Appendix 8-B

Brucejack Gold Mine Project: Environmental Noise Modelling Study

ERM

BRUCEJACK MINE PROJECT

ENVIRONMENTAL NOISE MODELLING STUDY

PREPARED FOR:

ERM RESCAN

DEC 2013

REVISION 0

BKL Consultants in Acoustics

BRUCEJACK MINE PROJECT

ENVIRONMENTAL NOISE MODELLING STUDY

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REVISION 0

Revision	Description	Date
A	Issued as draft for client review	20 Sep 2013
B	Issued as revised draft for client review	4 Dec 2013
0	Revised and issued as final	20 Dec 2013

PREPARED BY:

BKL CONSULTANTS LTD
acoustics • noise • vibration

#308-1200 LYNN VALLEY ROAD, NORTH VANCOUVER, BC, CANADA V7J 2A2
T: 604-988-2508 F: 604-988-7457
sound@bkl.ca
www.bkl.ca

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EXECUTIVE SUMMARY

BKL Consultants Ltd. (BKL) has been retained by ERM Rescan to provide an environmental noise assessment for the proposed Brucejack Mine Project (the Project). This report documents the predicted noise climate during construction and operations phases of the Project, and noise levels at nearby sensitive human and wildlife receptors.

The Project is located in the coastal mountains of northwestern British Columbia, and is an underground mine proposed to be operating over a 22-year period. The Project includes the mine site, Knipple Transfer Station, Bowser Aerodrome, and a 79 km access road from the entrance at Highway 37 to the Brucejack Lake and mine site.

The objective of this study was to complete noise predictions from various activities throughout construction and operations, including vehicle passbys, surface pit blasting, and aircraft and helicopter activity to enable ERM Rescan to perform potential effects assessments on sensitive human and wildlife receptors.

A noise model was constructed using Cadna/A software which incorporated internationally or nationally recommended algorithms to predict the environmental noise levels: ISO 9613-2:1996 (industrial noise), and ICAN/AzB 2008 (aircraft noise). Blasting noise was predicted to American National Standards Institute (ANSI) standards. Predicted noise levels for various construction and operations scenarios were presented over areas and in metrics suitable for effects assessments on humans and wildlife, as appropriate, and are presented in a series of tables and graphical figures in Section 9.

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List of Abbreviations and Acronyms

Abbreviation/Acronym	Definition
%HA	Percentage of persons highly annoyed
Δ%HA	Increase in percentage of persons highly annoyed
ANFO	Ammonium Nitrate Fuel Oil
ANSI	American National Standards Institute
µPa	Micropascal
BKL	BKL Consultants Ltd.
dB	Decibel
dBA	A-weighted decibel
dBZ	Decibel (no frequency weighting)
EA	Environmental Assessment
Hz	Hertz
ICAN	Instruction for the Calculation of Aircraft Noise
ICAO	International Civil Aviation Organization
kg	Kilogram
km	Kilometre
km/h	Kilometres per hour
kW	Kilowatt
L_{AE}	Sound exposure level
L_{max}	Maximum A-weighted, fast time constant sound level
L_d	Daytime (07:00 to 22:00) equivalent sound level
L_{dn}	Day-night equivalent sound level
L_{eq}	Equivalent sound level
L_n	Nighttime (22:00 to 07:00) equivalent sound level
L_{Ndn}	Adjusted day-night equivalent sound level
L_p	Sound pressure level
L_{peak}	Peak Z-weighted sound level
m	Metre
MTOM	Maximum Take Off Mass
N	Number of sonic booms per day
Project	Brucejack Mine Project
SWL	Sound power level
TNT	Trinitrotoluene
UBA	German Federal Environment Agency
WHO	World Health Organization

1 INTRODUCTION

BKL Consultants Ltd. has been retained by ERM Rescan to provide an environmental noise modelling study for the proposed Brucejack Mine Project (the Project).

This report documents the predicted noise climate during construction and operations phases at nearby human and wildlife receptors.

2 PROJECT DESCRIPTION

The Brucejack Mine Project is in the coastal mountains of northwestern British Columbia at approximately latitude 56°28′20″N and longitude 130°11′31″W. The site is 65 km northwest of Stewart, and within 35 km of the British Columbia-Alaska border.

The mine site is situated west of the Brucejack Lake and will be accessed from Highway 37 via an access road. The Project includes the mine site, Knipple Transfer Station, Bowser Aerodrome, and a 79 km access road between the mine site and the Highway 37 entrance, as shown in Figure 2-1.

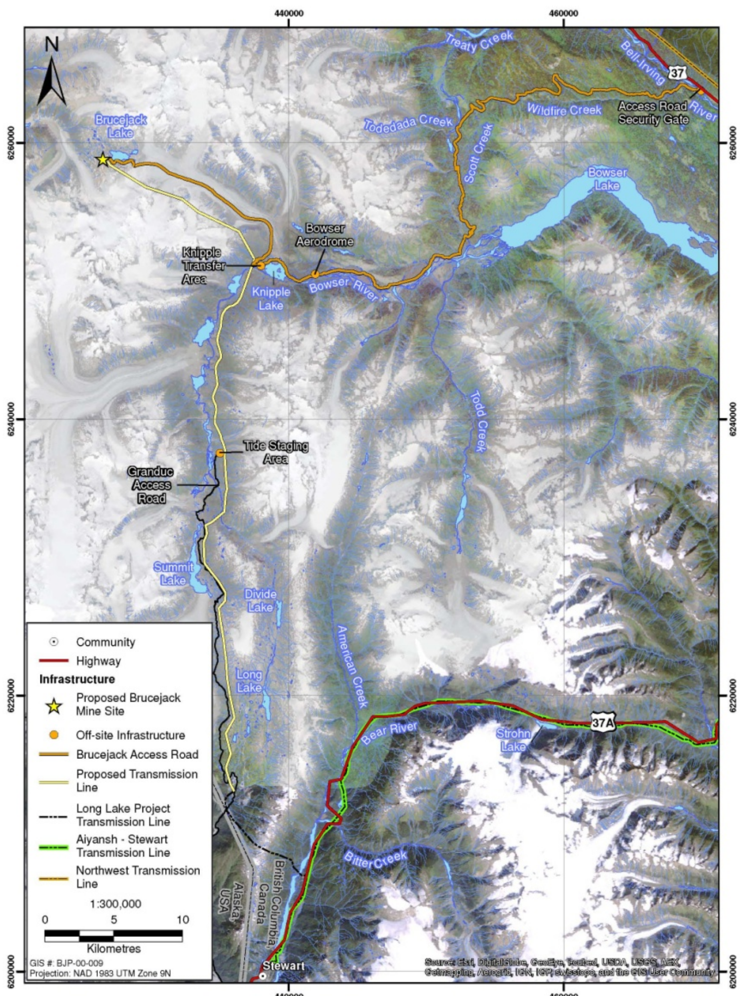

Figure 2-1 Brucejack Mine Project Components (Source: Rescan)

Figure 2-2 below shows the site layout of the Project mine site.

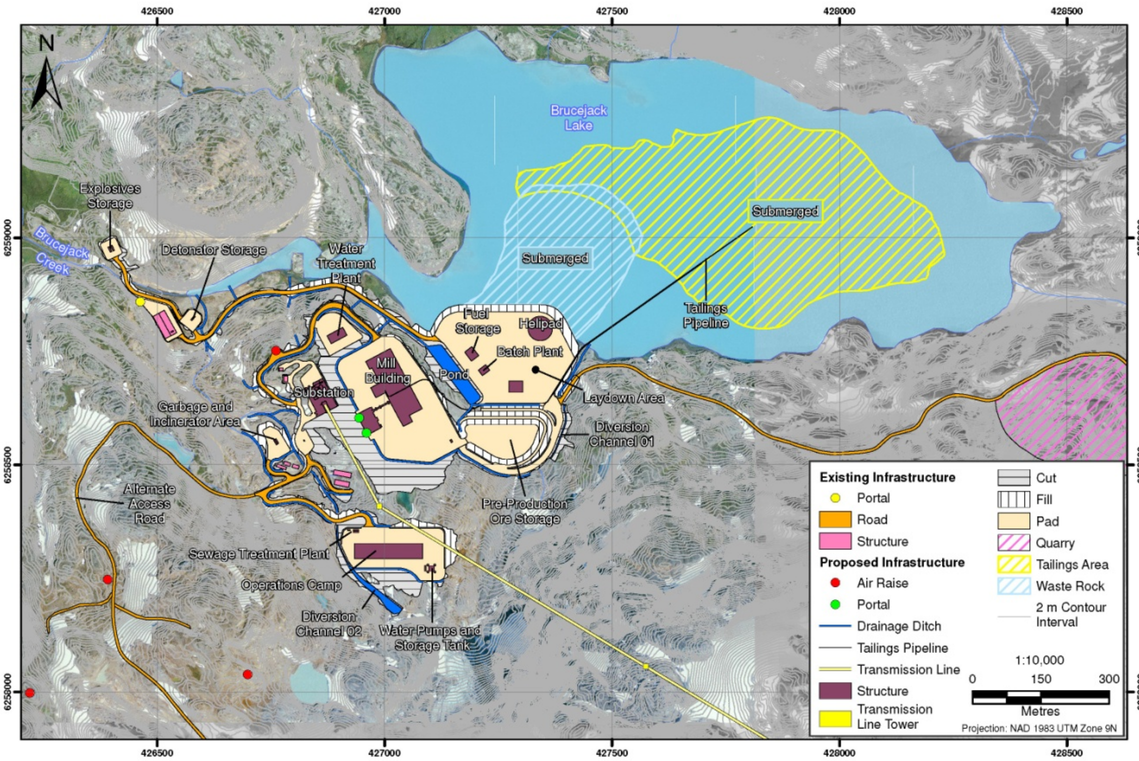

Figure 2-2 Brucejack Mine Site Layout (Source: Rescan)

The Project will include the following infrastructure and facilities:

- an upgraded 79 km access road at Highway 37 and travelling westward to Brucejack Lake with the last 12 km of access road to the mine site traversing the main arm of the Knipple Glacier;
- a 138 kV power supply line from the substation at Long Lake Hydro Substation to the Brucejack site substation;
- site roads and pads;
- water management and treatment infrastructure;
- potable water and sewage treatment infrastructure;
- waste management systems;
- ancillary facilities;
- power distribution;
- an upgraded airstrip; and,
- a transfer station.

The Project is estimated to take approximately 37 months to start introducing materials into the mill. The underground mine is proposed to be operating for a 22-year period. (Tetra Tech 2013)

An alternate snow route known as the Valley of Kings bypass road is available during the winter and will provide access to the mine site when high avalanche risks blocks access on the last segment of the access road entering the mine site. The bypass road detours around the south of the mine site and enters the mine site from the west end.

3 STUDY OBJECTIVES

The objectives of this study have been as follows:

- To complete noise predictions for each of the following activities:
    1. Mine, Knipple Transfer Station, and Bowser Aerodrome construction;
    2. Access road construction;
    3. Mine, Knipple Transfer Station, and Bowser Aerodrome operations;
    4. Access road operations;
    5. Aircraft and helicopter activity during construction and operations; and,
    6. Blasting during construction.
- To provide predicted noise levels suitable for assessing potential environmental noise effects on humans; and,
- To provide predicted noise levels suitable for assessing potential environmental noise effects on wildlife.

4 IDENTIFICATION OF POTENTIAL EFFECTS

Although this study does not include effects assessment, the identification of potential effects to establish appropriate criteria is required to ensure that:

1. Noise levels are calculated in metrics suitable for effects assessment; and
2. Noise levels are calculated over large enough areas to encompass all regions where criteria may be exceeded.

Research has shown over the years that noise complaints do not correlate well with actual community disturbance/response. A proper assessment of the noise impact in situations such as this is important because decisions regarding noise mitigation requirements should be based on the actual significance of the noise impact. This section summarizes four potential environmental effects pertaining to noise. Potential occupational health effects are not included in this study.

This section introduces several acoustic terms and metrics which are used throughout the study. Please consult Appendix A (Glossary) and Appendix B (Introduction to Sound and Environmental Noise Assessment) for definitions and information on these.

4.1 Sleep Disturbance

Sleep disturbance includes the following effects from noise: difficulty falling asleep, awakenings, curtailed sleep duration, alterations of sleep stages or depth, and increased body movements during sleep. The recommendations and guidelines of the World Health Organisation (WHO) regarding sleep disturbance have been used to assess these adverse health effects.

The WHO *Guidelines for Community Noise* (WHO 1999) reports:

- "If negative effects on sleep are to be avoided the equivalent sound pressure level should not exceed 30 dBA indoors for continuous noise"; and,
- "For a good sleep, it is believed that indoor sound pressure levels should not exceed approximately 45 dB L_{Amax} more than 10–15 times per night."

Sound is attenuated as it is transmitted indoors and the amount of reduction mostly depends on whether windows are open or not. An outdoor-to-indoor noise reduction of 15 dB if windows are slightly open, or 27 dB reduction if windows are closed, can be used to estimate the inside noise level (EPA 1974). The actual reduction depends on construction materials, geometry, etc. of the room.

4.2 Interference with Speech Communication

If continuous project noise indoors or outdoors is high enough, the Projects could interfere with speech communication, such that speakers will need to increase their vocal effort or move closer to each other. WHO (1999) suggests that "when listening to complicated messages (at school, listening to foreign languages, telephone conversation) the signal-to-noise ratio should be at least 15 dB". Assuming normal indoor speaking levels of 55-58 dBA (Levitt and Webster 1991), potential effects could occur if indoor noise levels exceed 40 dBA.

Speech interference is less likely to occur outdoors since humans naturally tend to speak louder when outdoors. An outdoor noise level of 55 dBA or lower should enable good speech comprehension (EPA 1974).

4.3 High Annoyance

The response to noise is subjective and is affected by many factors such as the:

- Difference between the Specific Sound (sound from the Project) and the Residual Sound (noise in the absence of the Specific Sound);
- Characteristics of the sound (e.g. if it contains tones, impulses, strong low-frequency content, etc.);
- Absolute level of sound;
- Time of day;
- Local attitudes to the Project; and
- Expectations for quiet.

Studies have found a consistent relationship between the percentage of a community that is highly annoyed by noise and the "adjusted" noise level. Health Canada (2010) suggests that the "Percent Highly Annoyed" or "%HA" metric, which is calculated using the adjusted L_{dn} (ANSI 2005, ISO 2003) – or Rating Level, L_{Ndn} – pre- and post-Project, is an appropriate indicator of noise-induced human health effects for project operational noise and for long-term construction noise exposure. Health Canada (2010) suggests that Project L_{dn} should be less than 75 dBA and that the increase in %HA should be less than 6.5%.

Annoyance from blasting can be estimated can be estimated using research conducted on sonic booms. According to the United States Environmental Protection Agency (EPA 1974), little or no public annoyance is expected to result from any number of daytime sonic booms per day (N) if the measured or predicted peak level is less than (125 - 10 log N) dBZ.

4.4 Loss of Wildlife Habitat

The potential effects on wildlife are described in terms of the following responses resulting in "loss of habitat":

- Reduction in biodiversity and population numbers due to 'above threshold' continuous noise levels; and
- Flight response, freezing or strong startle response due to event noise levels (helicopter and blasting).

Studies have identified the following noise level limits:

- Continuous Project noise during the day of 55 dBA (Environment Canada 2010);
- Continuous Project noise during the night of 45 dBA (Environment Canada 2010);
- A-weighted sound exposure level (L_{AE}) from passby events of 75 dBA; and
- Peak blasting noise level (L_{peak}) of 108 dBZ.

