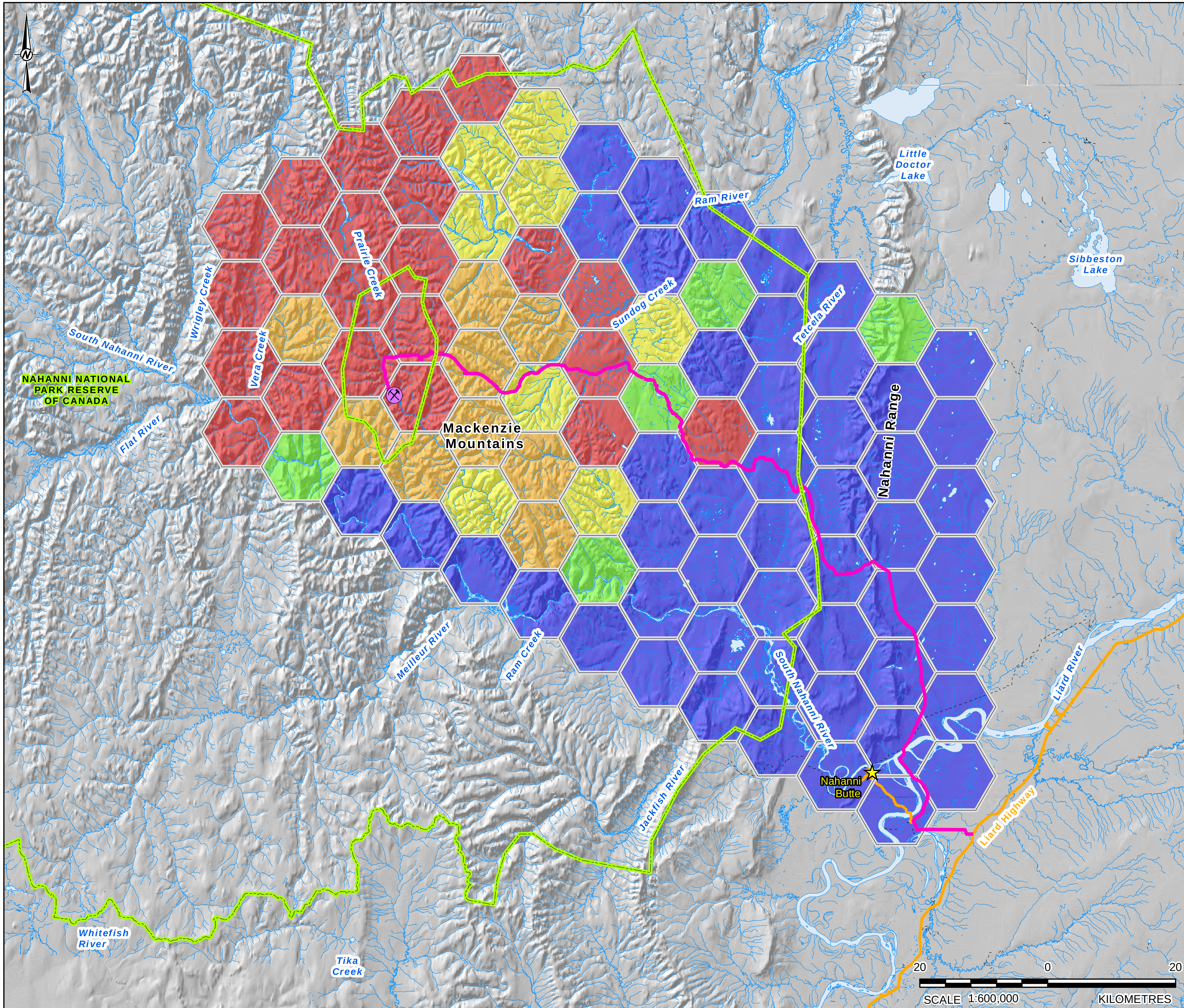

LEGEND

- Prairie Creek Mine
- City/Town
- Prairie Creek Mine Road Alignment
- Road
- Park Boundary
- Watercourse
- Waterbody
- Survey Unit (100 km^2 Hexagon)

