Kiggavik Project
Final Environmental Impact Statement

Tier 3 Technical Appendix 4E:
Noise and Vibration Impact Assessment

September 2014

History of Revisions

Revision Number	Date	Details of Revisions
01	December 2011	Initial release Draft Environmental Impact Statement (DEIS)
02	September 2014	FINAL Environmental Impact Statement

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Abbreviations

CadnaA	Computer Aided Noise Abatement software
dB	decibel
dBA	A-weighted decibel
DNL	day-night sound level
%HA	Percent highly annoyed
Hz	hertz
km	kilometer
LAA	Local Assessment Area
L_{eq}	energy equivalent sound level
L_P	sound pressure level
m	Metre
mm/sec	Millimetres per second
NLCA	Nunavut Land Claims Agreement
Pa	Pascal
µPa	Micropascal
PPV	peak particle velocity (mm/s)
RAA	Regional Assessment Area
UTM	Universal Transverse Mercator (Easting and Northing)
WHO	World Health Organization

Glossary

"A" Weighting	A curve applied to un-weighted sound level spectra that reduces the contribution of low and high frequencies to produce a sound that corresponds approximately to how a human would hear it.
Acoustics	The science of sound. Its production, transmission and effects.
Amplitude	The maximum extent of a vibration or oscillation, measured from a position of equilibrium
Attenuation	The reduction of sound energy as a function of distance traveled.
Decibel (dB)	Unit of level when the base of the logarithm is the 10th root of 10 and the quantities concerned are proportional to power.
Decibel, A-Weighted (dBA)	Unit representing the sound level measured with the A-weighting network on a sound level meter
Energy Equivalent Sound Level (L_{eq})	The constant sound level which would result in exposure to the same total A-weighted energy as would the specified time-varying sound, if the constant sound level persisted over an equal time interval
Frequency	Sound is a fluctuation of air pressure. The number of times the fluctuation occurs in one second is called its frequency. In acoustics, frequency is quantified in cycles per second, or Hertz (abbreviated Hz).
Ground-borne vibration	The regular repeated motion of a physical object about a fixed point.
%HA	Percent highly annoyed
Noise	See Sound
Octave Bands	Sounds that contain energy over a wide range of frequencies are divided into sections called bands. A common standard division is in 10 octave bands identified by their censer frequencies 31.5, 63, 125, 250, 500, 1000, 2000, and 4000 Hz
Peak Particle Velocity (mm/s)	Peak or maximum velocity (how fast the particles move when oscillating) that describes the magnitude of the motion.
Receptor	A building or land use that may be impacted by emissions from a facility (air, noise, vibration). A receptor is generally a place where people live, or conduct educational or recreational or religious activities.
Sound	Vibrations transmitted through an elastic solid or a liquid or gas, with frequencies in the approximate range of 20 to 20,000 hertz, capable of being detected by human organs of hearing.
Sound level	A measure of sound expressed in decibels as a comparison corresponding to familiar sounds experienced in a variety of situations
Sound Power Level (L_w)	A measure of the total airborne acoustic power generated by a noise source, expressed on a decibel scale referenced to a reference standard (usually 10-12 watts).

Sound Pressure Level (L_P)	A measure of the air pressure change caused by a sound wave, expressed on a decibel scale referenced to 20µPa
Sound level meter	A device that converts sound pressure variations in air into corresponding electronic signals. The signals are filtered to exclude signals outside frequencies desired.
Source	Any place or object from which noise and vibration are released. Sources that are fixed in space are stationary sources and sources that move are mobile sources.
Spectrum	The description of a sound wave's components of frequency and amplitude.
Stationary Sources	Non-mobile sources such as power plants, refineries, and manufacturing facilities which emit noise. (See also mobile sources).
Tonal Noise	Noise with a narrow sound frequency composition (i.e., the sound level at a certain frequency, or several adjacent frequencies, dominates over all other frequencies).

1 Introduction

1.1 Background

The Kiggavik Project ("the Project") is subject to the environmental review and related licensing and permitting processes established by the *Nunavut Land Claims Agreement* (NLCA) (NIRB 2011). The Minister of Indian and Northern Affairs Canada (the Minister) referred the Project to Nunavut Impact Review Board (NIRB) for a Review under Part 5 of Article 12 of the NLCA in March of 2010. Pursuant to Section 12.5.2 of the NLCA:

> "When a project proposal has been referred to NIRB by the Minister for review, NIRB shall, upon soliciting any advice it considers appropriate, issue guidelines to the Proponent for the preparation of an impact statement. It is the responsibility of the Proponent to prepare an impact statement in accordance with any guidelines issued by NIRB..." (NIRB 2011)

The final NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.'s Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) were issued in May of 2011 and forms the basis of the following assessment.

1.2 Overview of the Report

1.2.1 General Structure

In addition to this introductory section, the noise and vibration assessment report includes the following four sections as outlined in **Error! Reference source not found.** Section 2 describes the assessment methodology including Project-environment interactions, spatial, temporal and technical boundaries, Project effects criteria, and assessment analytical methods. Section 3 discusses the existing environment. Section 4 details the effects assessment inclusive of effects assessment scenarios, sensitive receptors, modelling parameters and assessment results. Section 5 lists the references used in the impact assessment inclusive of literature cited and personal communications.

Table 1.2-1 Report Structure

Section	Description
2	Assessment Methodology
3	Existing Conditions
4	Effects Assessment
5	References

1.3 Fundamentals of Noise and Vibration

1.3.1 Noise

Noise is typically defined as unwanted or undesirable sound. Sound is characterized by small air pressure fluctuations above and below atmospheric pressure. The terms “noise” and “sound” can be used interchangeably since there is no physical difference between them. Noise can be described in terms of the following three variables:

- amplitude;
- frequency; and
- variation with time.

Amplitude is determined by the extent that sound pressure fluctuates above and below atmospheric pressure. The quietest sound that can be heard by most humans is a sound pressure of approximately 20 micropascals (µPa) (i.e., the threshold of hearing), while the loudest sound can reach up to 20 pascals (Pa). Because of this extreme range of sound pressures, a logarithmic scale is used to describe the sound pressure level (L_P) expressed in decibels (dB). On a relative basis, a 3 dB change in L_P represents a barely perceptible change, whereas a 10 dB change in L_P would be perceived as a doubling (or halving) in the loudness of a sound.

The frequency of sound refers to the rate at which a sound wave oscillates. Frequency is expressed in hertz (Hz). The human ear can detect a wide range of frequencies from approximately 20 Hz to 17,000 Hz. However, the human hearing system does not respond equally to all frequencies of sound. Low frequencies below 250 Hz and high frequencies above 10,000 Hz are less audible than the frequencies in between. As a result, frequency response functions were developed that characterize the way people respond to different frequencies. These functions are referred to as the A-, B- and C-weighted curves, representing the way people respond to sounds of normal, very loud and extremely loud sounds, respectively. Environmental noise generally falls into the “normal” category so that the A-weighted L_P, expressed in A-weighted decibels (dBA), is considered the best representation of the non-linearity of the human ear.

Since environmental noise varies over time, it is common practice to condense sound level data into a single number, called the energy equivalent sound level (L_{eq}). L_{eq} can be described as a steady sound level that represents the same sound energy as the varying sound levels over a specified time period, typically 1-hour or 24-hour averages. The L_{eq} values over a 24-hour period are often used to calculate cumulative noise exposure in terms of the day-night sound level (DNL). DNL is the A-weighted L_{eq} for a 24-hour period with an added 10 dB penalty imposed on noise that occurs during the night-time hours. Many surveys have shown that DNL is well correlated with human annoyance, and therefore this descriptor is widely used for environmental noise impact assessments.

1.3.2 Vibration

Ground-borne vibration can be defined as the regular repeated motion of a physical object about a fixed point. It is described in terms of displacement, velocity or acceleration. Displacement is simply the distance that a point moves away from a static position. The velocity represents the instantaneous speed of movement. Acceleration is the rate of change of the speed. Although displacement is easier to understand than velocity or acceleration, it is rarely used for describing ground-borne vibration. Most methods used for measuring ground-borne vibration use either velocity or acceleration. Furthermore, the response of humans, buildings, and equipment to vibration is more accurately described using velocity or acceleration. Since sensitivity to vibration typically corresponds to the amplitude of vibration velocity within the low-frequency range (roughly 4 to 80 Hz), velocity is the preferred measure for evaluating ground-borne vibration. The most common measure used to quantify vibration amplitude is the peak particle velocity (PPV), defined as the maximum instantaneous peak of the vibratory motion.

Peak particle velocity is typically used to evaluate the potential for building damage and can be used to evaluate human response to vibration. Most perceptible indoor vibration is caused by sources within buildings including movement of individuals and operation of mechanical equipment within the building. Typical outdoor sources of perceptible ground-borne vibration are construction equipment and traffic on roads.

2 Assessment Methodology

Resource exploration, extraction, processing and transportation activities associated with the Project have the potential to affect ambient noise and vibration levels. This section describes the noise and vibration assessment methodology.

2.1 Project-Environment Interactions

Interactions are expected to occur between the atmospheric environment and Project activities during the construction, operation and final closure Project phases. The Project-environment interaction tables presented in Section 4.3 of the Tier 2 Environmental Assessment Report, Volume 4: Atmospheric Environment, Part B: Noise and Vibration were used to establish the maximum bounding assessment scenarios presented in Section 4.1 for construction, operation and final closure Project phases.

2.2 Spatial Boundaries

The assessment of potential effects of the Project focus largely on an area referred to as the Local Assessment Area (LAA). The cumulative effects assessment uses a broader spatial boundary referred to as the Regional Assessment Area (RAA).

2.2.1 Project Footprint

The Project footprint consists of three components; the Mine Development Area inclusive of the Kiggavik Mine Site and Sissons Mine Site, the Kiggavik-Sissons Haul Road, the Winter Road between the Dock and Storage Facility and the Mine Sites, and the Dock and Storage Facility. For the purpose of this assessment, the preferred transportation route between the Mine Development Area and Dock and Storage Facility is the Winter Road. However, the All-Season Road option has also been considered.