5 CRITERIA

Following the potential noise effects identified in the previous section, this section includes criteria suggested for best practice for assessing noise effects on humans and wildlife. Noise modelling for the Project has been performed to enable assessment of these criteria.

5.1 Human Receptors

Noise from construction activities often has the potential to negatively impact nearby human receptors, and is often the loudest noise source of project related noise. Health Canada (2010) advises the following assessments for construction noise:

- If construction noise lasts for less than 2 months at receptors it may be considered temporary, and community consultation is advised.
- If the construction period is less than one year, the assessment can be based on the US Environmental Protection Agency method (EPA 1974), where mitigation should be implemented if it is determined if the noise levels produced could cause widespread complaints.
- Construction noise should be treated the same as operations noise if the construction period is greater than one year.

Blasting during construction is treated separately from these assessments using the EPA (1974) formula.

Table 5-1 below lists the criteria applicable for the assessment of noise effects on humans residing in the area surrounding the Project.

Table 5-1 Criteria Applicable for Off-Site Human Receptors

Project Metric	Description	Limit
L_d	Day-time continuous noise level for assessing speech interference	55 dBA
L_n	Night-time continuous noise level for assessing sleep disturbance	45 dBA
L_{dn}	Project noise mitigation required due to excessive annoyance	75 dBA
Δ %HA	Increase in %HA metric due to Project for assessing annoyance	6.5%
L_{max}	Maximum sound level not to be exceeded more than 10 times per night for assessing sleep disturbance	60 dBA
L_{peak}	Peak sound pressure level for assessing public annoyance to impulsive blasting noise occurring *N* times per day	125 - 10 log *N* dBZ

The noise limit set for assessing sleep disturbance assumes that windows are open resulting in 15 dB of sound isolation.

All of the above criteria are for off-site human receptors. Project employees need not to be included in the annoyance assessment, but should be included for sleep disturbance assessment. Assuming that windows would be closed, resulting in 27 dB of sound isolation, Table 5-2 summarizes the applicable sleep disturbance criteria. Note that this criterion would also apply to daytime noise if there is potential for shift workers to be sleeping during daytime hours.

Table 5-2 Criteria Applicable for On-Site Human Receptors (Project Employees)

Project Metric	Description	Limit
L_n (possibly L_d as well)	Continuous noise level for assessing sleep disturbance	57 dBA
L_{max}	Maximum sound level not to be exceeded more than 10 times per sleep shift for assessing sleep disturbance	72 dBA

5.2 Wildlife Receptors

Table 5-3 below lists the criteria applicable for the assessment of noise effects on humans.

Table 5-3 Criteria Applicable for Wildlife Receptors

Project Metric	Description	Limit
L_d	Day-time continuous noise level for assessing wildlife habitat loss	55 dBA
L_n	Night-time continuous noise level for assessing wildlife habitat loss	45 dBA
L_{AE}	Sound exposure level for assessing wildlife sensitivity to helicopter noise	75 dBA
L_{peak}	Peak sound pressure level for assessing wildlife sensitivity to impulsive blasting noise	108 dBZ

6 SPATIAL & TEMPORAL BOUNDARIES

6.1 Spatial Boundaries

The study area for noise includes the following regions:

- 2 km from either side of the access road;
- A zone with a radius of 12 km around the mine site;
- A zone with a radius of 2.5 km around the Knipple Transfer Area and Bowser Aerodrome; and
- 3 km from either side of assumed helicopter and aircraft flight paths.

The study area was determined so that noise contours could be predicted to levels 5-10 dB below the criteria limits presented in Table 5-1 and Table 5-3.

6.2 Temporal Boundaries

Noise predictions were completed during two phases of the Project:

- The busiest year of construction; and,
- An average typical year of operations.

During the life of the mine, the production and mining activities are expected to be fairly consistent. Therefore, an average typical year was chosen to represent the operations phase.

The intent of the study is to predict the annual average daily noise levels during typical worse case years of the project in order to best correlate with the potential effects identified.

7 EXISTING ENVIRONMENTAL CONDITIONS

7.1 Existing Environment

The Project is situated within the Sulphurets District in the Iskut River region. The Property is located in the Boundary Range of the Coast Mountain physiographic belt along the western margin of the Intermontane tectonic belt. The climate is typical of northwestern BC, with cool, wet summers and relatively moderate but wet winters. Precipitation in the region is approximately 1,600 to 2,100 mm annually with approximately 70% of the precipitation falling during autumn and winter months. Snowpack typically ranges from 1 to 2 m deep. Permanent icefields are present in the upper reaches of the Brucejack Lake watershed. (Tetra Tech 2013)

Baseline noise monitoring was completed at six locations in the vicinity of the Project area, and the results are summarized in Table 7-1. Measurements were performed for both summer and winter conditions and the duration of each measurement is approximately 24 hours. The existing noise environment in the Project area is, for the most part, pristine. Aside from site S6, occasional aircraft noise and natural noise sources currently contribute to background noise levels. Site S6, being near the existing Brucejack Exploration Camp, logged other noise sources including vehicles and machinery. (Rescan 2013)

Table 7-1 Summary of Baseline Noise Monitoring Results

Monitoring Station	Location Description	L_{Aeq} for Total Noise Logging Period [dBA]		L_{90} for Total Noise Logging Period [dBA]	
		Winter (March)	*Summer (Sep/Oct)*	*Winter (March)*	*Summer (Sep/Oct)*
S01	5km south of access road entry from Highway 37	33	39	17	21
S02	North edge of Bowser Lake and 13km west of Highway 37	38	49	17	44
S03	South edge access road and 13km west of Highway 37	45	51	16	34
S04	750m north of Bowser River near Bowser Aerodrome	46	46	18	38
S05	2km north of Knipple Lake near Knipple Transfer Station	34	42	16	36
S06	500m north of Brucejack Lake near Project mine site	41	65	20	40

For the purposes of calculating the %HA, BKL suggests using the values shown in Table 7-2 below as a conservative assumption for baseline noise, based on experience with pristine areas such as the location of the Project. Actual levels in pristine areas would tend to be higher than these values.

Table 7-2 Estimated Baseline Noise Levels

Time Period	Noise Metric	Noise Level (dBA)
Day	L_d	35
Night	L_n	25
24 Hour	L_{dn}	35

7.2 Inventory of Noise Sensitive Receptors

Noise levels were predicted at both human and wildlife receptors. The following sections detail the existing and future human and wildlife locations regarded as sensitive to changes in noise levels. Noise levels at these receptors, which were provided by ERM Rescan, were calculated for both phases of the Project. A complete inventory of human and wildlife receptors can be found in Appendix D.

7.2.1 Human Receptors

Human receptors were identified both on-site and off-site as shown in Table 7-3 below. Potential effects related to each receiver type are also included.

Table 7-3 Summary of Human Receptors

Receiver Type	Off-site	On-site	Potential Effects
Workers Accommodation Camp	0	9	Sleep Disturbance
Human Cabin/Camping	2	1	Speech Interference, Sleep Disturbance, Annoyance

7.2.2 Wildlife Receptors

Wildlife receptors were distributed throughout the study area and were comprised of locations sensitive to the Mountain Goat, Grizzly Bear and Moose populations of this area as shown in Table 7-4 below. Potential effects include loss of wildlife habitat only.

Table 7-4 Summary of Wildlife Receptors

Receiver Type	Number of Receivers	Potential Effects
Goat	22	Loss of Wildlife Habitat
Grizzly	21	
Moose	12	

8 NOISE MODELLING METHODOLOGY

8.1 Acoustical Model

Transportation and industrial (airborne) noise levels have been predicted using the ISO 9613-2 (ISO 1996), ANSI S12.17 (ANSI 1996), ANSI S2.20 (ANSI 1983) and ICAN 2009 (Probst et al 2009) standards implemented in the outdoor sound propagation software Cadna/A, version 4.3. The Good Practice Guide for Noise Mapping (WG-AEN 2007) points out that the ISO 9613 noise calculation standard is recommended by the European Commission as current best practice to obtain accurate prediction results.

ISO 9613 describes a method for calculating the attenuation of sound during propagation outdoors in order to predict the levels of environmental noise at a distance from a variety of sources. The method predicts the equivalent continuous A-weighted sound pressure level under meteorological conditions favourable for sound propagation. It has been used to predict noise transmission from industrial sources.

The ICAN (Instruction for the Calculation of Aircraft Noise) methodology (Probst et al. 2009) has been used to predict aircraft noise, and uses geometrically defined flight paths and corridors, and grouped emission data of different aircraft types. It is based on a detailed procedure set up by the German Federal Environment Agency (UBA), and has been proved that the implementation in Cadna/A-FLG is in compliance with the procedure.

ANSI S12.17-1996 and ANSI S2.20-1983 standards, as implemented in BKL's in-house Matlab program, were used to calculate blasting noise. The blast noise level at receivers is dependent on the distance between the blast location and the receiver, the amount of explosive used as well as the depth at which each charge is buried. The relevant diffraction over terrain surrounding the Project site was performed using ISO 9613 as implemented in Cadna/A.

Due to the small number of reflective surfaces, and based on BKL's experience, reflections were not considered to be significant and were therefore not modelled. Model calculations were performed in octave bands, considering ground cover, topography and shielding objects (see following sections).

Table 8-1 Summary of Calculation Standards and Software Programs

Sound Source	Calculation Standards	Software Implementation
Mechanical sources (except aircraft)	ISO 9613-2	Cadna/A Version 4.3
Blasting	ANSI S12.17-1996 ANSI S2.20-1983 ISO 9613-2 (diffraction over terrain)	In-house computer programming of ANSI calculation formulas and Cadna/A Version 4.3
Aircraft and Helicopter	ICAN/AzB 08	Cadna/A Version 4.3 (FLG)

8.1.1 Ground Absorption

The acoustic properties of the ground surface can have a considerable effect on the propagation of noise. Flat non-porous surfaces such as concrete, asphalt, buildings, calm water etc. are highly reflective to noise, and according to ISO 9613-2 have a ground constant of G=0. Soft, porous surfaces such as foliage, loam, soft grass, fresh snow, etc. are highly absorptive to noise, and have a ground constant of G=1. The ISO standard does not use intermediate ground constants.

In order to approximate the ground effect on sound propagation, the ground surface has been modelled as reflective (G=0) for water bodies and ice covered ground and absorptive (G=1) for evergreen forest areas.

8.1.2 Meteorological Conditions

A temperature of 10ºC and relative humidity of 80% were used in the model settings to best represent weather conditions based on the selection available in Cadna/A. A moderate temperature inversion was assumed to represent typical, but not absolute, worst case conditions.

Variations in temperature and humidity have generally little effect on the overall noise propagation. However, detailed air absorption corrections with changing temperature are shown in Appendix C.

8.2 Geometrical Data

8.2.1 Topography

The intervening terrain has been modelled by directly importing ground contours of the area provided by ERM Rescan. Ground contours were imported at a 10 metre resolution. Some contours at the mine site were modified for the operations phase to incorporate terrain effects due to construction activity already completed at that stage.

8.2.2 Obstacles

The layout and dimensions of the Project buildings and equipment were incorporated into the model based on drawings and details provided by ERM Rescan.

8.3 Construction Noise Prediction Details

The following sections outline the noise sources, assumptions made and any other details relevant to noise predictions for each component of the construction noise assessment.

8.3.1 Project Construction

Project construction was modelled using several noise sources that each represented a larger group of equipment. These groups of equipment were based on equipment lists supplied by ERM Rescan, and BKL has estimated the sound power level for each equipment item based on similar equipment items or empirical formulae. The operating time and area of operation were also incorporated into the calculations.

Flight activities were also considered in the same model, but noise from blasting activities was considered separately.

Table 8-2 lists the simplified noise sources incorporated in the noise modelling along with calculated sound power levels (*SWL)*. Appendix D has a detailed breakdown of each of the noise sources.

Table 8-2 Construction Sources

Source	Sound Power Level [dBA]		Modelling Description
	Day	Night	
Mine site construction noise sources	125	122	Area source covering mine site
Quarry construction noise sources, including crushers and screen	134	130	Area source covering quarry
Knipple Transfer Station construction noise sources	124	0	Area source covering Knipple Transfer Station
Bowser Aerodrome construction noise sources	124	0	Area source covering Bowser Aerodrome
500 kW diesel generator	99	99	Point sources at mine site and Knipple Transfer Station
250 kW diesel generator	96	96	Point sources at Bowser Aerodrome and Knipple Transfer Station

8.3.2 Access Road Activity during Construction

Access road activity during construction will include road upgrades and project vehicle traffic. Calculation of the noise sources for the modelling of road construction was completed in the same fashion as the port construction, described in Section 8.3.1.

Access road activity was simplified into three noise sources:

1. Access road segment from Highway 37 entry to quarry;
2. Access road segment from quarry to mine site; and
3. Valley of King alternate access route from quarry to mine site.

The alternate access route was modelled with identical activity and sound power as the segment of access road between the quarry and mine site to be conservative and to study the potential range of noise effects south of the mine site.

Table 8-3 Access Road Activity Source lists the simplified noise sources incorporated in the noise modelling along with the calculated *SWL*. Appendix D has a detailed breakdown of each of the noise sources.

Table 8-3 Access Road Activity Sources

Source	Sound Power Level [dBA]		Modelling Description
	Day	Night	
Access road activity noise sources between Hwy 37 entry and quarry	123	114	Line source along access road between Hwy 37 entry and quarry
Access road activity noise sources between quarry and mine site	125	121	Line source along access road between quarry and mine site
Alternate access route activity noise sources between quarry and mine site	125	121	Line source along alternate access road between quarry and mine site

8.3.3 Helicopter Activity during Construction

Bell 205 or Kamov helicopters will be used for transportation of materials, transmission line construction, avalanche explosive control and support during the construction phase.

Table 8-4 shows a summary of the helicopter type and frequency.

Table 8-4 Helicopter Type and Frequency during Construction

Aircraft Type (or similar)	ICAO Group	ICAO Definition	Maximum No. Flights per day
10 Passenger Helicopter	H 1.2	Civil and military helicopters with MTOM from 3.0 to 5.0 tons	5

The following assumptions were used in the helicopter modelling:

- All helicopter ascend and descend at an angle of 8.9º;
- Helicopter cruising altitude is 600 m (1970 feet) above sea level;
- BKL have created flight routes for helicopters based on the preferred flight region provided by ERM Rescan and proximity to sensitive receiver locations (see Section 9.3 for assumed routes); and
- A maximum of two helicopter flyovers will occur at any point along the helicopter flight routes in a day.

8.3.4 Blasting

Two blast locations were modelled, including:

- The mill building at the mine site; and,
- The quarry.

The explosive to be used is Ammonium Nitrate Fuel Oil (ANFO), so ANSI S2.20–1983 has been used to convert the explosive mass to a Trinitrotoluene (TNT) equivalent. The table below summarises the input data used to calculate blasting noise levels.

Table 8-5 Blasting Input Data

Input	Construction Blasting
ANFO per hole (kg)	27.5
TNT mass equivalent per hole (kg)	22
Holes per delay	1
Charge burial depth (m)	4

8.4 Operations Noise Prediction Details

8.4.1 Project Operations

Project operations noise was modelled in the same fashion as the project construction described in Section 8.3.1.

All equipment assumed operating indoors in the mill building and water treatment plant was modelled as combined area sources (walls and roof) with the following characteristics of the building as a whole:

- Interior reverberant noise level of combined sources: 85 dBA; and
- 26 gauge corrugated steel with fibreglass lining façade.