REALIZED OCCUPANCY

2010-11 RESULTS

- 0.00 - 0.20
- 0.21 - 0.40
- 0.41 - 0.60
- 0.61 - 0.80
- 0.81 - 1.00

REFERENCE

PROJECT FEATURES OBTAINED FROM CANADIAN ZINC CORPORATION. BASE FEATURES OBTAINED FROM GEOBASE. PARK BOUNDARY OBTAINED FROM PARKS CANADA AGENCY, NAHANNI NATIONAL PARK RESERVE. OTHER DATA OBTAINED FROM CANVEC.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT

PARKS CANADA AGENCY

PROJECT

AERIAL CARIBOU OCCUPANCY SURVEY OF THE PRAIRIE CREEK MINE ROAD AND SURROUNDINGS

TITLE

2010-2011 POSTERIOR ESTIMATE OF CARIBOU OCCUPANCY IN EACH SAMPLE UNIT IN THE PRAIRIE CREEK ROAD STUDY AREA, NAHANNI NATIONAL PARK RESERVE

CONSULTANT

Golder Associates

YYYY-MM-DD	2014-06-24
PREPARED	JP
DESIGN	DG
REVIEW	DAG
APPROVED	MGJ

PROJECT No.	CONTROL	Rev.	FIGURE
13-1433-0002	00	00	03

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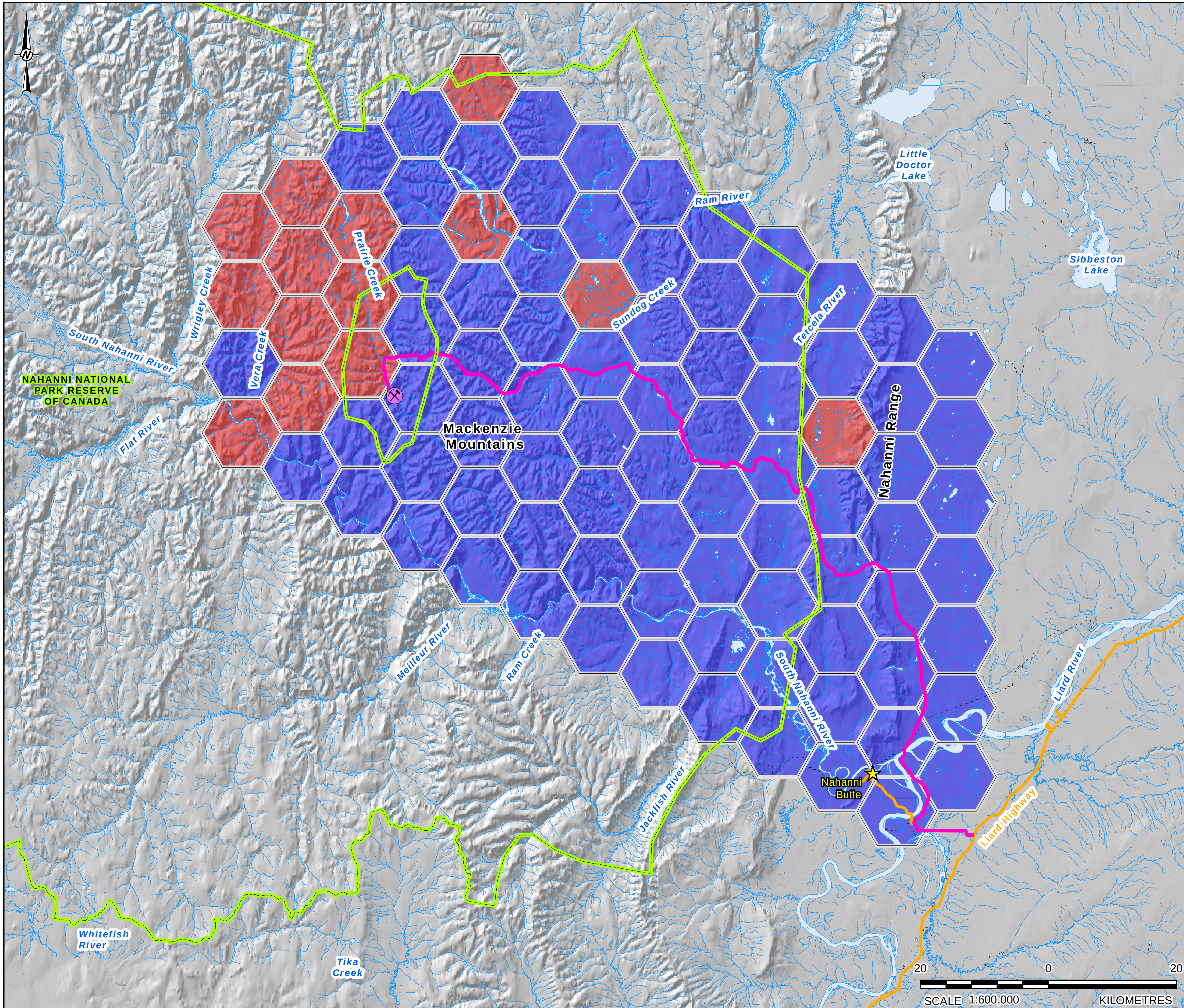