The Kiggavik Mine Site, located approximately 80 km (kilometres) west of the community of Baker Lake, includes three open pit mines (East Zone Pit, Centre Zone Pit and Main Zone Pit), waste rock and ore stockpiles, and ore processing and auxiliary facilities. The Sissons Mine Site, located approximately 90 km west of the community of Baker Lake and 15 km southwest of the Kiggavik Mine Site, includes one open pit mine (Andrew Lake Pit), one underground mine (End Grid Ore Zone), waste rock and ore stockpiles, and auxiliary facilities. The Kiggavik Mine Site and Sissons Mine Site are connected by the 18 km Kiggavik-Sissons Haul Road used to transport ore from the

Sissons Mine Site to the Kiggavik Mine Site for ore processing and personnel to and from the Sissons Mine Site. The Dock and Storage Facility, located approximately 2.5 km southeast of the community of Baker Lake, would act as a transfer station between the marine and road transportation routes. The predominant source of noise and vibration from the Project would be heavy equipment and mill operation, for which the associated effects would decrease with increasing distance from the activity. The Project footprint is illustrated in Figure 2.2-1.

2.2.2 Local Assessment Area

Figure 2.2-2 shows the LAA, which is defined by the Mine Development Area, inclusive of the Kiggavik Mine Site, the Sissons Mine Site and the Kiggavik-Sissons Haul Road, the preferred Winter Road, and the Dock and Storage Facility.

2.2.3 Regional Assessment Area

The RAA of the Project extends beyond the LAA to encompass Project effects that may interact with similar effects from other projects and activities in the region. For noise and vibration related effects, the RAA includes the broader area around Baker Lake. The Meadowbank Gold Mine barge landing facility and access road, the Baker Lake Airport, and the Project exploration and field study activities are included in the RAA. This area is defined by a 20 km buffer area extending beyond the LAA. The RAA is illustrated in Figure 2.2-2.

2.3 Temporal Boundaries

The temporal boundaries for the assessment are defined based on the timing and duration of potential effects from activities associated with the Project. The assessment covers the period of all major Project phases including construction, operation and final closure. The total life of the Project during which noise and vibration effects could occur from Project related activities is expected to be up to 34 years (up to four years of construction, 25 years of operation, and 5 years of final closure). Since the level of activity from each of the Project phases differs, the extent of any related potential effects would also differ. For this reason, potential noise and vibration effects of the Project were assessed for a:

- maximum construction / final closure scenario, and
- maximum operation scenario.

Additional details on the development of the above scenarios are provided in Section 4.1.

2.4 Technical Boundaries

The noise and vibration assessment is subject to some technical limitations due to a lack of scientific information with which to predict noise and vibration levels. These technical limitations have been considered in the assessment and pertain to the following:

- Specific noise data for each piece of equipment that would be operating at the Project, including heavy equipment, were not available. Sound levels for heavy equipment were derived from calculations using the energy output of the equipment. For other equipment, sound power levels were based on measurements from similar equipment, including mill processing equipment operating at the McClean Lake Operation.
- Site specific information on vibration and overpressure from blasting was not available. Vibration and overpressure predictions from blasting were based on an assumed mass of explosives used for each blast event. Specific data on the expected number of blasts, mass of charge and related details were based on data presented in the *"Drilling and Blasting Design and Related Regulatory Considerations – Kiggavik Project"* report (Golder Associates Ltd. 2011).
- Specific vibration data for each piece of Project equipment operating at the Mine Development Area were not available. Vibration predictions for heavy equipment operation were based on published vibration information for similar equipment.

These technical limitations were overcome by using highly conservative estimation techniques and professional judgment. Attachment B provides a detailed account of assumptions that have been used in the assessment.

2.5 Project Effects Criteria

Project effects of noise and vibration on the atmospheric environment are typically assessed in quantitative terms through comparison to noise and vibration regulatory guidelines. Project effects criteria are based on human health effects that are associated with sleep disturbance and annoyance.

2.5.1 Regulatory Criteria for Airborne Noise

2.5.1.1 Territorial

The *Nunavut Environmental Protection Act* is territorial legislation established to regulate contaminant discharges into the environment including emissions of noise and vibration. The Nunavut Department of Environment (Environmental Protection Service) regulates activities that have the potential to affect noise and vibration (via the Act). Currently, no environmental noise regulations, guidelines or criteria have been established in Nunavut.

2.5.1.2 Federal

In 2005, Health Canada published a draft guidance document for noise assessments under the *Canadian Environmental Assessment Act*. The information in this document was updated in a journal article published in *Canadian Acoustics* titled “Using a Change in Percent Highly Annoyed with Noise as a Potential Health Effect Measure for Projects under the Canadian Environmental Assessment Act” (D.S. Michaud et al. 2008). This document outlines a calculation method and suggested adjustments (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area) for determining the percentage of people that are highly annoyed by their exposure to noise at various levels. The calculation method is based on Annex D of ISO 1996-1: 2003, Acoustics - Description, measurement and assessment of environmental noise (ISO [International Organization for Standardization] 2003).

Health Canada uses %HA (percent highly annoyed) as an indicator of noise impacts of projects that are subject to environmental assessment under the *Canadian Environmental Assessment Act*. Under this assessment methodology, the annoyance levels are established using the day-night sound level (DNL), which is an adjusted 24-hour sound level that penalizes sound contributions that occur at night as they are considered to be more annoying (by adding a 10 dB penalty).

According to Health Canada, noise from a project is considered severe when Project %HA values exceeds the existing condition value by more than 6.5%. This is considered the threshold beyond which strong community reaction would be expected. As baseline DNL values increase, the incremental noise level required to trigger an increase in %HA of greater than 6.5% is reduced. In other words, communities with elevated baseline noise levels (and a higher baseline annoyance level) are less likely to accommodate an increase in the baseline sound levels.

2.5.1.3 International

The World Health Organization (WHO) Guidelines for Community Noise outline a set of noise exposure guideline values based on the lowest levels of noise that affect human health (critical health effects). The WHO considers an adverse health effect of noise as any temporary or long-term deterioration in physical, psychological or social functioning that is associated with noise exposure (WHO 1999). The guideline values represent the sound pressure levels that affect the most exposed receiver in a specific environment. The WHO guideline values (A-weighted) considered for the Project are presented in Table 2.5-1 below.

Table 2.5-1 WHO Guideline Values for Community Noise in Specific Environments

Specific Environment	Critical Health Effect(s)	L_{eq} (dBA)	Time Base (hours)
Outdoor Living Area	Serious annoyance, daytime and evening	55	16
	Moderate annoyance, daytime and evening	50	16
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8
Source: (WHO 1999)			

2.5.2 Regulatory Criteria for Ground-borne Noise and Vibration

Currently no ground-borne noise or vibration regulations, guidelines or criteria have been established in Nunavut or at the Federal Level.

2.5.2.1 Other Jurisdictions

Due to the lack of vibration criteria for Nunavut, examples of guidelines from provincial jurisdictions were reviewed to provide comparative regulatory context.

For impulsive vibration effects from blasting two different sets of assessment criteria are typically considered: blast induced air over pressure (concussive peak pressure) and peak particle velocity (vibration). For purpose of this evaluation, criteria from the Ontario Ministry of the Environment (OMOE) NPC-119: Blasting (OMOE, 1996) were applied. These limits are expressed in terms of the peak pressure level (dB) and peak particle velocity (mm/s [millimetres per second]). The following cautionary limits are specified by the OMOE:

- Concussion: peak pressure level limit of 120 dB; and
- Vibration: peak particle velocity limit of 10.0 mm/s.

2.5.2.2 International

A number of standards and guidelines have attempted to address the issue of whole body response to vibration in buildings. Vibration impacts are typically measured at the entry of the vibration to the body, which is usually the floor of a building. A set of guide vibration levels tolerated by humans in buildings is given in Table 2.5-2 below, as derived from the Department of Environment and Conservation NSW (North South Wales) publication *Assessing Vibration: a technical guideline* (Department of Environment and Conservation NSW 2006).

Table 2.5-2 Department of Environment and Conservation NSW Criteria for Exposure to Continuous and Impulsive Vibration

Place	Time	Assessment Criteria Peak Velocity (mm/s)[a] Preferred	Maximum
Continuous vibration – Residences	Daytime[b]	0.28	0.56
	Night-time	0.20	0.40
Impulsive vibration - Residences	Daytime[b]	8.6	17.0
	Night-time	2.8	5.6

NOTE:

[a] Values given for the most critical frequency range >8 Hz assuming sinusoidal motion. Where required, a more detailed analysis can be conducted as per AS 2670.2–1990. Sufficient justification should accompany the use of a peak velocity approach if used in an assessment.

[b] Specific values depend on social and cultural factors, psychological attitudes and expected degree of intrusion.

SOURCE: (Department of Environment and Conservation NSW 2006)

Methods for measuring, evaluating and assessing whole-body vibration and repeated shock are also given in ISO 2631-1: 1997, Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements (ISO 1997). However, ISO 2631-1 does not explicitly state vibration exposure limits relating to human health. For ease of assessment a single term, peak particle velocity, has been used to assess vibration impacts.

2.6 Analytical Methods for the Assessment

Environmental noise and vibration assessments require the use of a variety of analytical methods, including the use of computer models, engineering calculations and professional judgment. The following sections provide a detailed description of the analytical methods applied for the Project noise and vibration impact assessment.

2.6.1 General Project Data

Information prepared by AREVA was used in the preparation of the noise and vibration models. This information included, but was not limited to, the following:

- Project description and specifications (AREVA 2011a);

- Site layout drawings and infrastructure details; and
- Proposed equipment used in construction, operation, and final closure.

2.6.2 Airborne Noise

The CadnaA predictive noise model was used to assess the noise impacts from anticipated Project activities (DataKustik GmbH 2010a). The CadnaA model is based upon ISO 9613: Attenuation of sound during propagation outdoors; Part 2: General method of calculation (ISO 1996). The CadnaA visual interface allows the user to create a three-dimensional representation of the Mine Development Area and surrounding area. CadnaA also allows the user to place a variety of source types at locations representing those where the associated work is expected to be undertaken.