Table 8-6 lists the simplified noise sources incorporated in the noise modelling along with the calculated *SWL*. Appendix D has a detailed breakdown of each of the noise sources.

Table 8-6 Operations Sources

Source	Sound Power Level [dBA]		Modelling Description
	Day	Night	
Mine site operations noise sources	126	125	Area source covering mine site
Knipple Transfer Station operations noise sources	116	114	Area source covering Knipple Transfer Station
Bowser Aerodrome operations noise sources	125	123	Area source covering Bowser Aerodrome
500 kW diesel generators	99	99	Point sources at Knipple Transfer Station.

Source	Sound Power Level [dBA]		Modelling Description
	Day	Night	
250 kW diesel generators	96	96	Point sources at Bowser Aerodrome and Knipple Transfer Station.
Baghouses	114	114	Point sources at mine site
Scrubbers	113	113	Point sources at mine site
Portal Heaters	112	112	Point sources at mine site
Primary Fans	108	108	Point sources at mine site
Return Air Raises (Exhaust Fan)	111	111	Point sources at mine site
Indoor Equipment Reverberant Level	85	85	Area source covering mill building and water treatment plant

8.4.2 Access Road Activity during Operations

Access road activity during operations was modelled in the same fashion as in the construction phase described in Section 8.3.2.

For operations, access road activity was simplified into only two sources:

1. Entire access road from Highway 37 entry to mine site;
2. Valley of King alternate access route from quarry to mine site.

The sound power modelled for the alternate route is a duplicate of equivalent sound power of the segment of access road between the quarry and the mine site.

Table 8-7 Access Road Activity Sources

Source	Sound Power Level [dBA]		Modelling Description
	Day	Night	
Access road activity noise sources between Hwy 37 entry and mine site	123	121	Line Source along access road between Hwy 37 entry and mine site
Alternate access route activity noise sources between quarry and mine site	102	100	Line Source along alternate access road between quarry and mine site

8.4.3 Helicopter Activity during Operations

Helicopter activity during operations was modelled in the same way as construction described in Section 8.3.3. All assumptions remain the same as the construction phase.

Table 8-8 shows a summary of the helicopter type and frequency.

Table 8-8 Helicopter Type and Frequency during Operations

Helicopter Type (or similar)	ICAO Group	ICAO Definition	Maximum No. Flights per day
10 Passenger Helicopter	H 1.2	Civil and military helicopters with MTOM from 3.0 to 5.0 tons	3

8.4.4 Aircraft Activity during Operations

Regular chartered flights will transport mine personnel to and from the Project site during operations. The passenger aircrafts used will be the Beechcraft 1900 and potentially the DE Havilland Dash 8 turboprops and C-130 Hercules aircraft. To be conservative, the loudest aircraft type (C-130 Hercules aircraft) was used for all aircraft analyses.

Table 8-9 Aircraft Type and Frequency during Operations

Aircraft Type (or similar)	ICAO Group	ICAO Definition	Maximum No. Flights per day
Propeller Aircraft	P 2.2	Propeller aircraft with MTOM (Maximum Take-Off Mass) above 5.7 tons, that cannot be described by P 2.1*	1

* P2.1: Propeller aircraft with MTOM above 5.7 tons according to chapters 3, 4, or 10, ICAO annex 16

The following assumptions were used in aircraft modelling:

- All aircrafts ascend and descend at an angle of 3.6°;
- Aircraft would take-off and land in two directions (Runway 07 and 25) imposed by the orientation of the proposed Bowser airstrip;
- BKL have created flight routes based on the geography of the area (See Section 9.4 for assumed routes);
- Only aircraft departure noise was modelled and was considered equal to aircraft approach noise as an conservative assumption; and
- Two aircraft flyovers will occur at any point along the aircraft flight routes in a day given the worst case when an aircraft lands and takes off in the same direction in a day.

8.5 Pass-by Events

Pass-by noise levels (sound exposure levels, L_{AE}, or maximum sound levels, L_{max}) were modelled for vehicles along the access road and aircraft/helicopters along the flight paths.

Vehicle passby noise was modelled using the loudest mobile equipment, the Printoh Beast, travelling at a speed of 10 km/h. An additional calculation was performed using a Ski-Doo snowmobile.

Aircraft and helicopter passby noise was modelled using the same inputs as described in Sections 8.4.3 and 8.4.4. Maximum sound levels were not calculated because the number of events are not expected to exceed 10 during a shift when workers may be sleeping.

8.6 Receivers

For all assessments, calculations were performed for assumed receiver heights of 4 m above the ground in order to minimize terrain effects close to receivers due to the coarse (10 m) ground contour resolution.

Predicted average noise contours were calculated at 4 m high on 80 m by 80 m grids, to an extent that encompasses noise levels down to the 35 dBA noise contour. Predicted sound exposure level contours for single events were calculated to an extent that encompasses noise levels down to the 65 dBA noise contour. Predicted blasting noise contours were calculated to an extent that encompasses noise levels down to the 100 dBZ noise contour.

8.7 Sound Source Adjustments

In order to calculate the *%HA*, adjustments must be made to the received noise levels depending on their relative annoyance (e.g. helicopter noise may be more annoying than traffic noise). Additionally, adjustments are applied to the sound character of the source if it is impulsive, tonal or has significant low-frequency content. Appendix B describes these adjustments in detail.

For L_{dn} and *%HA* calculations, +10 dBA was added to the assumed baseline and predicted future noise to account for a rural community's increased sensitivity to noise and +5 dBA was added to the Project L_{dn} predicted at each receiver to account for increased annoyance due to tones, impulses or aircraft noise that may be audible at each receptor location.

8.8 Limitations

For sound calculated using the ISO 9613 standard, the indicated accuracy is ± 3 dBA at source to receiver distances of up to 1000 m and unknown at distances above 1000 m.

The estimated sound power levels for equipment were based on documented average noise levels for similar equipment. In general, for individually modelled noise sources (fixed and mobile equipment), the estimated accuracy of the sound power levels is ± 5 dBA, however, with many different sources combined the total sound power level is likely to be more accurate than this.

9 NOISE PREDICTION RESULTS

9.1 Continuous Construction Noise

Contours showing the day and night average noise levels during construction are presented in Figure 9-1 and Figure 9-2. These noise contours do not include helicopter noise which is considered an intermittent noise source.

Detailed construction results at human and wildlife receptors can be found in Appendix F.

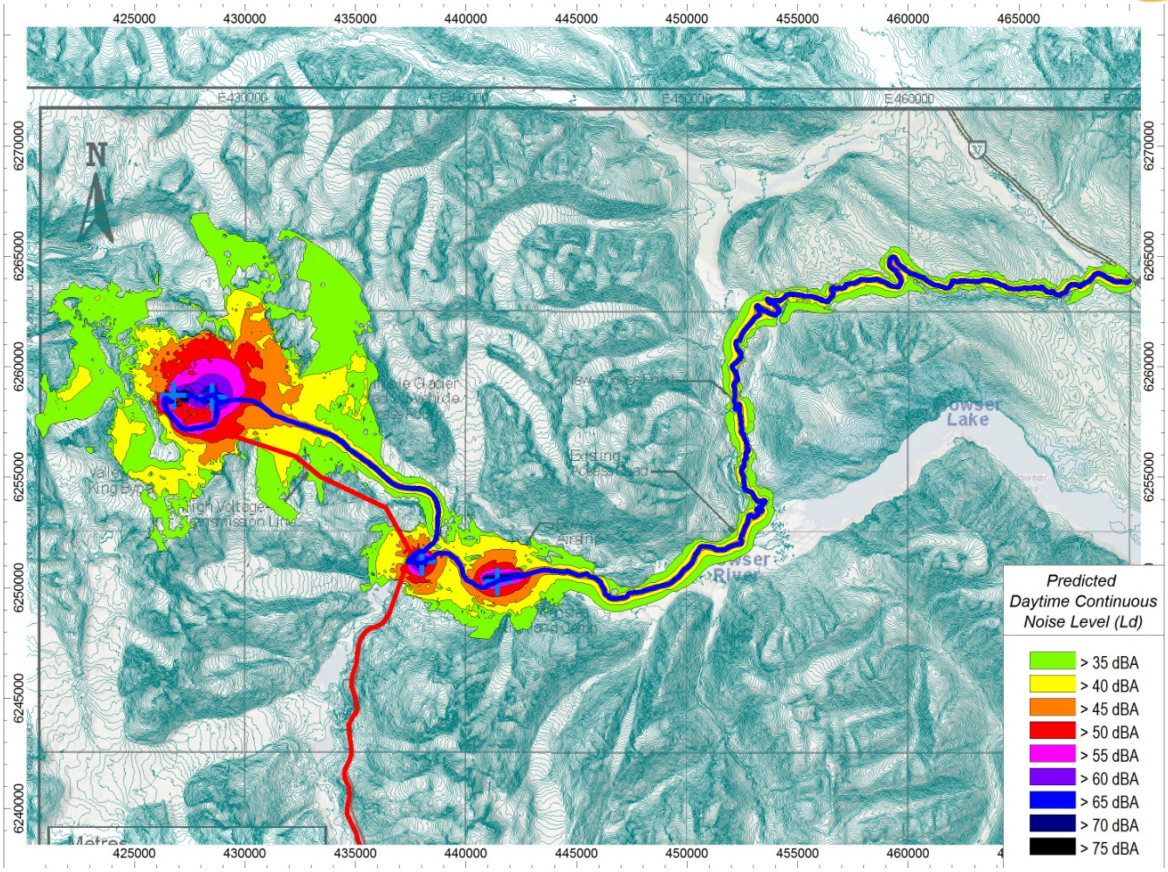

Figure 9-1 Construction Daytime Average Noise Level Contours

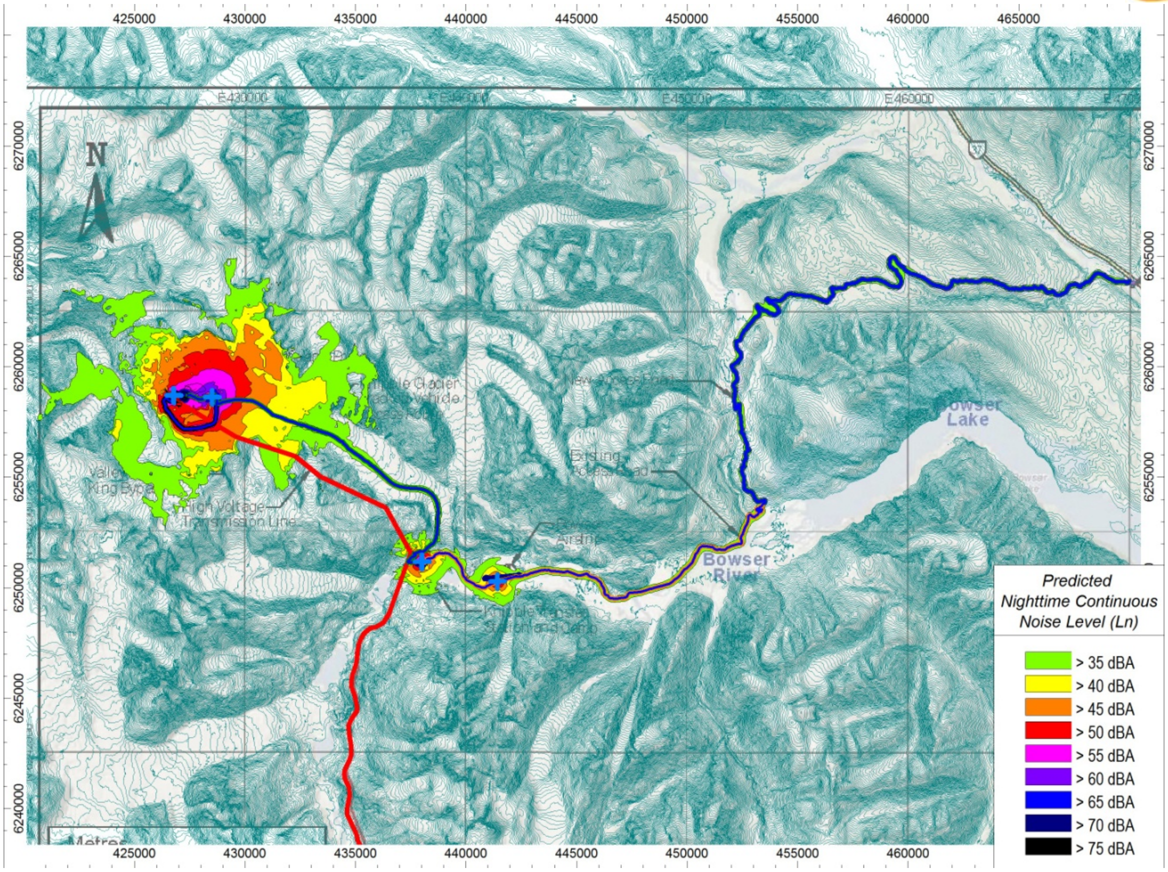

Figure 9-2 Construction Nighttime Average Noise Level Contours

9.2 Continuous Operations Noise

Contours showing the day and night average noise levels during construction are presented in Figure 9-3 and Figure 9-4. These noise contours do not include airplane or helicopter noise which are considered intermittent noise sources.

Detailed operations results at human and wildlife receptors can be found in Appendix F.