LEGEND

- Prairie Creek Mine
- City/Town
- Prairie Creek Mine Road Alignment
- Road
- Park Boundary
- Watercourse
- Waterbody
- Survey Unit (100 km² Hexagon)

REALIZED OCCUPANCY

2014 RESULTS

- 0.00 - 0.20
- 0.21 - 0.40
- 0.41 - 0.60
- 0.61 - 0.80
- 0.81 - 1.00

REFERENCE

PROJECT FEATURES OBTAINED FROM CANADIAN ZINC CORPORATION. BASE FEATURES OBTAINED FROM GEOBASE. PARK BOUNDARY OBTAINED FROM PARKS CANADA AGENCY, NAHANNI NATIONAL PARK RESERVE. OTHER DATA OBTAINED FROM CANVEC.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT

PARKS CANADA AGENCY

PROJECT

AERIAL CARIBOU OCCUPANCY SURVEY OF THE PRAIRIE CREEK MINE ROAD AND SURROUNDINGS

TITLE

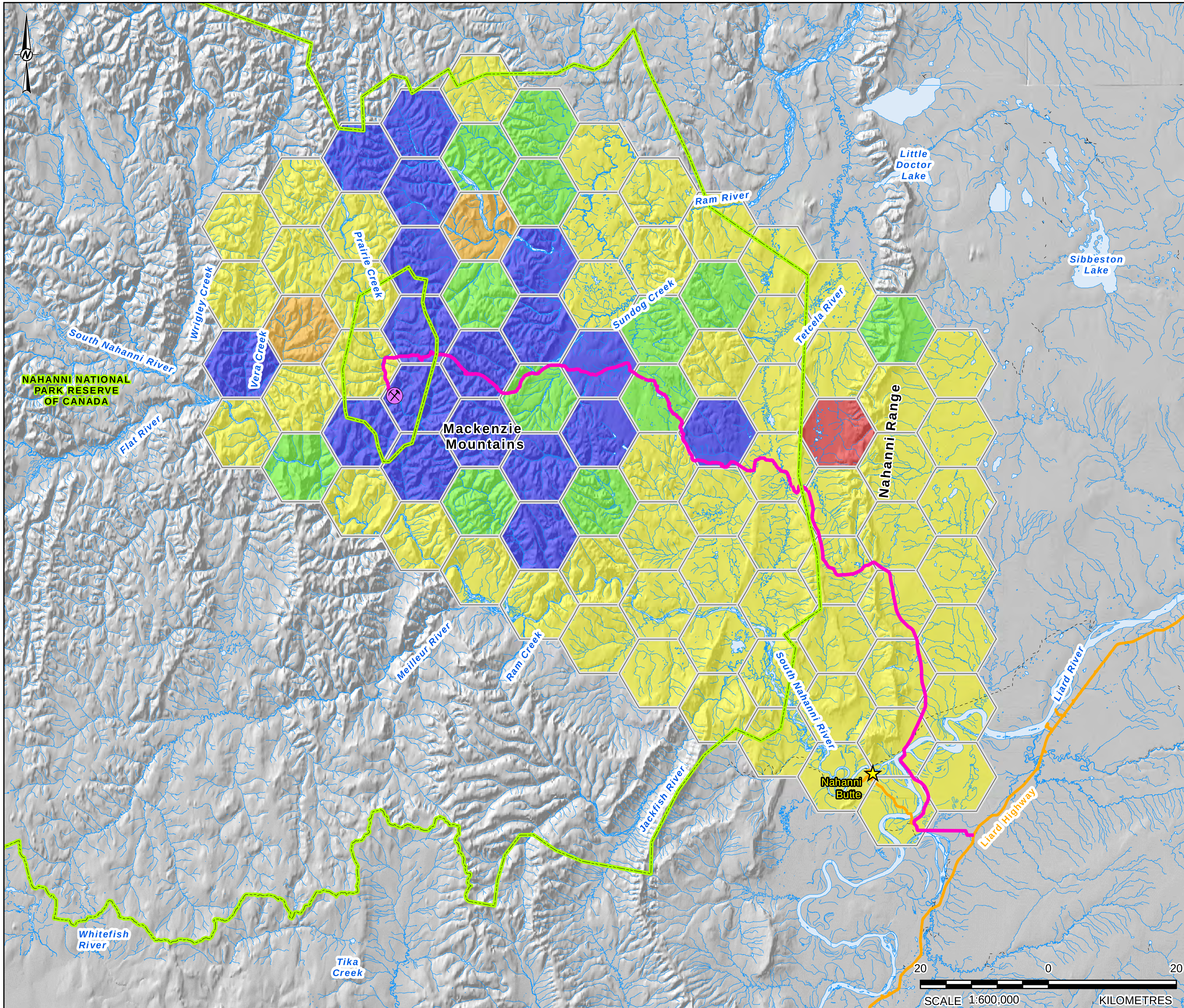
2014 POSTERIOR ESTIMATE OF CARIBOU OCCUPANCY IN EACH SAMPLE UNIT IN THE PRAIRIE CREEK ROAD STUDY AREA, NAHANNI NATIONAL PARK RESERVE