Sound level data are applied to each source as appropriate and the model calculates the sound level based on the distance between the source(s) and user-specified points of reception, accounting for intervening obstructions to noise propagation. The model is also able to account for atmospheric absorption and absorptive qualities of the intervening ground surface. Obstructions to noise propagation that may be incorporated into the modelling include buildings, acoustic barriers, earthen berms and natural changes in ground elevation. CadnaA calculates the individual impact of each noise source at each defined sensitive receptor. A sound level grid may also be created on a user-specified node spacing in order to provide a visual representation of the noise propagation in the form of isopleths.

Calculation methods used for determining the percentage of people that are highly annoyed by their exposure to noise at various levels are based on the following equations (ISO 2003):

$$HA = \frac{100}{[1 + \exp(10.4 - 0.132 L_{dn})]}\%$$

and

$$L_{dn} = 10\,\lg\left[\frac{d}{24} \times 10^{(L_d + K_d)/10} + \frac{24 - d}{24} \times 10^{(L_n + K_n)/10}\right] dB$$

Where

d is the number of daytime hours; L_d is the rating level for daytime, including adjustments for sound sources and sound character; L_n is the rating level for night-time, including adjustments for sound sources and sound character; K_d is the adjustment for weekend daytime, if applicable; and K_n is the adjustment for night-time (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area).

2.6.3 Ground-borne Noise and Vibration

Blast ground-borne vibration was estimated using an equation presented in "Drilling and Blasting Design and Related Regulatory Considerations – Kiggavik Project" (Golder Associates Ltd. 2011). The equation is based on methods presented by the U.S. Bureau of Mines and constants from an open pit mine in Northwest Territories (Siskind, D.E. et al. 1980a; Golder Associates Ltd. 2011). The equation is based on the estimated mass charge per delay and the scaled distance to calculate peak vibration levels (peak particle velocity) as noted below.

$$PPV = 964\left(\frac{D}{\sqrt{W}}\right)^{-1.47}$$

Where

PPV is the Peak Particle Velocity (mm/s)

D is the distance between the charge and the receptor (m)

W is the mass charge per delay (kg)

Impulse noise from blasting (i.e., air blast overpressure) was assessed using U.S. Bureau of Mines (Siskind, D.E. et al. 1980b) equations and constants for metal mines as noted below:

$$AB = 0.401\left(\frac{D}{W^{\frac{1}{3}}}\right)^{-0.713}$$

And

$$dB = 20\log_{10}\left(\frac{AB}{2.9E-09}\right)$$

Where

AB is the air blast overpressure (Pa)

D is the distance between the charge and the receptor (m)

W is the mass charge per delay (kg)

Typical semi-continuous and continuous vibration levels from key equipment were derived from empirical data presented in literature as detailed in Section 4.4.2. This represents the highest overall vibration potential for equipment operating at the Project on a semi-continuous / continuous basis. The general equation for the propagation of semi-continuous and continuous vibration levels is shown below (Federal Transit Administration 2006):

$$PPV_{equip} = PPV_{ref}\left(\frac{25}{D}\right)^{1.5}$$

Where

PPV (equip) is the peak particle velocity (mm/s) of the equipment adjusted for distance

PPV (ref) is the reference vibration level (mm/s) at 7.6 m

D is the distance from the equipment to the receiver (m)