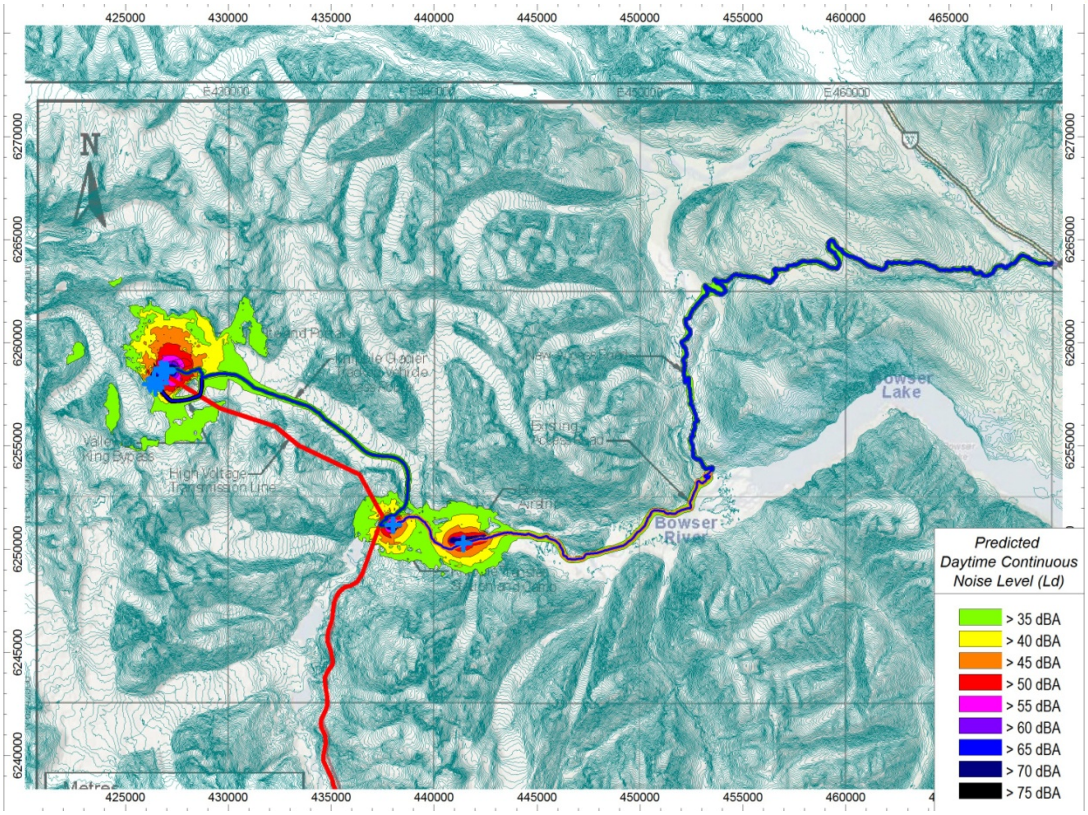

Figure 9-3 Operations Daytime Average Noise Level Contours

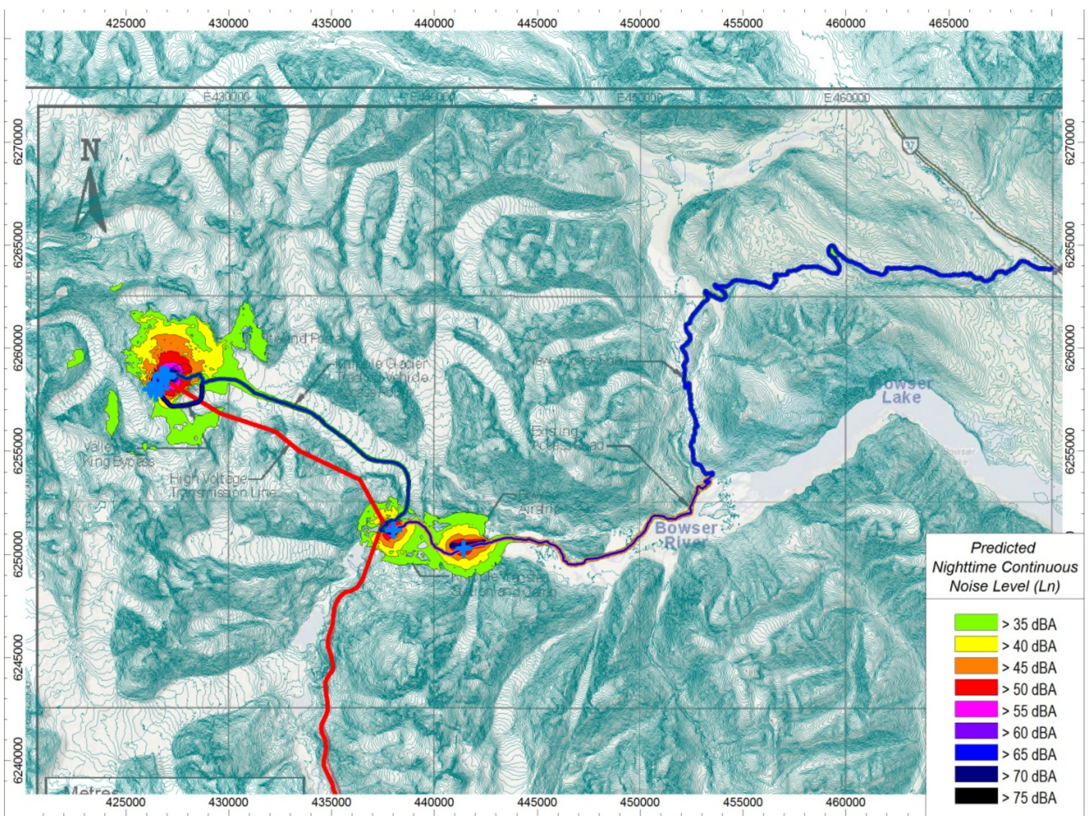

Figure 9-4 Operations Nighttime Average Noise Level Contours

9.3 Helicopter Activity during Construction and Operations

A single helicopter event was modelled passing through all possible routes, and contours of the single event noise exposure (L_{AE}) are presented in Figure 9-5. The contours show that when flying at the assumed 600 m altitude, the helicopter leaves an approximate 3 km wide noise path that exceeds 75 dBA L_{AE}.

Detailed helicopter L_{AE} results at wildlife receptors can be found in Appendix F.

Figure 9-5 Single Event Exposure (L_{AE}) Contours for Helicopter on Possible Routes

9.4 Aircraft Activity during Operations

Single event sound exposure levels (L_{AE}) were also modelled for aircraft departure on runway 07 and runway 25 and presented as noise contours in Figure 9-6. The contours show that the noise paths left by the planes exceeds 75 dBA L_{AE} for approximately 50 km along the flight path from the airstrip, and leaves an approximate 6 km wide noise path. Contours for aircraft approach would be expected to have a similar shape, but smaller footprint.

Detailed aircraft L_{AE} results at wildlife receptors can be found in Appendix F.

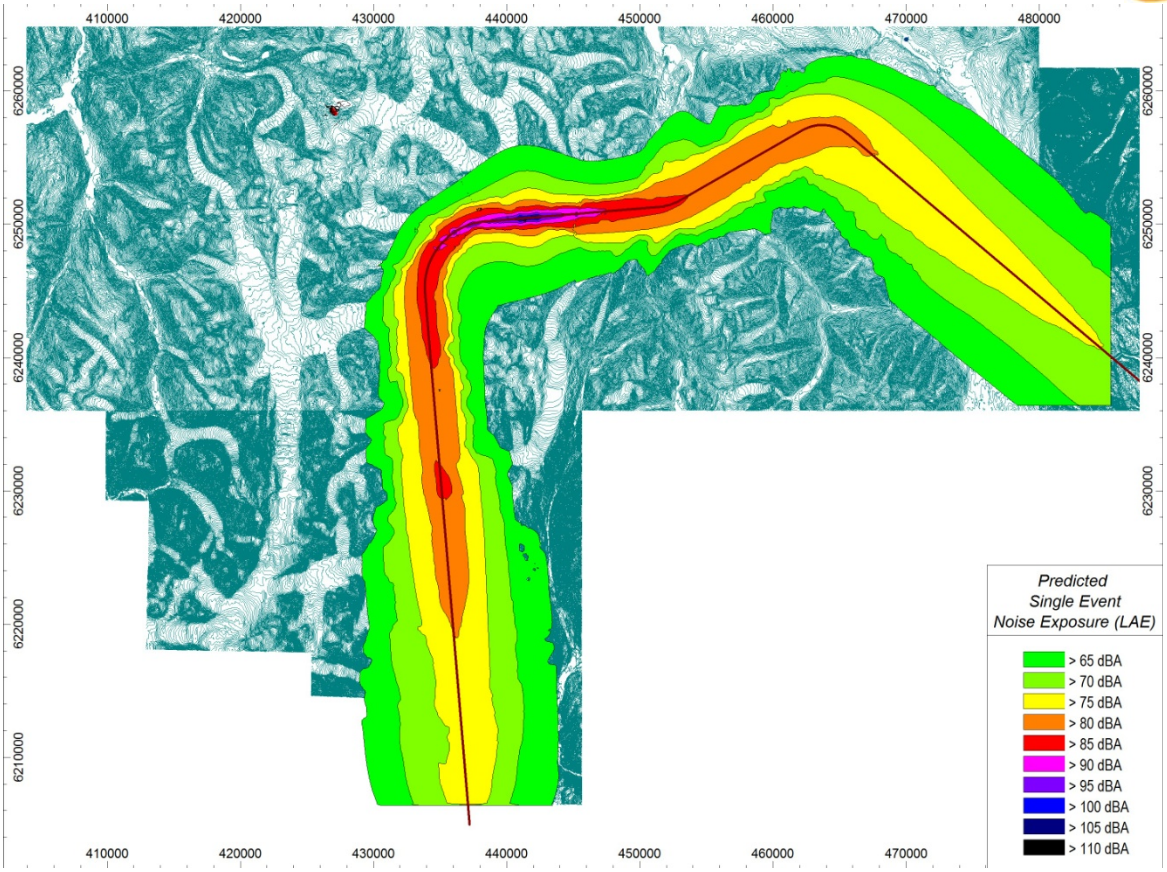

Figure 9-6 Single Event Exposure (*L_{AE}*) Contours for Aircraft Take-off on Runway 07 and 25

9.5 Adjusted Total Noise during Construction and Operations

Contours showing the adjusted day-night equivalent noise (L_{Ndn}) during construction and operations are presented in Figure 9-3 and Figure 9-4. These noise contours include continuous noise and airplane and helicopter noise, but do not include blasting noise which is treated separately. The predicted levels in areas not covered by the contours are between 45 and 50 dBA.

Detailed results at human receptors can be found in Appendix F.

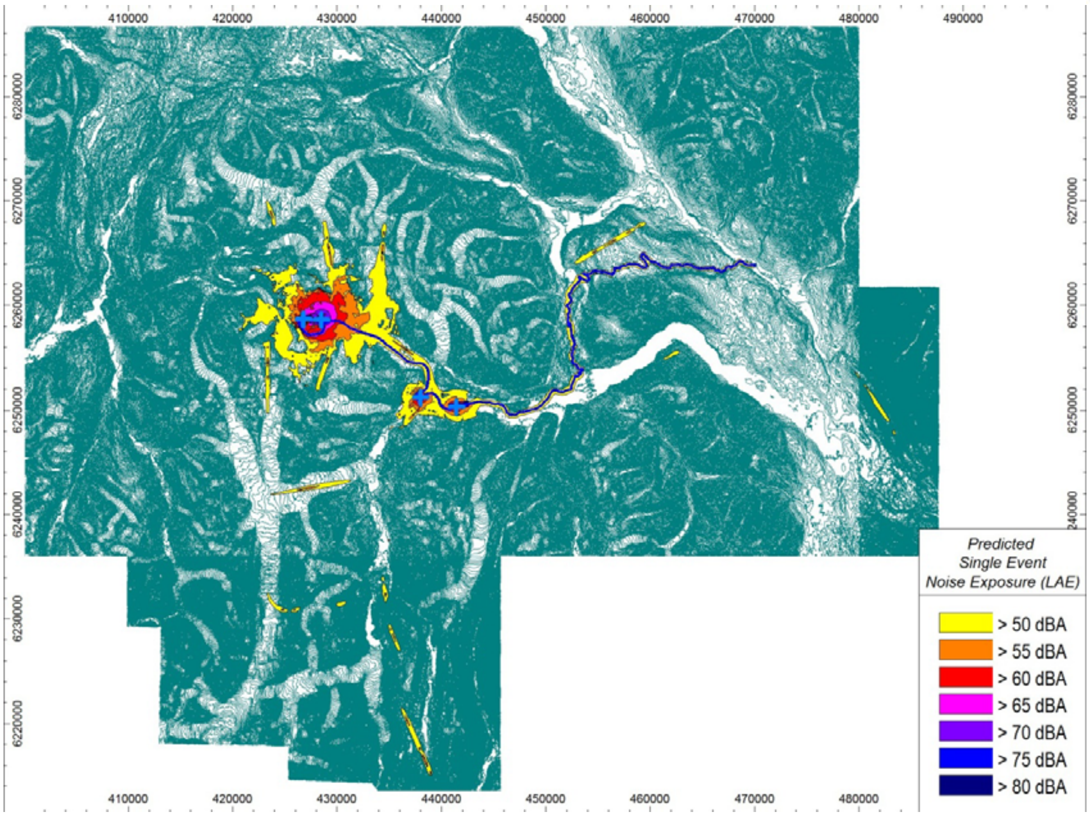

Figure 9-7 Construction Adjusted Day-Night Equivalent Noise Level (L_{Ndn}) Contours

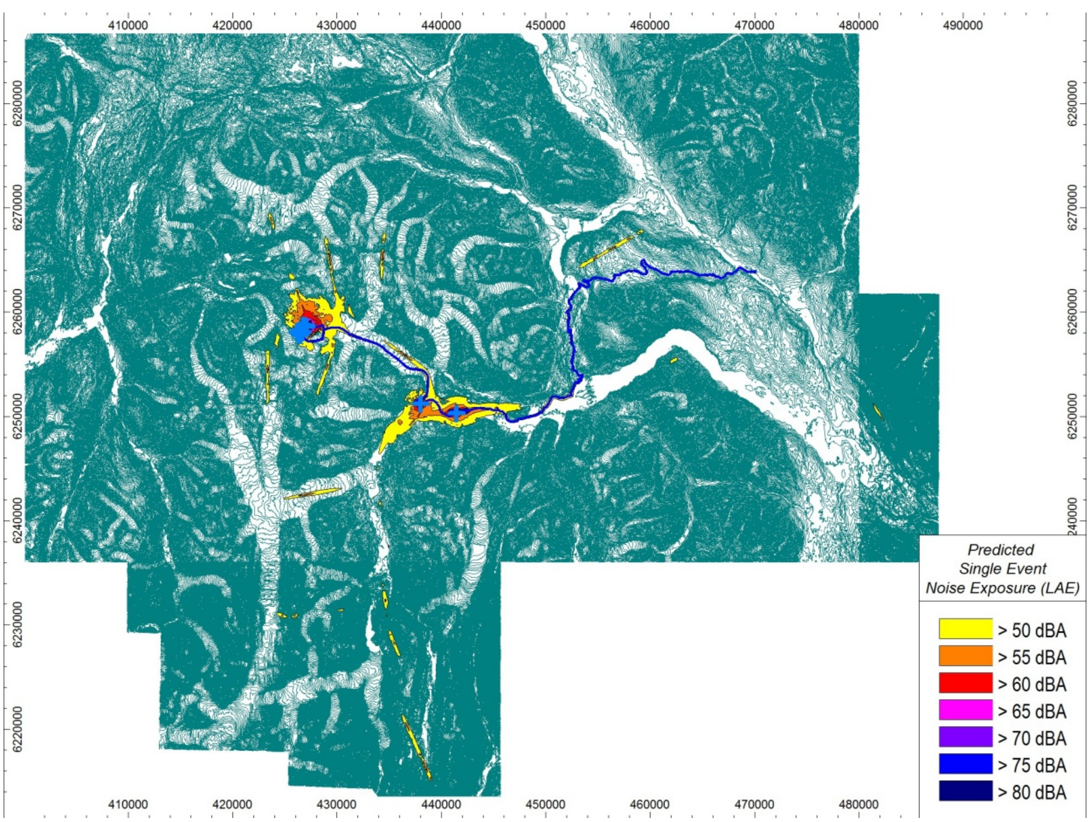

Figure 9-8 Operations Adjusted Day-Night Equivalent Noise Level (L_{Ndn}) Contours

9.6 Blasting during Construction

Peak levels from blasting at the mine site and quarry are presented in Figure 9-9 and Figure 9-10, respectively.