CONSULTANT

Golder Associates

YYYY-MM-DD	2014-06-24
PREPARED	JP
DESIGN	DG
REVIEW	DAG
APPROVED	MGJ

PROJECT No.	CONTROL	Rev.	FIGURE
13-1433-0002	00	00	04



LEGEND

- Prairie Creek Mine
- City/Town
- Prairie Creek Mine Road Alignment
- Road
- Park Boundary
- Watercourse
- Waterbody
- Survey Unit (100 km^2 Hexagon)

REALIZED OCCUPANCY

DIFFERENCE: 2010-11 AND 2014

- -1.00 - -0.60
- -0.59 - -0.20
- -0.19 - 0.20
- 0.21 - 0.59
- 0.60 - 1.00

REFERENCE

PROJECT FEATURES OBTAINED FROM CANADIAN ZINC CORPORATION. BASE FEATURES OBTAINED FROM GEOBASE. PARK BOUNDARY OBTAINED FROM PARKS CANADA AGENCY, NAHANNI NATIONAL PARK RESERVE. OTHER DATA OBTAINED FROM CANVEC.
PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT

PARKS CANADA AGENCY

PROJECT

AERIAL CARIBOU OCCUPANCY SURVEY OF THE PRAIRIE CREEK MINE ROAD AND SURROUNDINGS

TITLE

2010-2011 TO 2014 CHANGES IN POSTERIOR ESTIMATES OF CARIBOU OCCUPANCY IN EACH SAMPLE UNIT IN THE PRAIRIE CREEK ROAD STUDY AREA, NAHANNI NATIONAL PARK RESERVE