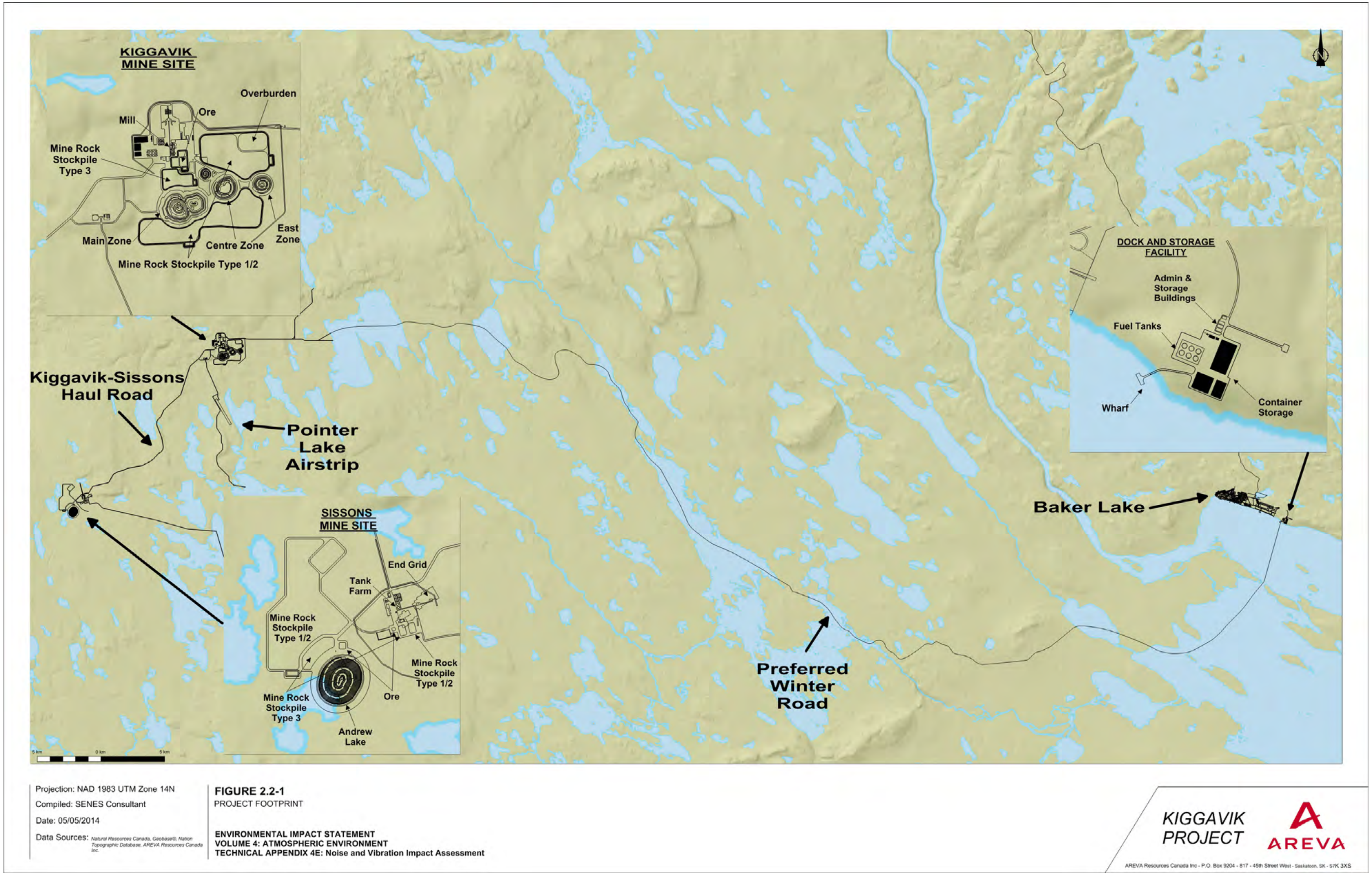

Figure 2.2-1: Project Footprint

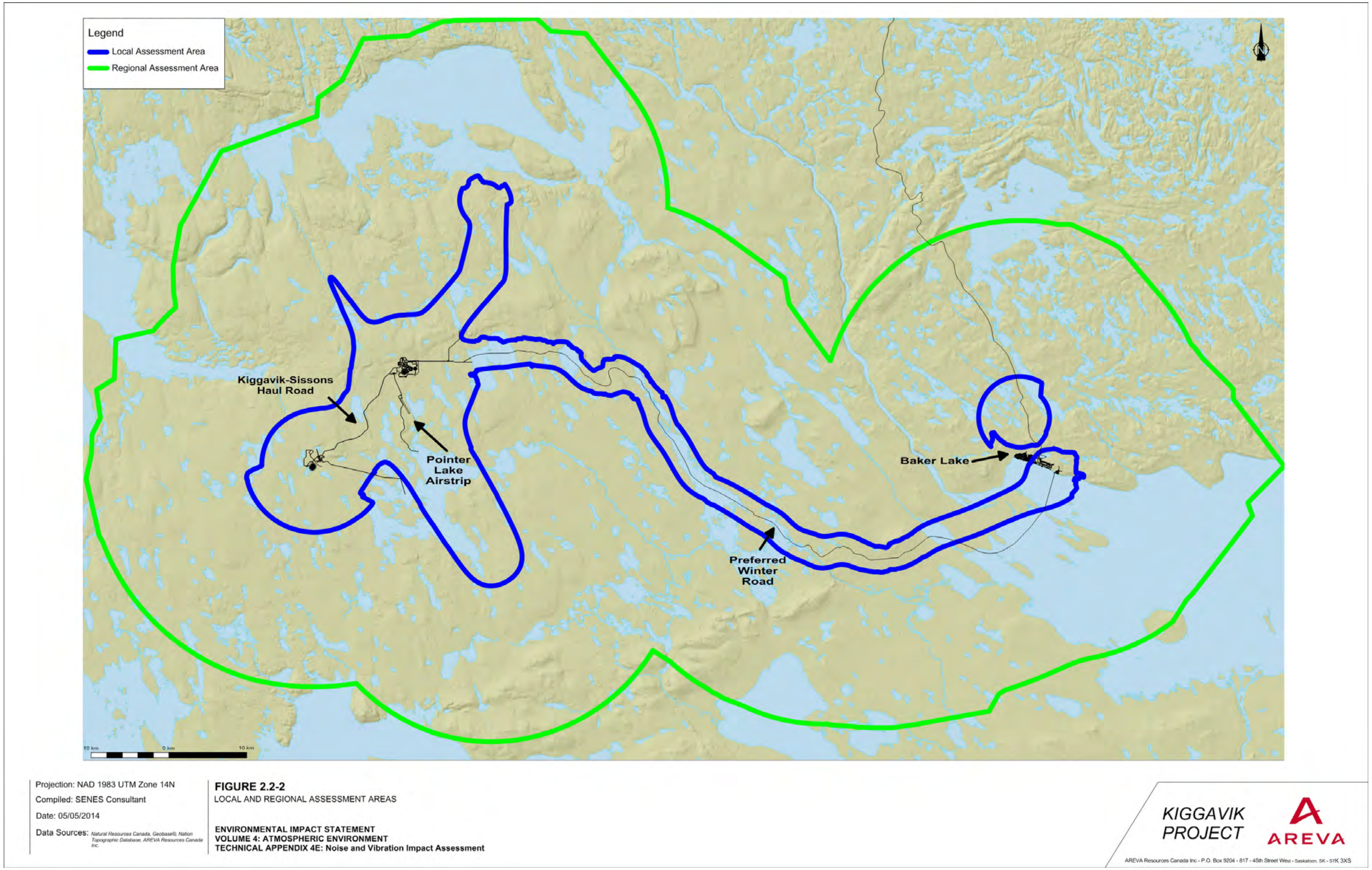

Figure 2.2-2: Local and Regional Assessment Areas

3 Existing Conditions

3.1 Noise

3.1.1 Noise Monitoring

In an effort to characterize the existing noise environment within the Project area, a noise monitoring program was completed at AREVA's McClean Lake Operation in September 2009. The McClean Lake Operation is located in a remote area of Northern Saskatchewan similar to the Mine Development Area. A monitoring location above the tree-line atop a clean waste rock stockpile was selected in order to simulate a tundra-type condition at the Mine Development Area. The noise monitoring data are summarized in Table 3.1-1.

Table 3.1-1 McClean Lake Operation Noise Monitoring Data

Period	Minimum Hourly L_{eq} (dBA)	Overall L_{eq} (dBA)
Daytime (7 a.m. to 11 p.m.)	19	41
Night-time (11 p.m. to 7 a.m.)	28	38
24-hour (7 a.m. to 7 a.m.)	n/a	41
NOTES: n/a = not available		

The above data are indicative of a remote wilderness environment where noise levels are relatively low and are strongly influenced by sounds of nature and wind induced noise effects. In addition to background noise measurements, on-site equipment sound levels were measured. Additional details on the application of these sound levels are provided in Section 4.4.1.

3.1.2 Literature Review

An analysis of noise and vibration effects assessments submitted to the Nunavut Impact Review Board (NIRB) was completed to identify noise and vibration levels in similar environments. The noise impact assessments considered are summarized in Table 3.1-2.

Table 3.1-2 Summary of Existing Conditions in NIRB Noise Impact Assessments

Project	Proponent	Year Submitted	Existing Sound Level (dBA)
Meadowbank Gold	Cumberland Resources Ltd.	2005	43 (daytime) and 35 (night-time)
Doris North	Miramar Hope Bay Ltd.	2005	35 (daytime and night-time)
Bathurst Inlet Port and Road	Kitikmeot Corporation and Nuna Logistics	2007	35 (daytime and night-time)
High Lake	Wolfden Resources Inc.	2006	35 (daytime and night-time)
SOURCES: (Cumberland Resources Ltd. 2005; Miramar Hope Bay Ltd. 2005; Rescan Environmental Services Ltd. 2007; Wolfden Resources Inc. 2006)			

A summary of the key data considerations from the above documents is provided below:

- Noise data reported in the Meadowbank Gold Project Noise Impact Assessment (Cumberland Resources Ltd. 2005) suggested that the existing daytime (16-hour) and night-time (eight-hour) L_{eq}s were 43 and 35 dBA, respectively. Sound data for this project were based on measurements taken in Fort McKay, Northern Alberta.
- The Doris North Noise Impact Assessment (Miramar Hope Bay Ltd. 2005) relied on noise data from noise impacts assessments for the Snap Lake and Diavik Diamond Mines. The daytime L_{eq} associated with the Snap Lake Diamond Mine was 36 dBA while the night-time L_{eq} was 30 dBA. Noise data were collected over a 12-hour period (nine hours night-time and three hours daytime). The overall L_{eq} for the monitoring period was 35 dBA. Existing hourly L_{eq} at the Snap Lake and Diavik Diamond Mines reportedly ranged from 23 to 40 dBA. The existing hourly sound levels at Doris North were presumed to be equivalent to those experienced at Snap Lake and Diavik Diamond Mines. An hourly L_{eq} of 35 dBA was used to represent existing sound levels.
- The Bathurst Inlet Port and Road Project (Rescan Environmental Services Ltd. 2007) and the High Lake Project (Wolfden Resources Inc. 2006) noise impact assessments also relied on the data used for the Snap Lake and Diavik Diamond Mines. These assessments also used an L_{eq} of 35 dBA for existing sound levels.

No existing vibration levels were reported in the above reports.

3.1.3 Existing Noise Conditions

The background sound levels measured at AREVA's McClean Lake Operation are comparable to the sound levels identified during the literature search. With consideration to the above information, a conservative approach to establishing background sound levels was applied. An L_{eq} of 35 dBA was selected for daytime (16-hour), night-time (eight-hour) and 24-hour sound levels. The L_{eq} of 35 dBA was used as the background value for assessing the relevance of potential changes in sound levels as a result of Project activities in the RAA.

3.2 Vibration

No information was available to establish baseline vibration within the Project area. It is expected that vibration levels are not perceptible. With the exception of some limited exploration activities, there are no substantial sources of vibration at the Mine Development Area. There are existing vibration sources in the vicinity of Baker Lake, including activities at the Meadowbank Gold Mine barge landing facility and access road and the Baker Lake Airport. These existing vibration sources, however, are not expected to generate any substantive vibration impact at the nearest sensitive receptor.

4 Effects Assessment

4.1 Assessment Scenarios – Preferred Option

The maximum noise and vibration impact of the Project was estimated based on a construction and an operation scenario during which noise from Project activities would be expected to be at a maximum. This typically occurs during the period where work activities are scheduled that require the greatest number of pieces of equipment to be operated simultaneously. The maximum final closure scenario was determined to be bounded by the maximum construction scenario (see details below).

Consideration was also given to the fact that work activities may occur in up to three primary areas (Kiggavik Mine Site, Sissons Mine Site and Dock and Storage Facility), each with its own maximum equipment usage requirements. As each of these activity areas has a different orientation to sensitive receptors, a separate maximum assessment scenario was assessed for each of the primary activity areas. For each of the maximum construction and operation scenarios, simultaneous operation in the other activity areas (as appropriate) were also included in the noise and vibration impact assessment.

Maximum bounding scenarios for predicting noise impact were developed based on the *Project Description* (AREVA 2011a). A matrix table was developed to link the equipment with the activities occurring in each Project phase throughout the duration of the Project (Attachment B).

The assessment covers the period of all major Project phases including construction, operation and final closure. The total life of the Project during which noise and vibration effects could occur from Project related activities is expected to be up to 34 years (up to four years of construction, 25 years of operation, and 5 years of final closure). Since the level of activity from each of the Project phases differs, the extent of any related potential effects would also differ. For this reason, the assessment of potential noise and vibration effects of the Project phases has been considered as defined in Table 4.1-1 below.

Table 4.1-1 Summary of Maximum Bounding Scenarios – Preferred Option

Maximum Bounding Scenario	Overview of Bounding Scenario
Construction / Final Closure	Dock and Storage Facility construction
	Winter Road construction (including quarry operation)
	Mine Development Area construction
Operation	Mine Development Area operation
	Dock and Storage Facility operation
	Winter Road operation

Additional details on the above scenarios are presented below.

4.1.1 Maximum Construction / Final Closure Scenario

The maximum construction scenario considered three phases, which included the following:

- Construction of the Dock and Storage Facility;
- Construction of the Winter Road, including quarry operation; and
- Simultaneous full-scale construction of the Kiggavik Mine Site and Sissons Mine Site (i.e., the Mine Development Area) infrastructure.

Activities for these scenarios include in-water and on-land construction activities, including, but not limited to, site grading, excavation, concrete production and pouring, pile driving, rock crushing and screening, power generation, and building construction. It should be noted that the simultaneous full-scale construction of both the Kiggavik Mine Site and Sissons Mine Site is not likely; however, it was considered as the most conservative bounding assumption possible for this scenario. In addition, the bounding scenario for the construction of the Winter Road and quarry operation were based on the closest geographic locations where these activities could occur that would yield the highest impact at the chosen sensitive receptors.

Environmental noise and vibration associated with the construction of the Project would consist of semi-continuous construction activities and road traffic as well as intermittent blasting (at the mine / quarry sites) and field survey and exploration activities (including exploration helicopters and periodic drilling activities within the lease boundary).

The maximum final closure scenario was determined to be bounded by the maximum construction scenario. Removal of site infrastructure during final closure involves activities similar to construction. However, some of the noisiest construction activities such as blasting and pile driving would not occur during final closure. Since noise at final closure is likely to be equal to, or less than, construction noise, predictions of construction noise and vibration have been used for both Project phases.

Attachment B provides a detailed account of the type and number of pieces of equipment and assumptions that have been used in the maximum construction scenario. This table is based on the Project-environment interaction tables in Section 4.3 of the Tier 2 Environmental Assessment Report, Volume 4: Atmospheric Environment, Part B: Noise and Vibration (AREVA 2011b).

4.1.2 Maximum Operation Scenario

The maximum operation scenario was considered to be the simultaneous full-scale operation of the Mine Development Area inclusive of the Kiggavik-Sissons Haul Road, the Dock and Storage Facility and the Winter Road. Activities for this scenario include the Main Zone Pit and Andrew Lake Pit open pit mining, End Grid Ore Zone underground mining, waste rock and ore stockpiling, mill operation (ore processing, power generation, water treatment, etc.), tailings management, road transportation of ore, fuel, reagents and supplies, air transportation of yellowcake and personnel, and field survey and exploration activities.

Environmental noise and vibration associated with the operation of the Project would consist of continuous excavation and processing activities and road traffic as well as intermittent blasting (at the mine/quarry sites), air traffic, and field survey and exploration activities (including exploration helicopters and periodic drilling activities within the lease boundary).