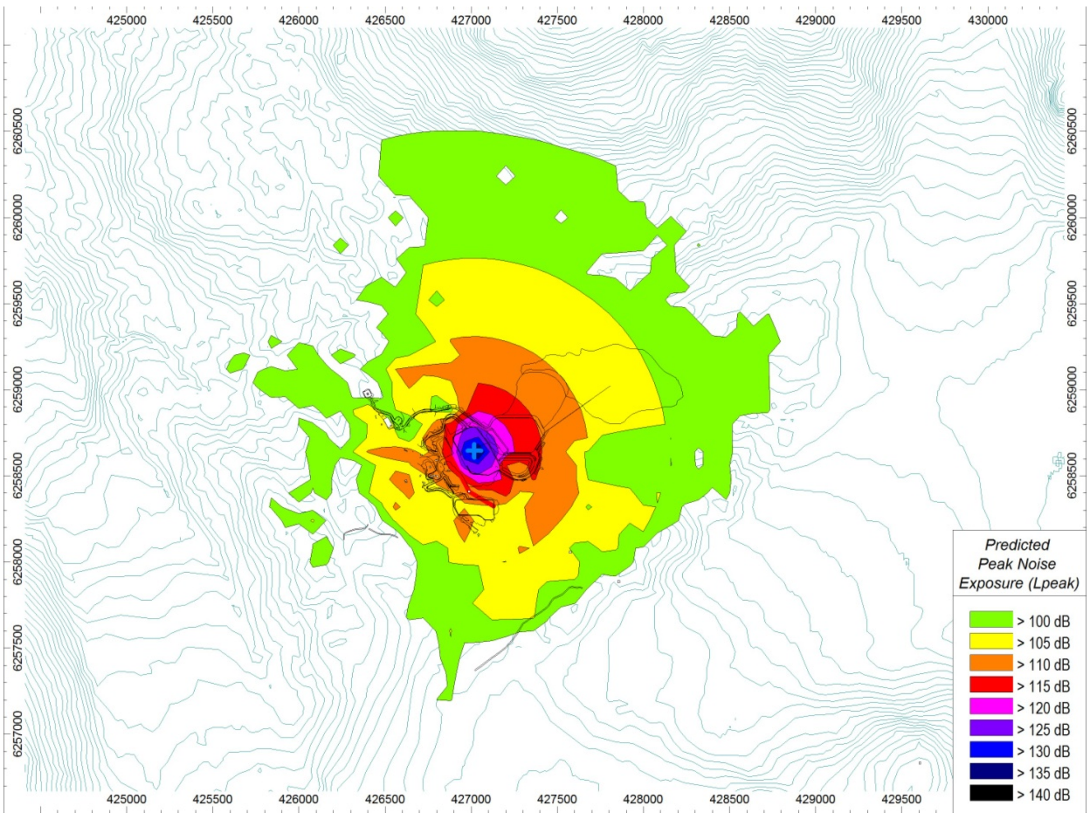

Figure 9-9 Peak Sound Level Contours for Blasting at Mine Site

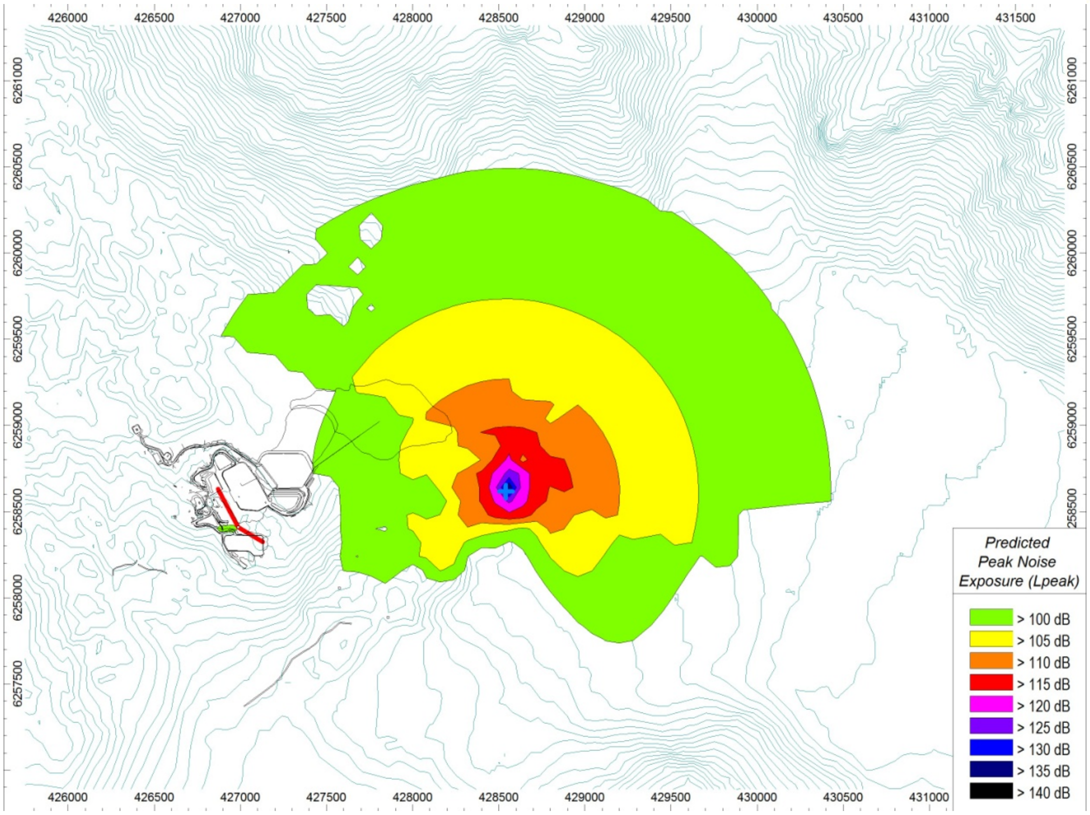

Figure 9-10 Peak Sound Level Contours for Blasting at Quarry

9.7 Vehicle Passby Noise

Single event sound exposure levels (L_{AE}) from a Printoh Beast mobile equipment are presented in Figure 9-12 below.

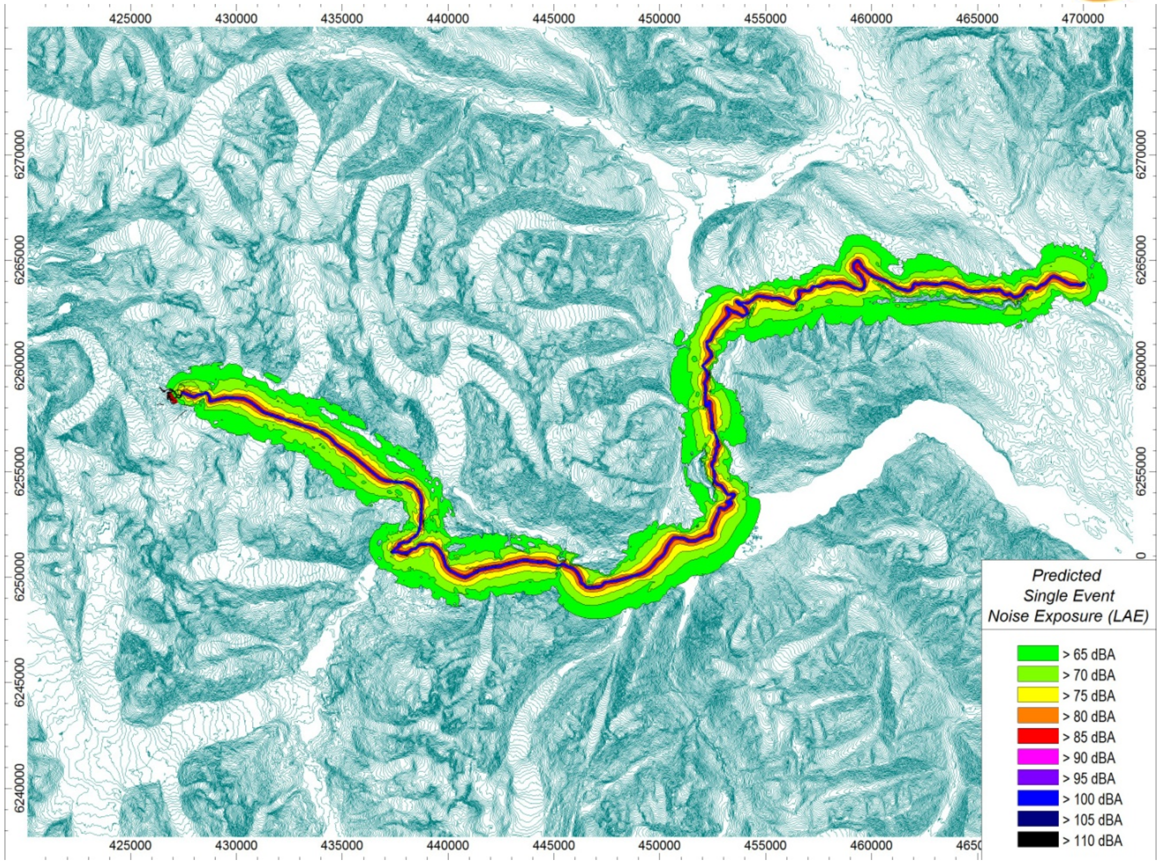

Figure 9-11 Single Event Exposure (L_{AE}) Contours for Printoh Beast Passby

When assuming the terrain is flat (worst case), the predicted L_{AE} versus distance from a Printoh Beast and a Ski-Doo snowmobile passby over hard and soft ground are presented in Figure 9-12. Realistically, the noise will be less at a given distance than predicted in the figure as the terrain will provide noise shielding.

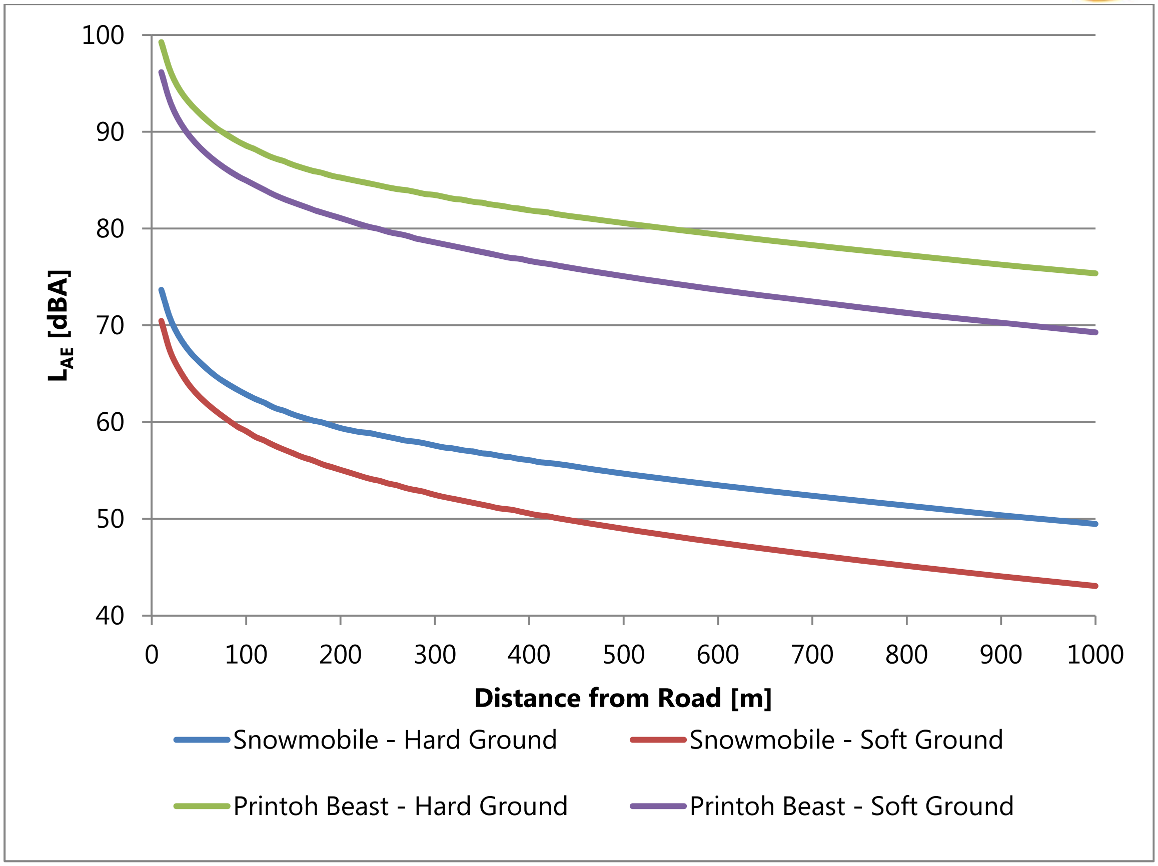

Figure 9-12 Single Event Exposure (L_{AE}) versus Distance from Printoh Beast and Ski-Doo Snowmobile Passby

Table 9-1 below shows the predicted L_{max} of a Printoh Beast mobile equipment passing by the closest receivers along the access road.

Table 9-1 Printoh Beast Passby Maximum Sound Level

Receptor	L_{max} (dBA)
Worker Transfer station camp	83
Worker Bowser staff house	84
Worker Bowser Cabin 1	80
Worker Bowser Cabin 2	79
Worker Bowser Cabin 3	77
Human Skii km Lax Ha Lodge	74
Worker Bowser Cabin 4	76
Worker Mine site existing camp 1	67
Worker Mine site existing camp 2	68
Worker Mine site operations camp	57

10 CONCLUSIONS

Noise predictions were completed for a variety of construction and operations activities on the Brucejack Mine Project, including project construction and operations, aircraft and helicopter activity, and blasting. Predicted noise levels were presented over areas and in metrics suitable for effects assessments on human and wildlife receptors.

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APPENDIX A GLOSSARY

A-weighting – A standardised filter used to alter the sensitivity of a sound level meter with respect to frequency so that the instrument is less sensitive at low and high frequencies where the human ear is less sensitive. Also written as dBA.

Ambient/existing level – The pre-project noise or vibration level.

C-weighting – The C-weighting provides a more discriminating measure of the low frequency sound pressures than provided by A-weighting. Unlike the A-weighting, the C-weighting retains its sensitivity to sounds between 100 and 1000 Hz. Also written as dBC.

Continuous sound level – Generally defined by many BC municipal noise bylaws as the A-weighted sound level, measured using the "slow" time constant, for any sound occurring for a duration of more than three minutes in a fifteen minute period.

Cumulative – The summation of individual sounds into a single total value related to the effect over time.

Day-night equivalent sound level (L_{dn}) – The sound exposure level for a 24-hour day calculated by logarithmically adding the sound exposure level obtained during the daytime (L_d) (7:00 am to 10:00 pm) to 10 times the sound exposure level obtained during the nighttime (L_n) (10:00 pm to 7:00 am) to account for greater human sensitivity to nighttime noise.

Decibel – The standard unit of measurement for sound pressure and sound power levels. It is the unit of level which denotes the ratio between two quantities that are proportional to pressure or power. The decibel is 10 times the logarithm of this ratio. The reference pressure used for airborne sound is 20 μPa while the typical reference pressure used for underwater sound is 1 μPa. Also written as dB.

Equivalent sound level - The steady level that would contain the same amount of energy as the actual time-varying level. Although it is, in a sense, an "average", it is strongly influenced by the loudest events because they contain the majority of the energy.

Frequency – The number of times that a periodically occurring quantity repeats itself in one second.

Frequency spectrum – Distribution of frequency components of a noise or vibration signal.

Hertz – The unit of acoustic or vibration frequency representing the number of cycles per second.

Impulsive sound – Non-continuous sound characterised by brief bursts of sound pressure. The duration of a single burst of sound is usually less than one second.

Intermittent – Non-continuous or transient noise or vibration that occurs at regular or irregular time intervals with each occurrence lasting more than about five seconds.

Intervening terrain – The terrain in between the noise/vibration source and sensitive receiver.

Maximum sound level – The highest exponential time-averaged sound level, in decibels, that occurs during a stated time period, using a "slow" or "fast" time constant.

Metric – Measurement parameter or descriptor.

Non-continuous sound level - Generally defined by many BC municipal noise bylaws as the maximum A-weighted sound level using the "slow" time constant.