CONSULTANT

Golder Associates

YYYY-MM-DD	2014-06-24
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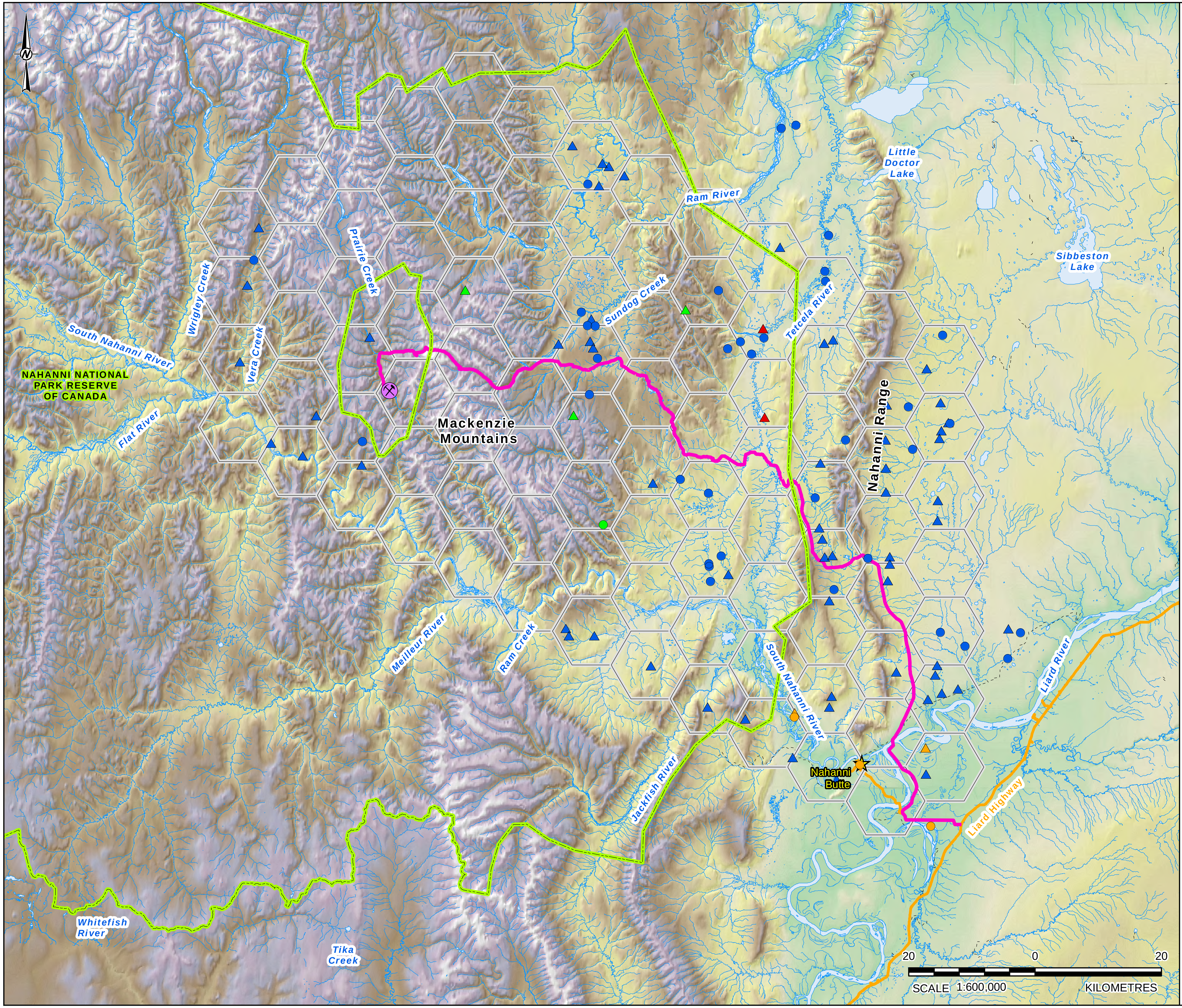
PROJECT No.	CONTROL	Rev.	FIGURE
13-1433-0002	00	00	**05**



LEGEND

Incidental Wildlife Observation

2014 Observation
- ▲ Moose
- ▲ Dall's Sheep
- ▲ Bison
- ▲ Wolf

2010-2011 Observation
- ● Moose
- ● Dall's Sheep
- ● Bison
- Prairie Creek Mine
- City/Town
- Prairie Creek Mine Road Alignment
- Road
- Park Boundary
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PROJECTION: UTM ZONE 10 DATUM: NAD 83

CLIENT
PARKS CANADA AGENCY

PROJECT
AERIAL CARIBOU OCCUPANCY SURVEY OF THE PRAIRIE CREEK MINE ROAD AND SURROUNDINGS

TITLE
INCIDENTAL WILDLIFE OBSERVATIONS DURING CARIBOU OCCUPANCY SURVEYS IN 2010-11 AND 2014

CONSULTANT
Golder Associates

YYYY-MM-DD	2014-06-24
PREPARED	JP
DESIGN	DG
REVIEW	DAG
APPROVED	MGJ

PROJECT No.	CONTROL	Rev.	FIGURE
13-1433-0002	00	00	06

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

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