Attachment B provides a detailed account of the type and number of pieces of equipment and assumptions that have been used in the maximum operation scenario. Attachment B is based on the Project-environment interaction tables in Section 4.3 of the Tier 2 Environmental Assessment Report, Volume 4: Atmospheric Environment, Part B: Noise and Vibration (AREVA 2011b).

4.2 Assessment Scenarios – Other Options

A series of options were considered in the context of the noise and vibration impact assessment, which included the All-Season Road access road option as well as an additional option for the Dock and Storage Facility location.

The bounding scenario for the construction of the alternate All-Season Road and quarry were based on the closest geographic locations where these activities could occur that would yield the highest impact at the chosen sensitive receptors. The alternate All-Season Road scenario was considered separately to allow for the independent assessment of the access road construction and truck traffic effects.

Attachment B provides a detailed account of the type and number of pieces of equipment and assumptions that have been used in the maximum construction and operation scenarios for the two additional access road options. Attachment B is based on the Project-environment interaction tables in Section 4.3 of the Tier 2 Environmental Assessment Report, Volume 4: Atmospheric Environment, Part B: Noise and Vibration (AREVA 2011b).

The Dock and Storage Facility options are located further east (approximately 10 km) of Baker Lake than the preferred Dock and Storage Facility location. As such, it is expected that the noise and vibration levels would be lower and bounded by the preferred Dock and Storage Facility location.

4.3 Determination of Sensitive Receptors

The criteria presented in Section 2.5 for the assessment of noise and vibration impacts on human health were applied at sensitive receptors within the RAA. Sensitive receptors were established through an analysis of the following:

- Aerial photographs;
- Bake Lake community planning documents (i.e., future residential planning zones); and
- Historical information on semi-permanent hunting camps as provided by AREVA (Banton, N. 2010).

A total of three receptors were identified as being representative of the most sensitive receptors in the vicinity of the Project and are summarized in Table 4.3-1 below. Receptors R1 and R2 are residences located in the community of Baker Lake that would be the most exposed to activities occurring at the Dock and Storage Facility and access road, including the closest potential quarry location. Receptor R3 is located southeast of the Pointer Lake Airstrip at the inlet to Judge Sissons Lake and would be the closest semi-permanent receptor exposed to the Mine Development Area.

Table 4.3-1 Summary of Sensitive Receptors

Receptor ID	Description	Relative Position	Location (Coordinates)		
			UTM-X (m)	UTM-Y (m)	UTM-Z (m)[a]
R1	Baker Lake Residence (North)	South of North Access Road Options and Quarry	645846	7135184	32
R2	Baker Lake Residence (East)	West of Dock and Storage Facility	644380	7136551	53
R3	Seasonal Hunting Camp(b)	South-East of Pointer Lake Airstrip	574169	7134786	103

NOTES:

UTM = Universal Transverse Mercator (Easting and Northing)

(a) A height of 1.5 m (metres) above grade was used to represent the height of exposure of an individual.

(b) Additional seasonal hunting camps may be present within the RAA. This location is the closest known seasonal hunting camp location based on information provided by AREVA (Banton, N. 2010).

4.4 Modelling Parameters

4.4.1 Airborne Noise

The sound power levels for the various equipment and activities included in the assessment were obtained from the following sources:

- Sound levels for the majority of on-site equipment were derived from standard sound level prediction methods based on the maximum equipment power output;
- Measured data from AREVA's McClean Lake Operation was used to assess noise impacts from the mill operation, where applicable; and
- Where available and applicable, the SENES noise database was also used to estimate sound power levels from selected equipment. The database consists of full spectrum noise data from various noise-emitting equipment/processes at various site operations.

Attachment B provides a list of sources, their respective sound power level based on the above data and the key assumptions used in the modelling.

Sound propagation from stationary sources (e.g., pumps, rock breakers) and mobile sources (e.g., truck and loader routes) were considered in the assessment. In addition, as some sources (e.g., blowers, pumps, motors, crushers, screeners) would be located inside buildings, the noise model also analyzed sound propagating through the building structure due to the overall contribution of indoor sound sources. The amount of noise transmitted through a building shell depends on its sound transmission loss characteristics. The minimum building design configuration used in the noise model was as follows:

- Walls: minimum 22 gauge (0.80 mm) steel sheet interior and exterior insulated with fiberglass (thermal resistance of 3.5 $K{\cdot}m^2/W$); and
- Roof: minimum 22 gauge (0.80 mm) steel sheet interior and exterior insulated with fiberglass (thermal resistance of 7.0 $K{\cdot}m^2/W$).

This design results in wall and roof partitions with a minimum sound transmission class rating of approximately 29. The noise assessment was conducted using the above building shell design.

The scenarios described in Section 4.1 were assessed through predictive computer modelling using the CadnaA noise propagation model (DataKustik GmbH 2010a). The modelling software results are presented as A-weighted energy equivalent sound levels. As noted above, an A-weighted sound level represents a sound level that has been adjusted to account for the response of a human ear, which is more sensitive to sounds at higher frequencies. An energy equivalent sound level is the sound level which if constant over a specified period would contain the same sound energy as sound of varying levels over that same period of time (Cowan, J.P. 1994).

The CadnaA model was configured to estimate equivalent sound levels over various time periods. The time periods for which modelling were performed include:

- Maximum 16-hr L_{eq} (representing the daytime period between 7 a.m. and 11 p.m.); and
- Maximum 8-hr L_{eq} (representing the night-time period between 11 p.m. and 7 a.m.);
- Maximum 24-hour L_{eq}.

The following general assumptions were used in modelling:

Terrain

Terrain contours were prepared based on Lidar Data supplied by AREVA and Federal Topographic Maps for the Study Area to account for major changes in elevation. Site specific terrain contours, including berms, pits, piles and similar features, were not considered in the assessment to allow for a worst case assessment of noise propagation (i.e., all noise sources were placed a grade to allow for unimpeded noise propagation).

Ground Absorption

Reflective ground absorption was applied to all activity areas to represent a permafrost condition.

Buildings

All Project infrastructures were included in the model setup based on information provided by AREVA.

Source Operating Times

During construction, a 10-hour operating period was applied to all semi-continuous sources. For modelling runs completed for the operation phase, a 24-hour operating period was applied to all continuous sources. This is a conservative assumption as equipment use would likely not be operating continuously over the entire work day. The operating times applied for intermittent sources (road and air traffic) are defined in Attachment B.

Meteorology

The default meteorology used in the model assumes downwind conditions at all receptor locations when calculating sound propagation according to ISO 9613-2: 2003 (ISO 1996). This is considered conservative since these meteorological conditions are favourable to sound propagation.

Ground-borne Noise and Vibration

Blasting vibration was estimated using equations presented in the *"Drilling and Blasting Design and Related Regulatory Considerations – Kiggavik Project"*, which are based on methods presented by the U.S Bureau of Mines and constants from an open pit mine in Northwest Territories (Golder Associates Ltd. 2011; Siskind, D.E. et al. 1980a).

The bounding blasting scenario consisted of the maximum amount of explosives (kg) that could be used in any single blast (either aboveground or underground) within the Mine Development Area. It was assumed that there was no attenuation of the blast from nearby structures and topography. Impulsive noise from blasting (air blast) was assessed using U.S. Bureau of Mines vibration propagation equations and generalized constants from metal mining (Siskind, D.E. et al. 1980b).

The closest sensitive receptor to the Mine Development Area, R3, is approximately 15 km from the closest potential blast site in the Mine Development Area. Groundborne noise and vibration from blasting was not assessed at receptors R1 and R2 as blasting was not expected to occur in the vicinity of Baker Lake.

Because ground-borne vibration is a complex phenomenon that is difficult to model and predict accurately, most methodologies that have been used rely on empirical data. Typical vibration levels from key equipment were derived from empirical models presented in literature (Federal Transit Administration 2006; Wiss, J.F. 1981). The approximations presented in Table 4.4-1 represent major sources of vibration that would be operating on a semi-continuous to continuous basis at the Mine Development Area and Dock and Storage Facility during construction, operation and final closure.

Table 4.4-1 Vibration Source Levels for Heavy Equipment

Equipment	PPV at 7.6 m (mm/s)
Pile Driver	38.6
Excavator / Large Dozer / Drilling	2.3
Loaded Trucks	1.9
Crane	0.2
Small Bulldozer	0.1
SOURCES: (Federal Transit Administration 2006; Wiss, J.F. 1981)	

4.5 Results and Discussion

4.5.1 Construction / Final Closure – Preferred Option

Tables 4.5-1 to 4.5-6 summarize the predicted daytime and night-time receptor sound levels and %HA predictions for the maximum construction / final closure scenario. The predicted sound levels and change in %HA during the maximum construction / final closure scenarios are all below their respective Project effects criteria and are not expected to cause a human health effect.

4.5.1.1 Airborne Noise

The predicted sound levels at R1 and R2 during construction of the Dock and Storage Facility are 41.5 and 29.3 dBA, respectively. The overall sound levels (i.e., baseline and Dock and Storage Facility construction) at R1 and R2 are 42.4 and 36.0 dBA, respectively, which are below the 50 dBA project effects criteria. The overall sound levels result incremental changes of 7.4 and 1.0 dBA, respectively.

Table 4.5-1 Predicted Sound Levels at Sensitive Receptors – Dock and Storage Facility Construction

Receptor ID	Time Period[(a)]	Baseline Sound Level (dBA)	Predicted Sound Level, L_{eq} (dBA)	Overall Sound Level, L_{eq} (dBA)	Project Effects Criteria, L_{eq} (dBA)
R1	Daytime	35	41.5	42.4	50
R2	Daytime	35	29.3	36.0	50

NOTE:
(a) Does not apply at night since construction occurs during daytime hours only.

Figure C-1 in Attachment C shows a sound level contour plot of the Dock and Storage Facility construction. Sound levels are predicted to return to background within five kilometres of main activity areas.

The predicted sound levels at R1 and R2 during construction of the Winter Road, including the quarry operation, are 36.9 and 32.8 dBA, respectively. The overall sound levels at R1 and R2 are 39.1 and 37.0 dBA, respectively, which are below the 50 dBA project effects criteria. The overall sound levels result in incremental changes of 4.1 and 2.0 dBA, respectively.