Noise - Noise is unwanted sound, which carries no useful information and tends to interfere with the ability to receive and interpret useful sound.

Noise sensitive human receptors – A place occupied by humans with a high sensitivity to noise. These include residences, hospitals, schools, hotels etc.

Octave bands – A standardized set of bands making up a frequency spectrum. The centre frequency of each octave band is twice that of the lower band frequency. The bands are centred at standardized frequencies.

Peak sound level – The maximum absolute value of the instantaneous sound pressure. Most other metrics use root mean square (RMS) and not instantaneous values of sound pressure.

Receiver/Receptor – A stationary far-field position at which noise or vibration levels are specified.

Root Mean Square (RMS) – The square root of the mean-square value of an oscillating waveform, where the mean-square value is obtained by squaring the value of amplitudes at each instant of time and then averaging these values over the sample time.

Sound – The fluctuating motion of air or other elastic medium which can produce the sensation of sound when incident upon the ear.

Sound exposure level – Defined as the constant sound level which has the same amount of energy in one second as the original noise event.

Time constant (slow, fast) – Used to describe the exponential time weighting of a signal. The standardised time periods are 1 second for "slow" and 0.125 seconds for "fast" exponential weightings.

Tonal sound – Sound characterized by a single frequency component or multiple distinct frequency components that are perceptually distinct from the total sound.

Total noise – Results from a combination of multiple noise sources at multiple spatial locations and is typically described by a 24-hour equivalent sound level.

Vibration – An oscillation wherein the quantity is a parameter that defines the motion of a mechanical system.

Z-weighting – The Z-weighting denotes "zero" or no frequency weighting and is commonly used for communicating octave band or peak sound levels. Also written as dBZ.

APPENDIX B INTRODUCTION TO SOUND AND ENVIRONMENTAL NOISE ASSESSMENT

B.1 General Noise Theory

The two principle components used to characterize sound are loudness (magnitude) and pitch (frequency). The basic unit for measuring magnitude is the decibel (dB), which represents a logarithmic ratio of the pressure fluctuations in air relative to a reference pressure. The basic unit for measuring pitch is the number of cycles per second, or Hertz (Hz). Bass tones are low frequency and treble tones are high frequency. Audible sound occurs over a wide frequency range, from approximately 20 Hz to 20,000 Hz, but the human ear is less sensitive to low and very high frequency sounds than to sounds in the mid frequency range (500 to 4,000 Hz). "A-weighting" networks are commonly employed in sound level meters to simulate the frequency response of human hearing, and A-weighted sound levels are often designated "dBA" rather than "dB".

If a continuous sound has an abrupt change in level of 3 dB it will generally be noticed while the same change in level over an extended period of time will probably go unnoticed. A change of 6 dB is clearly noticeable subjectively and an increase of 10 dB is generally perceived as being twice as loud.

B.2 Basic Sound Metrics

While the decibel or A-weighted decibel is the basic unit used for noise measurement, other indices are also used to describe environmental noise. The Equivalent Sound Level, abbreviated L_{eq}, is commonly used to indicate the average sound level over a period of time. The L_{eq} represents the steady level of sound which would contain the same amount of sound energy as the actual time-varying sound level. Although the L_{eq} is an average, it is strongly influenced by the loudest events occurring during the time period, because these loudest events contain most of the sound energy. Another common metric used is the L_{90}, which represents the sound level exceeded for 90% of a time interval and is typically referred to as the background noise level.

The L_{eq} can be measured over any period of time using an integrating sound level meter. Some common time periods used are 24 hours, noted as the L_{eq24}, daytime hours (07:00 to 22:00), noted as the L_d, and night time hours (22:00 to 07:00), noted as the L_n. As the impact of noise on people is judged differently during the day and during the night, 24 hour noise metrics have been developed that reflect this.

The day-night equivalent sound level (L_{dn}) is one metric commonly used to represent community noise levels. It is derived from the L_d and the L_n with a 10 dB penalty applied to the L_n to account for increased sensitivity to night time noise.

B.3 Human Annoyance to Noise

Studies have consistently shown that an increase in noise in a community will bring an increase to the amount of people who are highly annoyed (ISO 2003). However, the sound pressure level is not the only factor in how annoying noise is. The type of noise, or the quality of it, can also greatly affect how annoying the sound is perceived. In general, tonal, impulsive or sounds with excessive low frequency content can all increase the level of annoyance. These characteristics are often referred to as intrusive noise characteristics.

Aircraft, tonal (e.g. backup alarms on trucks) and impulsive noise (e.g. hammering) are often perceived as more annoying than continuous neutral noise and have a higher potential to disturb receptors (ISO 2003). Therefore noise with these characteristics should be penalized to reflect their true impact. ISO 2003 recommends making a +3-6 dB adjustment to aircraft or tonal noise, +5 dB adjustment to regular impulsive noise and a +12 dB adjustment to highly impulsive noise. In practice, these adjustments should be made to the noise at the receiver.

APPENDIX C TEMPERATURE AND HUMIDITY EFFECTS

Variations in temperature and humidity generally have little effect on the overall noise propagation. A graph showing the correction that can be applied to the received level for a range of temperatures, based on a typical noise spectrum emission relevant to the Project, has been produced based on the air absorption tables in ANSI S1.26 (ANSI 1995). The graph is shown in Figure C-1.

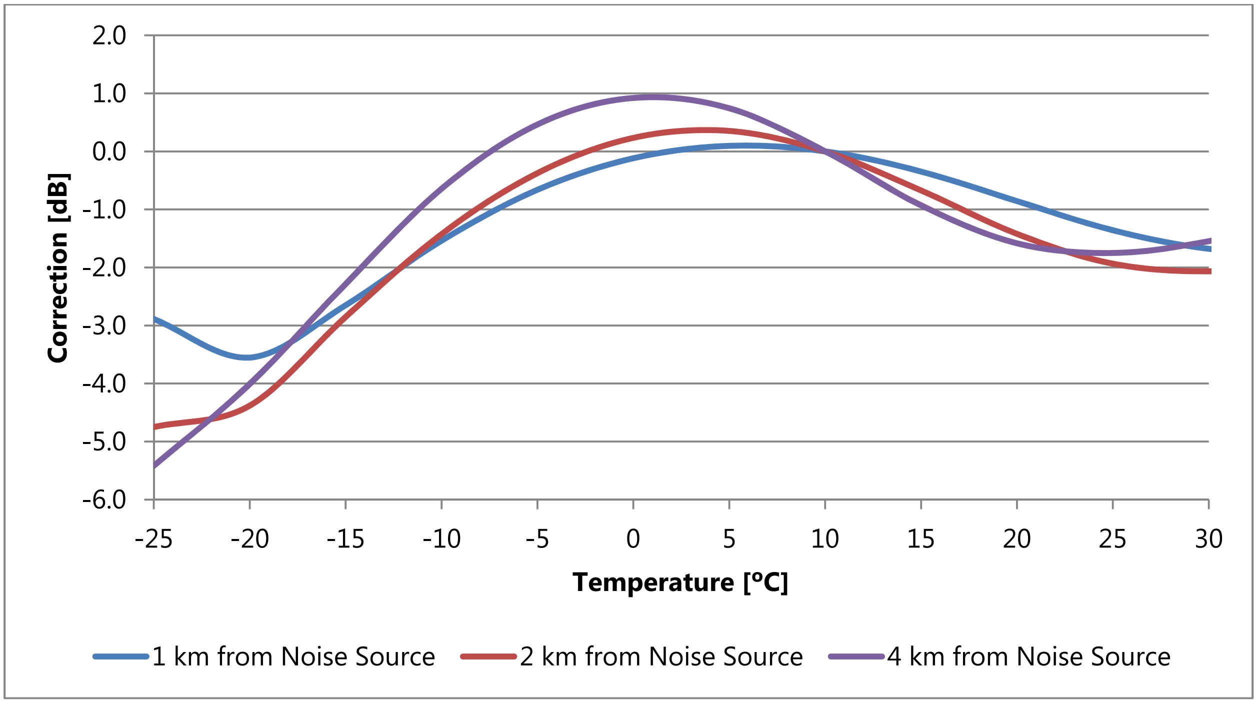

Figure C-1 Correction for Modelled Results for Different Temperatures at Various Distances at 80% Relative Humidity