Table 4.5-2 Predicted Sound Levels at Sensitive Receptors – Winter Road Construction

Receptor ID	Time Period[(a)]	Baseline Sound Level (dBA)	Predicted Sound Level, L_{eq} (dBA)	Overall Sound Level Leq (dBA)	Project Effects Criteria, L_{eq} (dBA)
R1	Day	35	36.9	39.1	50
R2	Day	35	32.8	37.0	50

NOTE:
(a) Does not apply at night since construction occurs during daytime

Figure C-2 in Attachment C shows a sound level contour plot of the Winter Road construction, including the quarry operation. Sound levels are predicted to return to background within four kilometres of the main activity areas and within six kilometres of the quarry operation.

The predicted sound level at R3 during construction of the Mine Development Area, including field survey and exploration activities, is 15.2 dBA, which is not unexpected given the distance that the receptor is from the Mine Development Area (i.e., 15 km). Construction of the Mine Development Area would not be perceptible at this receptor location.

Table 4.5-3 Predicted Sound Levels at Sensitive Receptor – Mine Development Area Construction

Receptor ID	Time Period[a]	Baseline Sound Level (dBA)	Predicted Sound Level, L_{eq} (dBA)	Overall Sound Level L_{eq} (dBA)	Project Effects Criteria, L_{eq} (dBA)
R3	Day	35	15.2	35	50

NOTE:
(a) Does not apply at night since construction occurs during daytime

Figure C-3 in Attachment C shows a sound level contour plot of the Mine Development Area construction, including field survey and exploration activities. Sound levels are predicted to return to background within eight kilometres of main activity areas and within four kilometres of field survey and exploration activities.

The baseline %HA at all receptors is 0.68, which is based on the presumed baseline sound level of 35 dB and the application of a 10 dB penalty to night-time hours. The predicted %HA at R1 and R2 during the Dock and Storage Facility construction are very low (0.94 and 0.70, respectively) and result in incremental changes in %HA of 0.26 and 0.02, respectively. Similarly, the Winter Road and Mine Development Area construction scenarios yielded even lower %HA values of 0.77, 0.72 and 0.68 for R1, R2 and R3, respectively, resulting in incremental change in %HA of less than 0.1. In conclusion, the predicted change in %HA during the construction scenarios are well below the 6.5% criteria at all sensitive receptors evaluated.

Table 4.5-4 Predicted %HA at Sensitive Receptors – Dock and Storage Facility Construction

Receptor ID[a]	Baseline (B)		Maximum Construction (MC), including Baseline		Change in %HA (MC %HA – B %HA)
	Sound Level DNL (dBA)[b]	%HA	Overall Sound Level DNL (dBA)[b]	%HA	
R1	41.0	0.68	43.5	0.94	0.26
R2	41.0	0.68	41.2	0.70	0.02

NOTE:
(a) R3 was not considered is this scenario given the distance away from the Dock and Storage Facility (>70 km)
(b) Adjusted in accordance with ISO 1996-1: 2003 (ISO 2003) (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area)

Table 4.5-5 Predicted %HA at Sensitive Receptors –Winter Road Construction

Receptor ID[a]	Baseline (B)		Maximum Construction (MC), including Baseline		Change in %HA (MC %HA – B %HA)
	Sound Level DNL (dBA)[b]	%HA	Overall Sound Level DNL (dBA)[b]	%HA	
R1	41.0	0.68	42.0	0.77	0.09
R2	41.0	0.68	41.4	0.72	0.04

NOTE:

(a) R3 was not considered is this scenario given the distance away from the location where the Winter Road construction was assessed (>70 km)

(b) Adjusted in accordance with ISO 1996-1: 2003 (ISO 2003) (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area)

Table 4.5-6 Predicted %HA at Sensitive Receptors – Mine Development Area Construction

Receptor ID[a]	Baseline (B)		Maximum Construction (MC), including Baseline		Change in %HA (MC %HA – B %HA)
	Sound Level DNL (dBA)[b]	%HA	Overall Sound Level DNL (dBA)[b]	%HA	
R3	41.0	0.68	41.0	0.68	NC

NOTE:

(a) R1 and R2 were not considered is this scenario given the distance from the Mine Development Area (>70km)

(b) Adjusted in accordance with ISO 1996-1: 2003 (ISO 2003) (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area)

(c) NC = No change in %HA

4.5.1.2 Ground-borne Noise

Predictions of blast induced air overpressure are provided in Table 4.5-7. The predicted air overpressure at the closest off-site receptor (R3) is 109 dB, which is less than the Project effects criteria of 120 dB. The predictions below do not consider any attenuation from local topography, vegetation and other structures.

Table 4.5-7 Predicted Air Overpressure

Distance From Blast Centroid (m)	Predicted Air Overpressure (dB)
100	140
200	136
300	134
400	132
500	130
1,000	126
2,000	122
3,000	119
5,000	116
10,000	112
15,000	109
SOURCE: (Siskind, D.E. et al. 1980b; Golder Associates Ltd. 2011)	

4.5.1.3 Ground-borne Vibration

Table 4.5-8 shows the predicted PPV from blasting. There are no sensitive receptor locations close to the Mine Development Area. The closest sensitive receptor, R3, is approximately 15 km from the closest mine in the Mine Development Area and is not expected to experience any perceptible vibration from blasting.

Table 4.5-8 Predicted Blasting Vibration Velocity

Distance From Blast Centroid (m)	Predicted PPV (mm/s)
100	76.4
200	27.6
300	15.2
400	10.0
500	7.2
1000	2.6
2000	0.9

Distance From Blast Centroid (m)	Predicted PPV (mm/s)
3000	0.5
5000	0.2
7000	0.1
SOURCE: (Siskind, D.E. et al. 1980a; Golder Associates Ltd. 2011)	

Ground-borne vibration levels were predicted for typical construction equipment and typical soil conditions. Since site-specific propagation effects are not considered in the available empirical models, vibration levels were not predicted at each sensitive location. Instead, an impact-distance table was generated to outline setback distances. The predicted peak particle velocity and distance relationships for selected heavy equipment are shown in Table 4.5-9. In all cases, the predicted vibration levels are less than 0.1 mm/s at a distance of 500 m from the activity, which is well below the threshold of perception. The closest receptor is over 2,000 m from Project activities and would not experience perceptible vibration from heavy equipment operation.

Table 4.5-9 Predicted Heavy Equipment Vibration Levels at Distances

Equipment Description	Distance From Equipment (m)	Predicted PPV (mm/s)
Pile Driver	100	0.8
	200	0.3
	300	0.2
	400	0.1
	500	0.1
Excavator / Large Dozer / Caisson Drilling	100	0.05
	200	0.02
	300	0.01
	400	0.01
	500	0.004
Small Bulldozer	100	0.002
	200	0.001
	300	0.0003
	400	0.0002
	500	0.0001

Equipment Description	Distance From Equipment (m)	Predicted PPV (mm/s)
Crane	100	0.05
	200	0.02
	300	0.01
	400	0.01
	500	0.004
Loaded Trucks	100	0.04
	200	0.01
	300	0.01
	400	0.01
	500	0.004
SOURCE: (Federal Transit Administration 2006; Wiss, J.F. 1981)		

4.5.2 Operation – Preferred Option

Tables 4.5-10 and 4.5-11 summarize the predicted daytime and night-time receptor sound levels and %HA predictions for the maximum operation scenario. The predicted sound levels and change in %HA during the maximum operation scenario are all below their respective daytime and night-time Project effects criteria and are not expected to cause a human health effect.

4.5.2.1 Airborne Noise

The predicted sound levels at R1 and R2 during Project operation are 37.9 and 27.3 dBA, respectively, for both daytime and night-time operation. The overall sound levels at R1 and R2 are 39.7 and 35.7 dBA, respectively, which are below the 50 dBA daytime and 45 dBA night-time project effects criteria and results in incremental changes of 4.7 dBA and 0.7 dBA, respectively.

The predicted sound level at R3 during Project daytime and night-time operation are 36.9 and 38.0 dBA, respectively. The overall sound level at R3 during daytime and night-time operation are 39.1 and 39.8 dBA, respectively, which are below the 50 dBA daytime and 45 dBA night-time project effects criteria and result in incremental changes of 4.1 and 4.8 dBA, respectively.

Table 4.5-10 Predicted Sound Levels at Sensitive Receptors – Operation

Receptor ID	Time Period	Baseline Sound Level (dBA)	Predicted Sound Level, L_{eq} (dBA)	Overall Sound Level, L_{eq} (dBA)	Project Effects Criteria, L_{eq} (dBA)
R1	Daytime	35	37.9	39.7	50
	Night-time	35	37.9	39.7	45
R2	Daytime	35	27.3	35.7	50
	Night-time	35	27.3	35.7	45
R3	Daytime	35	36.9[a]	39.1	50
	Night-time	35	38.0[a]	39.8	45

NOTE:
[a] Differences in the daytime and night-time predictions are associated with varying daytime and night-time aircraft flights at the Pointer Lake airstrip. Additional details are provided in Attachment B.

Figure C-4 in Attachment C shows a sound level contour plot of the Mine Development Area, Winter Road and Dock and Storage Facility operation and Figure C-5 in Attachment C shows a sound level contour plot of the Winter Road and Dock and Storage Facility operation in the vicinity of Baker Lake. Sound levels are predicted to return to background within eight kilometres of the Kiggavik and Sissons Mine Sites, 25 km of the Point Lake Airstrip, two kilometres of the Winter Road, four kilometres of the Dock and Storage Facility, and four kilometres of the field survey and exploration activities.

The predicted %HA at R1, R2 and R3 during Project operation are very low (1.25, 0.74 and 1.25, respectively) and result in incremental changes in %HA of 0.57, 0.06 and 0.57, respectively. The predicted changes in %HA during Project operation are well below the 6.5% criteria at all sensitive receptors.

Table 4.5-11 Predicted %HA at Sensitive Receptors – Operation

Receptor ID	Baseline (B)		Maximum Operation (MO), including Baseline		Change in %HA (MO %HA – B %HA)
	Sound Level DNL(dBA)[(a)]	%HA	Overall Sound Level DNL (dBA)[(a)]	%HA	
R1	41.0	0.68	45.7	1.25	+0.57
R2	41.0	0.68	41.7	0.74	+0.06
R3	41.0	0.68	45.7	1.25	+0.57

NOTE

(a) Adjusted in accordance with ISO 1996-1: 2003 (ISO 2003) (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area)

4.5.2.2 Ground-borne Noise

The ground-borne noise effects during operation were considered to be the same as those presented in Section 4.5.1.2.

4.5.2.3 Ground-borne Vibration

The ground-borne vibration effects during operation were considered to be the same as those presented in Section 4.5.1.3.

4.5.3 Construction / Final Closure – Other Options

Tables 4.5-12 and 4.5-13 summarize the predicted daytime and night-time receptor sound levels and %HA predictions for during construction of the All-Season Road access road option. The predicted sound levels and change in %HA during construction of the All-Season Road option are all below their respective Project effects criteria and are not expected to cause a human health effect.

4.5.3.1 Airborne Noise

The predicted sound levels during construction of the All-Season Road, including quarry operation, at R1 and R2 are 42.8 and 34.7 dBA, respectively. The overall sound levels at R1 and R2 are 43.5 and 37.9 dBA, respectively, which are below the 50 dBA project effects criteria however higher than those predicted for the preferred access road option (39.1 and 37.0 dBA, respectively). The overall sound levels result incremental changes of 8.5 and 2.9 dBA, respectively.

Table 4.5-12 Predicted Sound Levels at Sensitive Receptors – Construction – All-Season Road Option

Receptor ID	Time Period[(a)]	Baseline Sound Level (dBA)	Predicted Sound Level, L_{eq} (dBA)	Overall Sound Level, L_{eq} (dBA)	Project Effects Criteria, L_{eq} (dBA)
R1	Daytime	35	42.8	43.5	50
R2	Daytime	35	34.7	37.9	50
Note: (a) Does not apply at night since construction occurs during daytime hours only.					

Figure D-1 in Attachment D shows a sound level contour plot of the All-Season Road construction, including the quarry operation. Sound levels are predicted to return to background within five kilometres of main activity areas and within six kilometres of the quarry operation.

The predicted %HA during the All-Season Road construction scenario at R1 and R2 were very low (1.01 and 0.74, respectively) and yielded changes in %HA of 0.33 and 0.68, respectively. The predicted changes in %HA during the All-Season Road construction scenario are well below the 6.5% criteria at all sensitive receptors evaluated.

Table 4.5-13 Predicted %HA at Sensitive Receptors – Construction – All-Season Road Option

Receptor ID[a]	Baseline (B)		Maximum Construction (MC), including Baseline		Change in %HA (MC %HA – B %HA)
	Sound Level DNL (dBA)[b]	%HA	Overall Sound Level DNL (dBA)[b]	%HA	
R1	41.0	0.68	44.1	1.01	0.33
R2	41.0	0.68	41.6	0.74	0.68

NOTE:

(a) R3 was not considered is this scenario given the distance away from the location where the All-Season Road construction was assessed (>70 km)

(b) Adjusted in accordance with ISO 1996-1: 2003 (ISO 2003) (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area)

4.5.3.2 Ground-borne Noise

The ground-borne noise effects were considered to be the same as those presented in Section 4.5.1.2.

4.5.3.3 Ground-borne Vibration

The ground-borne vibration effects were considered to be the same as those presented in Section 4.5.1.3.

4.5.4 Operation – Other Options

Tables 4.5-14 and 4.5-17 summarize the predicted daytime and night-time receptor sound levels and %HA predictions for the All-Season Road operation scenario. The predicted sound levels and change in %HA during the All-Season Road operation scenario are all below their respective daytime and night-time Project effects criteria and are not expected to cause a human health effect.

4.5.4.1 Airborne Noise

The predicted sound levels at R1 and R2 during Project operation for the All-Season Road option are 37.5 and 26.4 dBA, respectively, for both daytime and night-time operation. The overall sound levels at R1 and R2 are 39.4 and 35.6 dBA, respectively, which are below the 50 dBA daytime and 45 dBA night-time project effects criteria and result in incremental changes of 4.4 dBA and 0.6 dBA, respectively.

The predicted sound level at R3 during Project daytime and night-time operation for the All-Season Road option are 36.9 and 38.0 dBA, respectively. The overall sound level at R3 during daytime and night-time operation are 39.1 and 39.8 dBA, respectively, which are below the 50 dBA daytime and 45 dBA night-time project effects criteria and result in incremental changes of 4.1 and 4.8 dBA, respectively.

Table 4.5-14 Predicted Sound Levels at Sensitive Receptors – Operation – All-Season Road Option

Receptor ID	Time Period	Baseline Sound Level (dBA)	Predicted Sound Level, L_{eq} (dBA)	Overall Sound Level, L_{eq} (dBA)	Project Effects Criteria, L_{eq} (dBA)
R1	Daytime	35	37.5	39.4	50
	Night-time	35	37.5	39.4	45
R2	Daytime	35	26.4	35.6	50
	Night-time	35	26.4	35.6	45
R3	Daytime	35	36.9[a]	39.1	50
	Night-time	35	38.0[a]	39.8	45

NOTE:
[a] Differences in the daytime and night-time predictions are associated with varying daytime and night-time aircraft flights at the Pointer Lake airstrip. Additional details are provided in Attachment B.

Figure D-2 in Attachment D shows a sound level contour plot of the Mine Development Area, All-Season Road and Dock and Storage Facility operation. Sound levels are predicted to return to background within one kilometre of the All-Season Road.

The predicted %HA at R1, R2 and R3 during Project operation for the All-Season Road option are very low (1.21, 0.73 and 1.25, respectively) and result in incremental changes in %HA of 0.53, 0.05 and 0.57, respectively. The predicted changes in %HA during Project operation for the All-Season Road option are well below the 6.5% criteria at all sensitive receptors.

Table 4.5-15 Predicted %HA at Sensitive Receptors – Operation – All-Season Road Option

Receptor ID	Baseline (B)		Maximum Operation (MO), including Baseline		Change in %HA (MO %HA – B %HA)
	Sound Level DNL(dBA)[(a)]	%HA	Overall Sound Level DNL (dBA)[(a)]	%HA	
R1	41.0	0.68	45.5	1.21	0.53
R2	41.0	0.68	41.6	0.73	0.05
R3	41.0	0.68	45.7	1.25	0.57

NOTE:
(a) Adjusted in accordance with ISO 1996-1: 2003 (ISO 2003) (i.e., +10 dB adjustment to night-time project sound level in a quiet rural area)

4.5.4.2 Ground-borne Noise

The ground-borne noise effects were considered to be the same as those presented in Section 4.5.1.2.

4.5.4.3 Ground-borne Vibration

The ground-borne vibration effects were considered to be the same as those presented in Section 4.5.1.3.

5 References

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Attachment A Noise Sources: Assumptions and Sound Levels

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
CONSTRUCTION PHASE					
Kiggavik and Sissons Sites					
Haul Truck	Kiggavik to Type II (4) & Purpose Built to Kiggavik (4) & Sissons to Type II (4) & Andrew Lake Pit to Sissons (4)	10-hr work day	124.7	119.3	(Beranke, L. 2006)
Crew Bus (40+ People)	Kiggavik-Sissons Haul Road (2)	10-hr work day	115.5	110.1	(Beranke, L. 2006)
Waste Hydraulic Excavator	Kiggavik Mill Area (2) & Sissons Mine Shop Area (2)	10-hr work day	126.4	121.0	(Beranke, L. 2006)
Large Wheel Loader	Kiggavik Mill Area (1) & Sissons Mine Shop Area (1)	10-hr work day	123.1	117.8	(Beranke, L. 2006)
Motor Grader	Kiggavik Mill Area (1) & Sissons Mine Shop Area (1)	10-hr work day	118.1	112.7	(Beranke, L. 2006)
Large Dozer	Kiggavik Mill Area (3) & Sissons Mine Shop Area (3)	10-hr work day	120.3	115.0	(Beranke, L. 2006)
Mobile Crane	Kiggavik Mill Area (1) & Sissons Mine Shop Area (1)	10-hr work day	116.7	111.3	(Beranke, L. 2006)
Crusher	Kiggavik Mill Area (2) & Sissons Mine Shop Area (2)	10-hr work day	-	119.5	SENES Database
Screen Plant	Kiggavik Mill Area (1) & Sissons Mine Shop Area (1)	10-hr work day	-	103.4	SENES Database
Generator	Kiggavik Mill Area (2) & Sissons Mine Shop Area (1)	10-hr work day	-	104.1	SENES Database
Small Wheel Loader	Kiggavik Mill Area (2) & Sissons Mine Shop Area (1)	10-hr work day	122.4	117.0	(Beranke, L. 2006)
Ready-mix Plant	Kiggavik Mill Area (1)	10-hr work day	-	107.8	SENES Database
Pile Driver	Kiggavik Mill Area (1)	10-hr work day	-	132.0	(Environmental Protection Department 1997)
Dock Facility					