APPENDIX D HUMAN AND WILDLIFE RECEPTORS

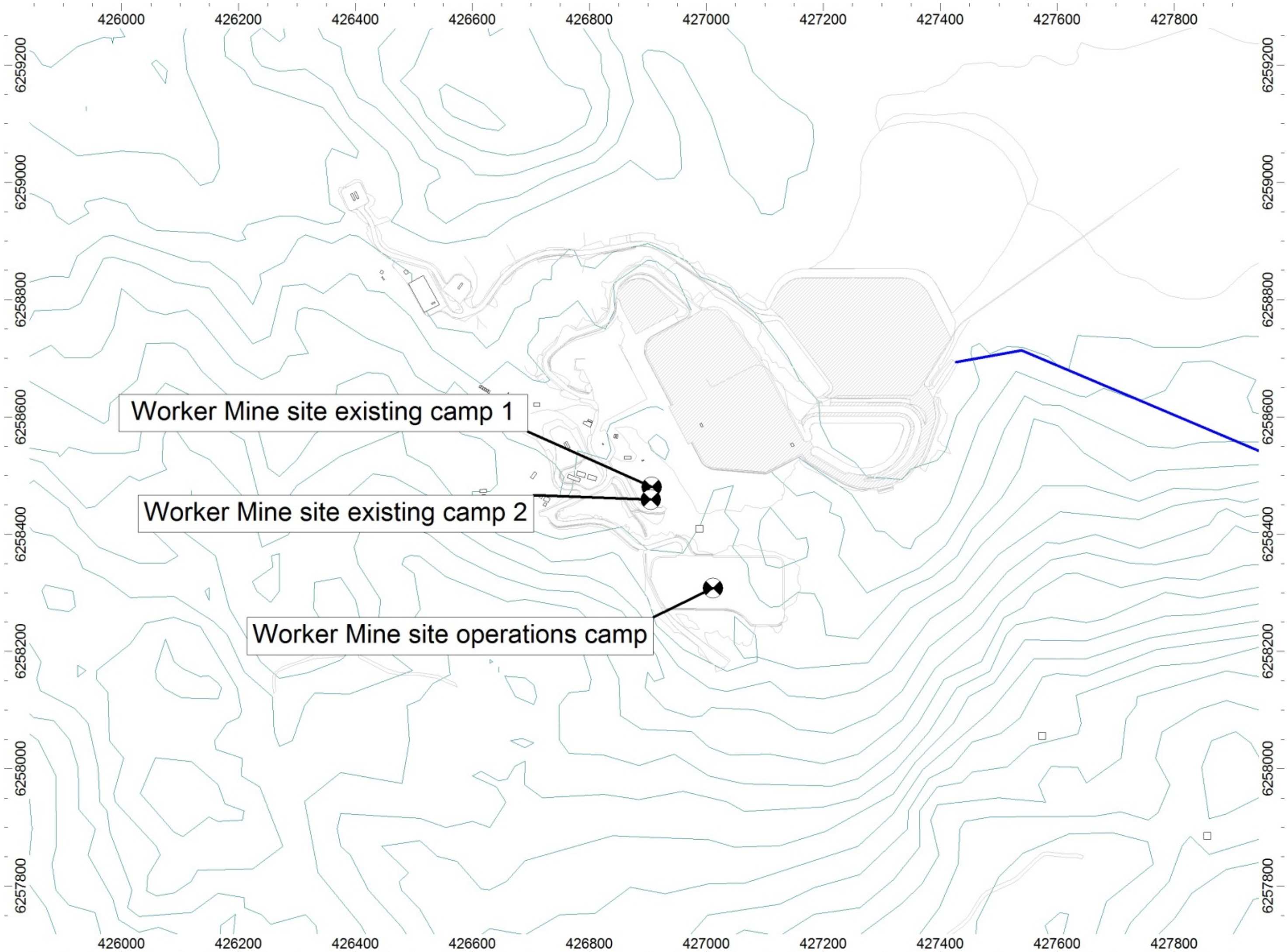

Figure D-1 Human Worker Receptors at Mine Site

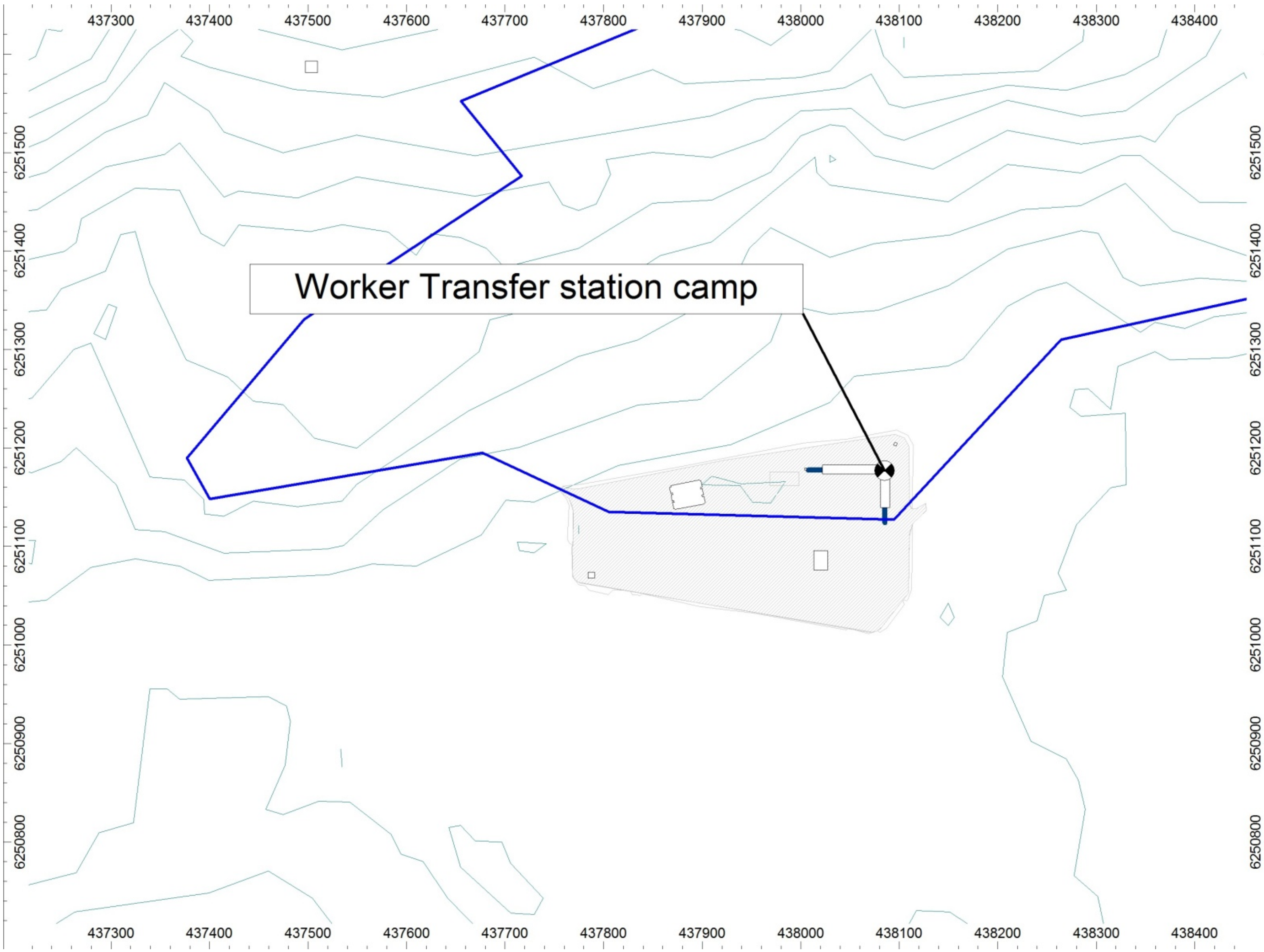

Figure D-2 Human Worker Receptors at Knipple Transfer Station

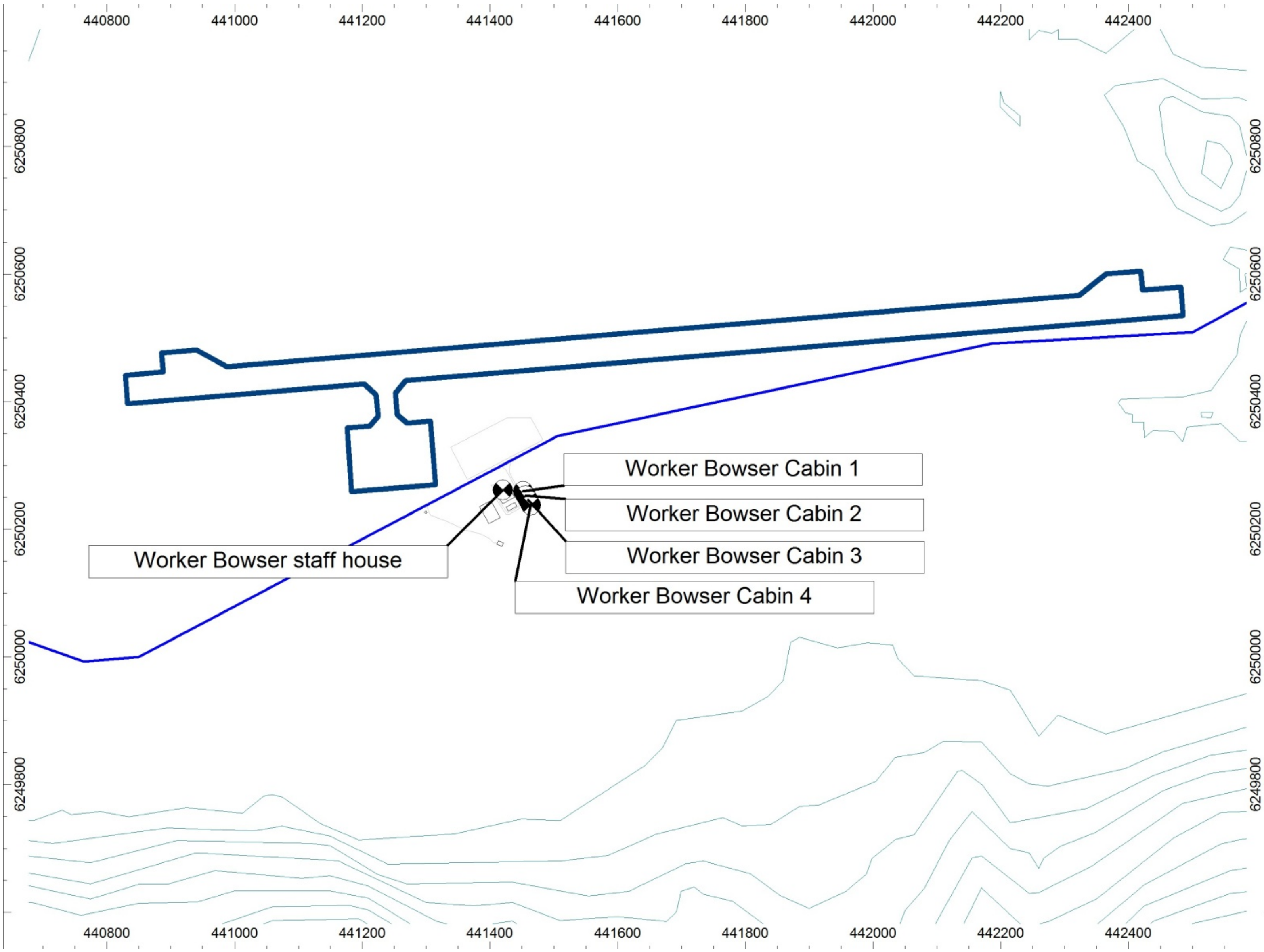

Figure D-3 Human Worker Receptors at Bowser Aerodrome

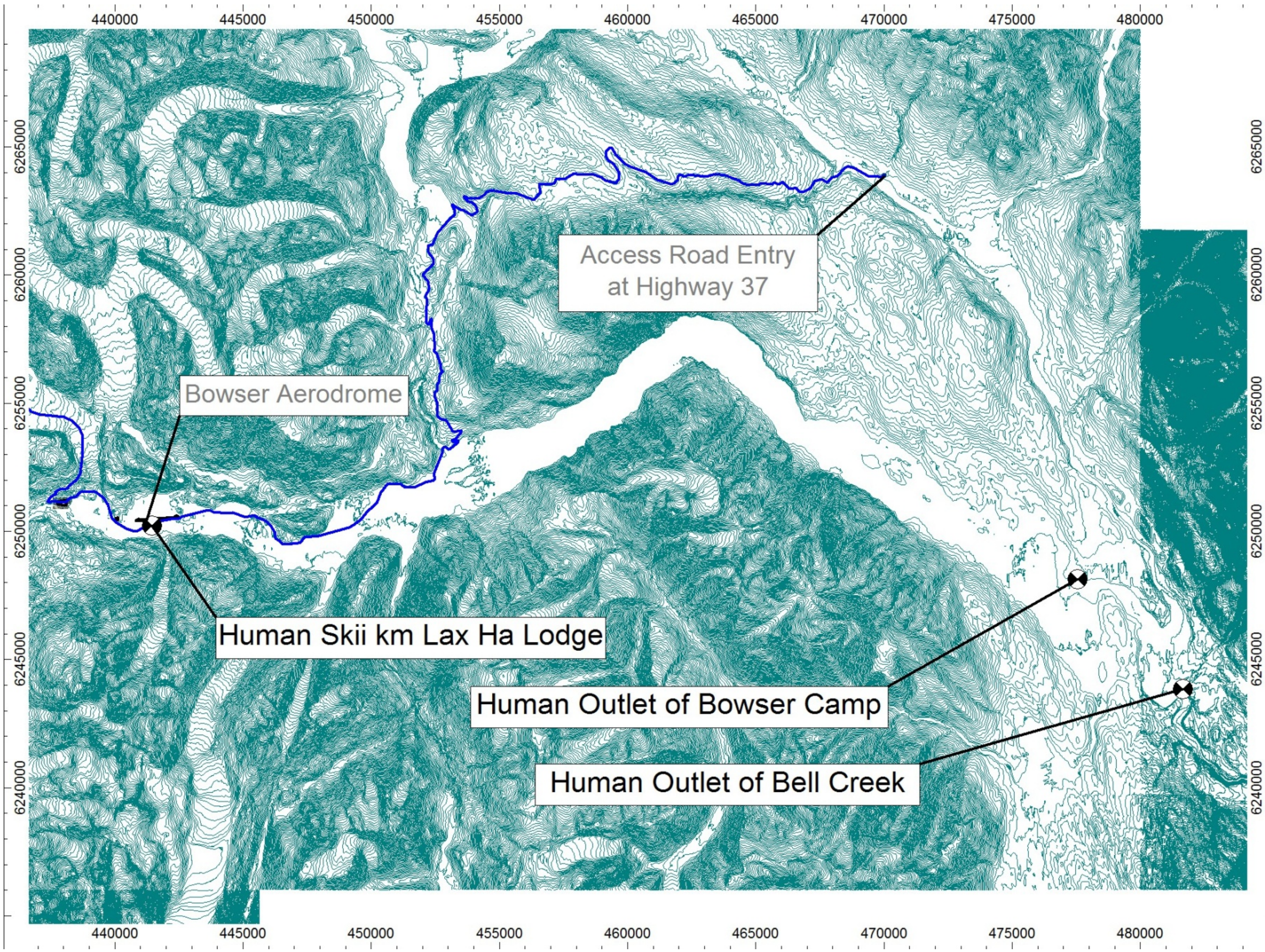

Figure D-4 Human Receptors

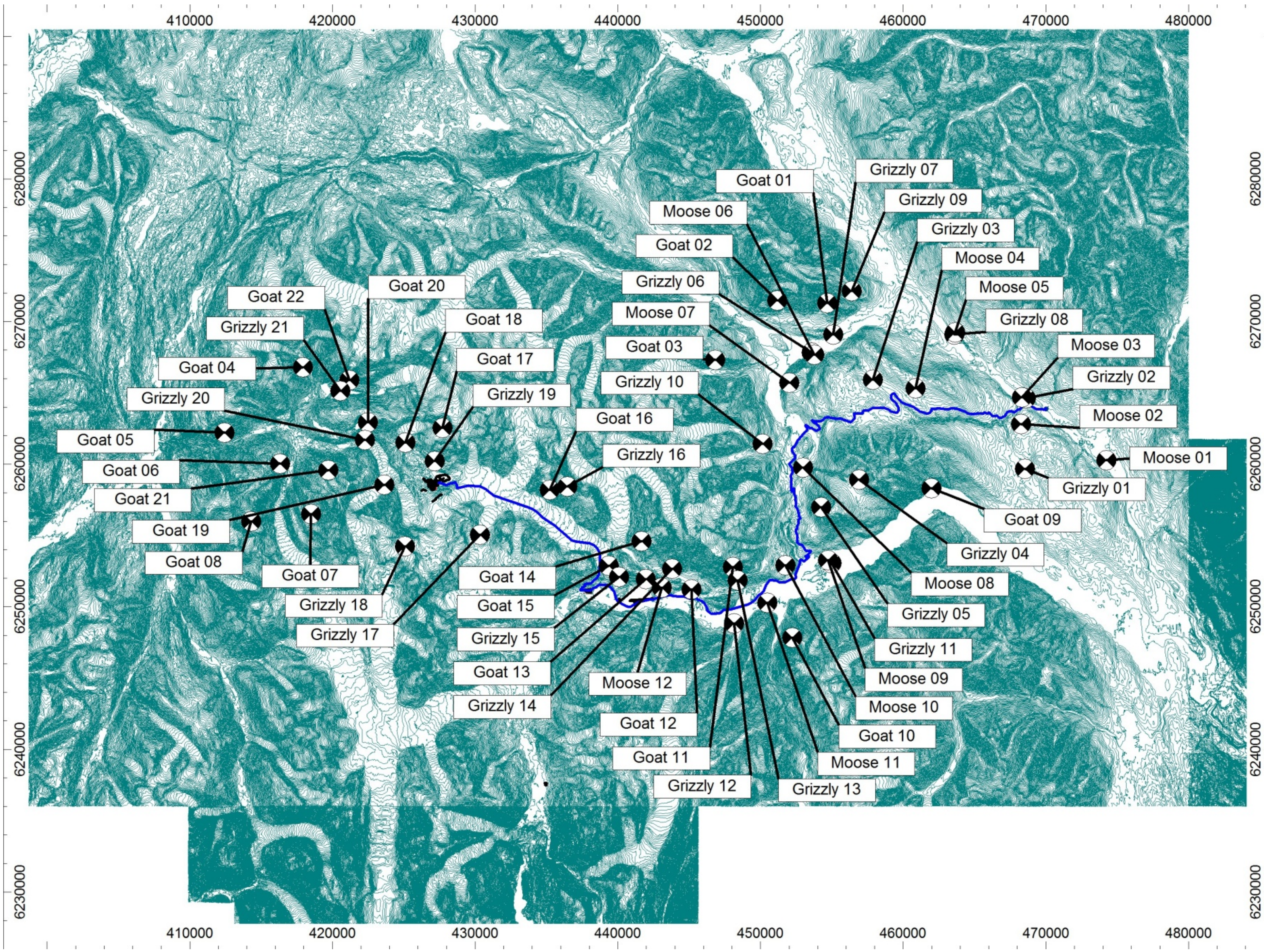

Figure D-5 Wildlife Receptors

Table D-1 Inventory of Sensitive Human Receptors

Human Receptors	Coordinates			Worker Receptors	Coordinates		
	X	Y	Z		X	Y	Z
	(m)	(m)	(m)		(m)	(m)	(m)
Human Outlet of Bell Creek	481659	6243861	390	Worker Bowser Cabin 1	441452	6250260	464
Human Outlet of Bowser Camp	477538	6248126	384	Worker Bowser Cabin 2	441456	6250253	464
Human Skii km Lax Ha Lodge	441441	6250220	464	Worker Bowser Cabin 3	441460	6250246	464
				Worker Bowser Cabin 4	441464	6250238	464
				Worker Bowser staff house	441420	6250262	464
				Worker Mine site existing camp 1	426906	6258481	1444
				Worker Mine site existing camp 2	426905	6258459	1444
				Worker Mine site operations camp	427011	6258308	1444
				Worker Transfer station camp	438085	6251177	484

Table D-2 Inventory of Sensitive Wildlife Receptors

Wildlife Receptors	Coordinates			Wildlife Receptors	Coordinates		
	X	Y	Z		X	Y	Z
	(m)	(m)	(m)		(m)	(m)	(m)
Goat 01	454657	6271291	1360	Grizzly 08	463581	6269084	505
Goat 02	451178	6271477	1429	Grizzly 09	456398	6272152	980
Goat 03	446834	6267316	1316	Grizzly 10	450148	6261415	988
Goat 04	417938	6266795	1006	Grizzly 11	454986	6253058	384
Goat 05	412415	6262208	920	Grizzly 12	448140	6248845	429
Goat 06	416321	6260044	983	Grizzly 13	448404	6251848	788
Goat 07	418497	6256502	1440	Grizzly 14	443788	6252666	1004
Goat 08	414306	6255979	1977	Grizzly 15	440082	6252083	882
Goat 09	461968	6258312	389	Grizzly 16	436452	6258428	1869
Goat 10	452238	6247851	1133	Grizzly 17	430334	6255055	1559
Goat 11	448057	6252784	1392	Grizzly 18	425092	6254245	2224
Goat 12	445171	6251224	605	Grizzly 19	427175	6260231	1672
Goat 13	441974	6251939	900	Grizzly 20	422264	6261703	733
Goat 14	441649	6254616	1449	Grizzly 21	420542	6265137	844
Goat 15	439361	6252875	767	Moose 01	474230	6260287	424
Goat 16	435228	6258204	1787	Moose 02	468259	6262816	644
Goat 17	427702	6262545	2098	Moose 03	468308	6264677	455
Goat 18	425096	6261518	1444	Moose 04	460854	6265334	1156
Goat 19	423627	6258568	1046	Moose 05	463638	6269262	530
Goat 20	422484	6262948	1447	Moose 06	453776	6267686	564
Goat 21	419715	6259582	1269	Moose 07	452029	6265702	1001
Goat 22	421197	6265912	944	Moose 08	452984	6259774	604
Grizzly 01	468534	6259669	644	Moose 09	454744	6253265	384
Grizzly 02	468602	6264639	445	Moose 10	451754	6252921	617
Grizzly 03	457869	6265936	1008	Moose 11	450471	6250288	404
Grizzly 04	456892	6258910	1475	Moose 12	443076	6251347	521
Grizzly 05	454247	6256990	1318				
Grizzly 06	453573	6267840	564				
Grizzly 07	455089	6269104	560				

APPENDIX E NOISE SOURCE TABLES

Table E-1 Construction Equipment Noise Emissions

Activity Area	Type of Equipment	Qty.	Operating Hours Per Day		Area of Operation						SWL [dBA]
			Day (7 am to 10 pm)	Night (10 pm to 7 am)	Access Road Between Quarry And Mine	Mine area	Quarry	Access Road	Knipple Transfer	Bowser Aerodrome	
Mine Site Construction Equipment	30T CAT 730 Haul Trucks	4	15	5	1.0						114
	Dozer CAT D8T	2	15	5		0.5	0.5				116
	Loaders CAT 988H	2	15	5		0.5	0.5				117
	Grader CAT 14M	1	15	5	1.0						113
	Drills Atlas ROC L8	3	15	5			1.0				127
	Excavators CAT 374D	2	15	5		0.5	0.5				118
	Back Hoe CAT 450F	2	15	5		0.5	0.5				111
	Mobile Heavy Crane LTM 1160 (160t)	1	15	5		1.0					110
	Mobile light Cranes LTM 1035 (35t)	2	15	5		0.5	0.5				109
	Pickers	2	15	5		1.0					107
	Man Lifts (Genie)	4	15	5		1.0					94
	Welding Units	4	15	5		1.0					102
	Pickup trucks	16	15	5	0.3	0.2	0.2	0.3			107
	Quads	16	15	5	0.3	0.3	0.3				105
	Telehandler CAT TL1255C	2	15	5		1.0					111
	Buses	3	15	5	0.5			0.5			109
	Water Truck	1	15	5				1.0			107

	Fuel Truck	1	15	5				1.0			107
	Ambulance	1	15	5							107
	Fire Truck	1	15	5							107
	Snowmobiles	10	15	5	0.3	0.3	0.3				96
	Generators	2	15	5		1.0					102
	Compressors	4	15	5	1.0						112
	Jaw Crusher	1	15	0			1.0				124
	Screen	1	15	0			1.0				109
	Cone Crusher	1	15	0			1.0				124
Knipple Glacier, Transfer Station, Access Road and Aerodrome Construction	Husky	4	10	-					0.5	0.5	117
	30T CAT 730 Haul Trucks	2	10	-	1.0						114
	Dozer CAT D8T	4	10	-					0.5	0.5	116
	Loaders CAT 988H	2	10	-					0.5	0.5	117
	Grader CAT 14M	3	10	-							113
	Excavators CAT 374D	3	10	-					0.5	0.5	118
	Back Hoe CAT 450F	2	10	-					0.5	0.5	111
	Mobile Cranes LTC 1045 (45t)	2	10	-					0.5	0.5	109
	Pickers	1	10	-					0.5	0.5	107
	Man Lifts (Genie)	1	10	-					0.5	0.5	94
	Welding Units	1	10	-					0.5	0.5	102
	Pickup trucks	8	10	-				0.3	0.3	0.3	107
	Quads	4	10	-					0.5	0.5	105
	Telehandler CAT TL1255C	1	10	-					0.5	0.5	111
	Buses	2	10	-				1.0			109
	Water Truck	1	10	-				1.0			107
	Fuel Truck	1	10	-				1.0			107
	Ambulance	1	10	-							107
	Fire Truck	1	10	-							107
	Snowmobiles	4	10	-				0.3	0.3	0.3	96
	Generators	2	15	5							102
	Compressors	2	10	-					0.5	0.5	112

Existing Mine Site Owners Equipment that will Remain on Site During Construction	Printoh Beast Snowcat #1	1	10	-	0.3	0.3	0.3				117
	Printoh Beast Snowcat #2	1	10	-	0.3	0.3	0.3				116
	Bobcat UTV 3400XL	1	10	-	1.0						113
	T140 Bobcat Surfwood Equipment	1	10	-	1.0						114
	Hitachi 200 Zaxis excavator	1	10	-		0.5	0.5				112
	Marooka 2200	1	10	-				1.0			116
	Marooka 800	1	10	-				1.0			110
	Marooka 4000	1	10	-				1.0			114
	Cat D6K LGP Dozer	1	10	-		0.5	0.5				109
	Hitachi 200 Zaxis Excavator	1	10	-		0.5	0.5				109
	Pisten Bully 600 Polar 2011 #1	1	10	-				1.0			115
	Pisten Bully 600 Polar 2010 #1	1	10	-				1.0			115
	Caterpillar D8T	1	10	-		0.5	0.5				113
	All-Track AT80 - 2012	1	10	-		0.5	0.5				112
	Foremost Chieftan C - 2000	1	10	-				1.0			113
	Formost Nodwell 110 - 2000	1	10	-				1.0			112
	ATV's - Canam	4	10	-		0.5	0.5				106
	ATV - Polaris Rangers	4	10	-		0.5	0.5				106
	ATV - John Deer Gators	1	10	-		0.5	0.5				106
	ATV - Canam Side by side	1	10	-		0.5	0.5				104
	Snowmobiles - Skidoo Skandiks	6	10	-		0.5	0.5				100
	Snowmobiles - Skidoo Summits	2	10	-		0.5	0.5				106
	Kubota RTV 1140	1	10	-		0.5	0.5				113

Table E-2 Operations Equipment Noise Emissions

Activity Area	Type of Equipment	Qty.	Operating Hours Per Day		Area of Operation				SWL [dBA]
			Day (7 am to 10 pm)	Night (10 pm to 7 am)	Access Road	Mine Site	Knipple Transfer	Bowser Aerodrome	
Mine Site	Backhoe Loader	2	3	1		1.0			107
	Dump Truck	1	3	1	0.5	0.5			114
	Forklifts	4	4	1		1.0			120
	Mobile Crane - 50T	1	2	1		1.0			109
	Boom Truck -20T	1	2	1		1.0			112
	Loader F/E	1	3	1		1.0			113
	Ambulance/Mine Rescue	1	0	0					107
	Truck 1/2 Tonne	4	5	1	0.5	0.5			107
	HDPE Fusion Machine	1	1	1		1.0			101
	Flatbed Truck	1	3	1	0.5	0.5			107
	Fire Truck	1	0	0					107
	Forklift (25 t)	1	2	1		1.0			120
	Mechanics Truck	1	1	1	0.5	0.5			107
	Welding Truck	1	1	1		1.0			107
	Pick-up Trucks	2	4	2	0.5	0.5			107
	Buses - On-Site	3	4	2	0.5	0.5			109
	Water Truck	1	2	1	1.0				107
	Sewage Truck	1	2	0	1.0				107
	Foremost Husky 8	4	12	7		1.0			116
	Printoh Beast Snowcat #1	1	2	1		1.0			117
	Printoh Beast Snowcat #2	1	4	3		1.0			117

	Printoh Beast Snowcat #3	1	4	3		1.0			117
	Bobcat UTV 3400XL	1	3	1		1.0			101
	T140 Bobcat Surfwood Equipment	1	2	1		1.0			106
	Hitachi 200 Zaxis excavator	1	2	1		1.0			112
	Morooka 2200 - Handlers Equipment	1	3	1	1.0				113
	Marooka 800 - Handlers Equipment	1	3	1	1.0				109
	Marooka 4000 - Handlers Equipment	1	3	1	1.0				116
	Cat D6K LGP Dozer - Finning	1	1	0		1.0			110
	Hitachi 200 Zaxis Excavator	1	1	0		1.0			112
	Pisten Bully 600 Polar	1	2	1		1.0			117
	Pisten Bully 600 Polar	1	2	1		1.0			117
	Caterpillar D8T	1	1	0		1.0			115
	All-Track AT80	1	3	1		1.0			112
	Foremost Chieftain C	1	3	1		1.0			115
	Formost Nodwell 110	1	3	1		1.0			114
	ATV's - Canam	4	4	2		1.0			105
	ATV - Polaris Rangers	4	4	2		1.0			105
	ATV - John Deer Gators	1	4	2		1.0			105
	ATV - Canam Side by Side	1	4	2		1.0			105
	Snowmobiles - Skidoo Skandiks	6	4	2		1.0			96
	Snowmobiles - Skidoo Summits	2	4	2		1.0			96
Transfer Station	Mobile Crane - 50T	1	4	1			1.0		109
	Forklift	1	4	1			1.0		120
	Forklift (25t)	1	2	1			1.0		120
	Water Truck	1	2	1	1.0				107
Airstrip	Forklift	2	4	1				1.0	120
	Forklift (10t)	1	1	1				1.0	120
	Grader CAT 14 M	1	1	1				1.0	112

APPENDIX F   RESULT TABLES

Table F-1 Noise Prediction Results at Worker Accommodation Receptors

Receiver Name	Construction		Operations	
	Average Noise L_d	Average Noise L_n	Average Noise L_d	Average Noise L_n
	dBA	dBA	dBA	dBA
Worker Bowser Cabin 1	62	55	57	56
Worker Bowser Cabin 2	61	52	56	55
Worker Bowser Cabin 3	60	51	55	53
Worker Bowser Cabin 4	59	49	54	52
Worker Bowser staff house	64	60	61	60
Worker Mine site existing camp 1	58	54	61	60
Worker Mine site existing camp 2	57	54	60	59
Worker Mine site operations camp	54	51	55	55
Worker Transfer station camp	71	55	63	61

Table F-2 Construction Noise Prediction Results at Human Receptors

Receiver Name	Baseline			Construction								
	Assumed L_{dn}	Adjusted L_{dn} for Rural Quiet Area	%HA	Mine Site Blasting L_{peak}	Quarry Blasting L_{peak}	Avg Noise L_d	Avg Noise L_n	Project L_{dn}	+5 Aircraft/ Tonal /Impulsive Penalty	Total Adj. L_{dn} (L_{Ndn})	% HA	Δ% HA
	dBA	dBA	%	dBZ	dBZ	dBA	dBA	dBA	dBA	dBA	%	%
Human Outlet of Bell Creek	35	45	1.1	63	63	14	11	28	33	45	1.1	0.0
Human Outlet of Bowser Camp	35	45	1.1	64	64	14	11	36	41	46	1.3	0.2
Human Skii km Lax Ha Lodge	35	45	1.1	74	75	59	45	58	63	63	11.1	10.0

Table F-3 Operations Noise Prediction Results at Human Receptors

Receiver Name	Baseline			Operations						
	Assumed L_{dn}	Adjusted L_{dn} for Rural Quiet Area	%HA	Avg Noise L_d	Avg Noise L_n	Project L_{dn}	+5 Aircraft/ Tonal /Impulsive Penalty	Total Adj. L_{dn} (L_{Ndn})	%HA	Δ%HA
	dBA	dBA	%	dBA	dBA	dBA	dBA	dBA	%	%
Human Outlet of Bell Creek	35	45	1.1	6	6	31	36	46	1.3	0.2
Human Outlet of Bowser Camp	35	45	1.1	7	7	37	42	47	1.5	0.4
Human Skii km Lax Ha Lodge	35	45	1.1	53	51	59	64	64	12.4	11.3

Table F-4 Construction Noise Prediction Results at Wildlife Receptors

Receiver Name	Construction					Operations			
	Helicopter L_{AE}	Mine Site Blasting L_{peak}	Quarry Blasting L_{peak}	Continuous Noise L_d	Continuous Noise L_n	Aircraft L_{AE}	Helicopter L_{AE}	Continuous Noise L_d	Continuous Noise L_n
	dBA	dBZ	dBZ	dBA	dBA	dBA	dBA	dBA	dBA
Goat 01	64	69	69	22	19	48	64	14	14
Goat 02	70	70	70	23	21	47	70	15	15
Goat 03	67	67	73	26	23	51	67	18	17
Goat 04	58	67	69	29	26	37	58	23	23
Goat 05	46	66	60	26	24	36	46	20	20
Goat 06	52	63	57	29	27	39	52	24	24
Goat 07	58	78	71	14	11	42	58	10	10
Goat 08	47	65	62	29	26	39	47	23	23
Goat 09	67	67	68	4	1	79	67	0	0
Goat 10	63	55	69	25	22	65	63	17	17
Goat 11	61	66	72	25	20	72	61	16	14
Goat 12	72	57	70	36	26	90	72	29	27
Goat 13	69	75	80	43	22	79	69	37	35
Goat 14	61	73	76	33	30	68	61	25	24
Goat 15	86	76	77	36	28	71	86	29	27
Goat 16	71	70	78	38	35	56	71	29	29
Goat 17	71	87	88	34	31	46	71	22	22
Goat 18	78	78	72	40	37	44	78	36	35
Goat 19	80	88	86	38	35	45	80	33	33
Goat 20	66	64	67	35	32	42	66	29	29

Receiver Name	Construction					Operations			
	Helicopter L_{AE}	Mine Site Blasting L_{peak}	Quarry Blasting L_{peak}	Continuous Noise L_d	Continuous Noise L_n	Aircraft L_{AE}	Helicopter L_{AE}	Continuous Noise L_d	Continuous Noise L_n
	dBA	dBZ	dBZ	dBA	dBA	dBA	dBA	dBA	dBA
Goat 21	60	74	80	28	25	41	60	18	18
Goat 22	68	80	79	32	29	39	68	23	23
Grizzly 01	60	66	66	19	15	71	60	11	11
Grizzly 02	77	66	66	32	24	59	77	24	22
Grizzly 03	76	68	69	23	18	55	76	15	15
Grizzly 04	58	69	69	22	19	65	58	15	15
Grizzly 05	65	70	70	28	22	66	65	20	18
Grizzly 06	77	69	70	22	19	52	77	15	14
Grizzly 07	73	69	69	22	19	51	73	14	14
Grizzly 08	83	67	67	19	16	51	83	11	11
Grizzly 09	61	68	68	21	19	47	61	13	13
Grizzly 10	67	71	72	27	22	57	67	19	18
Grizzly 11	79	69	70	27	20	84	79	19	18
Grizzly 12	83	71	72	32	25	76	83	24	22
Grizzly 13	67	64	72	27	21	84	67	20	19
Grizzly 14	63	73	75	34	23	73	63	28	26
Grizzly 15	75	76	77	37	26	75	75	31	29
Grizzly 16	66	65	62	34	31	57	66	26	26
Grizzly 17	78	82	76	30	27	54	78	18	18
Grizzly 18	67	91	85	33	30	49	67	28	28
Grizzly 19	85	92	94	49	46	47	85	45	45

Receiver Name	Construction					Operations			
	Helicopter L_{AE}	Mine Site Blasting L_{peak}	Quarry Blasting L_{peak}	Continuous Noise L_d	Continuous Noise L_n	Aircraft L_{AE}	Helicopter L_{AE}	Continuous Noise L_d	Continuous Noise L_n
	dBA	dBZ	dBZ	dBA	dBA	dBA	dBA	dBA	dBA
Grizzly 20	68	68	82	35	32	42	68	29	29
Grizzly 21	65	80	79	30	27	39	65	16	16
Moose 01	81	64	65	15	12	63	81	8	8
Moose 02	66	66	66	29	21	63	66	21	19
Moose 03	77	66	66	33	25	59	77	25	23
Moose 04	62	67	68	29	22	56	62	21	19
Moose 05	83	66	67	19	16	51	83	11	11
Moose 06	77	69	70	22	19	52	77	14	14
Moose 07	72	64	63	23	20	53	72	16	15
Moose 08	80	70	71	21	14	63	80	13	12
Moose 09	78	67	70	28	21	84	78	20	19
Moose 10	83	70	71	25	20	82	83	17	16
Moose 11	82	69	71	34	27	83	82	26	24
Moose 12	75	74	75	42	26	84	75	36	33