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Waste Hydraulic Excavator	Dock and Storage Facility (1)	10-hr work day	126.4	121.0	(Beranke, L. 2006)
Large Wheel Loader	Dock and Storage Facility (1)	10-hr work day	123.1	117.8	(Beranke, L. 2006)
Motor Grader	Dock and Storage Facility (1)	10-hr work day	118.1	112.7	(Beranke, L. 2006)
Large Dozer	Dock and Storage Facility (1)	10-hr work day	120.3	115.0	(Beranke, L. 2006)
Mobile Crane	Dock and Storage Facility (1)	10-hr work day	116.7	111.3	(Beranke, L. 2006)
Quarries					
Crusher	Quarry 17C (2)	10-hr work day	-	119.5	SENES Database
Haul Truck	Quarry 17C (2)	10-hr work day	124.7	119.3	(Beranke, L. 2006)
Waste Hydraulic Excavator	Quarry 17C (1)	10-hr work day	126.4	121.0	(Beranke, L. 2006)
Small Wheel Loader	Quarry 17C (2)	10-hr work day	122.4	117.0	(Beranke, L. 2006)
Generator	Quarry 17C (1)	10-hr work day	-	104.1	SENES Database
Screen Plant	Quarry 17C (1)	10-hr work day	-	103.4	SENES Database
Access Road					
Snow cat	Winter Road (2)	10-hr work day	113.9	108.5	(Beranke, L. 2006)
Delta Commander	Winter Road (2)	10-hr work day	114.4	109.0	(Beranke, L. 2006)
Wheel Loader	Winter Road (2)	10-hr work day	117.5	112.2	(Beranke, L. 2006)
Water Truck	Winter Road (2)	10-hr work day	116.1	110.8	(Beranke, L. 2006)
Haul Truck	All-season Road (2) (Option)	10-hr work day	124.7	119.3	(Beranke, L. 2006)
Large Wheel Loader	All-season Road (1) (Option)	10-hr work day	123.1	117.8	(Beranke, L. 2006)
Large Dozer	All-season Road (1) (Option)	10-hr work day	120.3	115.0	(Beranke, L. 2006)
Motor Grader	All-season Road (1) (Option)	10-hr work day	118.1	112.7	(Beranke, L. 2006)
Waste Hydraulic Excavator	All-season Road (1) (Option)	10-hr work day	126.4	121.0	(Beranke, L. 2006)
Field Survey					
Helicopter transportation (H1.1)	Kiggavik (2 day-time flights)	10-hr work day	87.4	81.5	(DataKustik GmbH 2010a)
Exploration					
Drill Rig	Kiggavik (1)	10-hr work day	125.1	119.8	(Beranke, L. 2006)
Helicopter	Kiggavik (1)	10-hr work day	87.4	81.5	(DataKustik GmbH 2010a)
OPERATION PHASE					

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Kiggavik and Sissons Open Pit Mines					
Waste Haul Truck	Main Zone Pit to Type II (10) & Main Zone Pit to Type III (1) & Andrew Lake Pit to Type II (10) & Andrew Lake Pit to Type III (1)	15 km/hr (site road); 24-hr operation at part power	124.7	119.3	(Beranke, L. 2006)
Ore Haul Truck	Main Zone Pit to Ore (2) & Kiggavik-Sissons Haul Road (2)	15 km/hr (site road) & 60 km/hr (Kiggavik-Sissons Haul Road); 24-hr operation at part power	123.1	117.7	(Beranke, L. 2006)
Waste Hydraulic Excavator	Main Zone Pit (3) & Andrew Lake Pit (3)	24-hr operation at part power	126.4	121.0	(Beranke, L. 2006)
Ore Hydraulic Excavator	Main Zone Pit (1) & Andrew Lake Pit (1)	24-hr operation at part power	123.5	118.1	(Beranke, L. 2006)
Blasthole Drill Rig	Main Zone Pit (4) & Andrew Lake Pit (4)	24-hr operation at part power	125.1	119.8	(Beranke, L. 2006)
Small Wheel Loader	Main Zone Pit (1) & Andrew Lake Pit (1)	24-hr operation at part power	122.4	117.0	(Beranke, L. 2006)
Large Wheel Loader	Kiggavik Ore to Crushing & Grinding (1) & Sissons Ore (1)	15 km/hr (site road); 24-hr operation at part power	123.1	117.8	(Beranke, L. 2006)
Motor Grader	Kiggavik Type II (3) & Kiggavik Type III (1) & Sissons Type II (3) & Sissons Type III (1)	24-hr operation at part power	118.1	112.7	(Beranke, L. 2006)
Small Dozer	Main Zone Pit (1) & Kiggavik Type II (1) & Andrew Lake Pit (1) & Sissons Type II (1)	24-hr operation at part power	118.8	113.5	(Beranke, L. 2006)
Large Dozer	Kiggavik Type II (1) & Kiggavik Type III (1) & Sissons Type II (1) & Sissons Type III (1)	24-hr operation at part power	120.3	115.0	(Beranke, L. 2006)
Fuel Truck	Main Zone Pit to Tank Farm (2) & Andrew Lake Pit to Tank Farm (2)	15 km/hr (site road); 1 round trip per truck per hour	116.4	111.0	(Beranke, L. 2006)
Pick-up Trucks	Kiggavik-Sissons Haul Road (16)	60 km/hr (Kiggavik-Sissons Haul Road); 1 round trip per truck per day	97.2	96.6	(Miller, L.N. 1981)

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Crew Bus (40+ People)	Kiggavik-Sissons Haul Road (2)	60 km/hr (Kiggavik-Sissons Haul Road); 1 one-way trip per bus per hour	115.5	110.1	(Beranke, L. 2006)
Water Truck	Kiggavik Site Roads (2) & Sissons Site Roads (2)	15 km/hr (site road); 24-hr operation at part power	116.1	110.8	(Beranke, L. 2006)
Explosive Truck	Main Zone Pit to Explosives Storage (2) & Andrew Lake Pit to Explosives Storage (2)	15 km/hr (site road); 1 round trip per truck per hour	118.8	113.4	(Beranke, L. 2006)
Sissons Underground Mine					
Haul Truck	End Grid Ore Zone to Type II (2) & End Grid Ore Zone to Type III (1) & End Grid Ore Zone to Ore (1)	15 km/hr (site road); 24-hr operation at part power & 100% utilization	121.0	115.7	(Beranke, L. 2006)
Explosive Truck	End Grid Ore Zone to Explosives Storage (1)	15 km/hr (site road); 24-hr operation at part power & 50% utilization	113.0	107.7	(Beranke, L. 2006)
Shotcrete Carrier	End Grid Ore Zone to Batch Plant (2)	15 km/hr (site road); 24-hr operation at part power & 50% utilization	113.0	107.7	(Beranke, L. 2006)
Fuel Truck	End Grid Ore Zone to Tank Farm (1)	15 km/hr (site road); 24-hr operation at part power & 50% utilization	113.0	107.7	(Beranke, L. 2006)
Personnel Carrier	End Grid Ore Zone to Kiggavik-Sissons Haul Road (1)	15 km/hr (site road); 24-hr operation at part power & 50% utilization	113.0	107.7	(Beranke, L. 2006)
Load Haul Dumper	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Twin boom drill jumbo	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Rock Bolter	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Underground Road Grader	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Scissor Lift	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Boom Truck	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Underground Vehicles (Jeeps)	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Underground Vehicles (Trucks)	End Grid Ore Zone (0)	Insignificant (Underground Operation)	NA	NA	NA
Fresh Air Raise	End Grid Ore Zone (3)	24-hr operation	112.3	98.8	SENES Database
Fresh Air Raise Motor w/ Tonality	End Grid Ore Zone (3)	24-hr operation	107.9	99.9	SENES Database
Return Air Raise	End Grid Ore Zone (1)	24-hr operation	128.2	125.2	SENES Database
Incinerator					
Incinerator Exhaust Stack	Kiggavik (1)	24-hr operation	87.2	86.2	(Beranke, L. 2006)
Water Treatment Plant					
Water Treatment Plant Interior	Kiggavik Water Treatment Plant & Sissons Water Treatment Plant	24-hr operation	-	85.0	SENES Database
Water Treatment Plant Compressor Exhaust	Kiggavik (1) & Sissons (1)	24-hr operation	-	99.1	McClean Lake Measurements
Power Plant					
Generator-set Engine Casing	Kiggavik (3)	24-hr operation	128.0	126.6	(Miller, L.N. 1981)
	Sissons (3)	24-hr operation	123.4	122.0	(Miller, L.N. 1981)
Generator-set Air Intake	Kiggavik (3)	24-hr operation	113.0	110.1	(Miller, L.N. 1981)
	Sissons (3)	24-hr operation	110.7	107.8	(Miller, L.N. 1981)
Generator-set Engine Exhaust	Kiggavik (3)	24-hr operation	126.7	114.5	(Miller, L.N. 1981)
	Sissons (3)	24-hr operation	122.0	109.9	(Miller, L.N. 1981)
Generator-set Radiator Fan	Kiggavik (18) & Sissons (18)	24-hr operation	86.3	81.0	SENES Database

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Utilities					
Utilities Interior	Kiggavik Utilities	24-hr operation	-	85.2	McClean Lake Measurements
Crushing & Grinding					
Crushing & Grinding Interior	Kiggavik Crushing & Grinding	24-hr operation	-	92.4	McClean Lake Measurements
Crushing & Grinding Process Exhaust	Kiggavik (1)	24-hr operation	-	98.2	McClean Lake Measurements
Crushing & Grinding Rock Breaker	Kiggavik (2)	24-hr operation	-	120.4	McClean Lake Measurements
Leaching & Pulp Storage					
Slurry Receiving Louver	Kiggavik (1)	24-hr operation	-	98.8	McClean Lake Measurements
Slurry Receiving West Fan	Kiggavik (1)	24-hr operation	-	92.5	McClean Lake Measurements
Slurry Receiving North Fan	Kiggavik (1)	24-hr operation	-	88.4	McClean Lake Measurements
Slurry Receiving East Fan	Kiggavik (1)	24-hr operation	-	102.3	McClean Lake Measurements
Resin-in-Pulp					
Resin-in-Pulp Interior	Kiggavik Resin-in-Pulp	24-hr operation	-	83.9	McClean Lake Measurements
Met Lab					
Metallurgy Lab Scrubber	Kiggavik (1)	24-hr operation	-	106.5	McClean Lake Measurements
Elution & Regeneration					
Elution & Regeneration Interior	Kiggavik Elution & Regeneration	24-hr operation	-	84.4	McClean Lake Measurements
Drying & Packaging					
Calciner Interior	Kiggavik Drying & Packaging	24-hr operation	-	101.6	McClean Lake Measurements
Packaging Wall Exhaust	Kiggavik (1)	24-hr operation	-	95.7	McClean Lake Measurements
Calciner & Packaging Scrubbers	Kiggavik (2)	24-hr operation	-	105.4	McClean Lake Measurements
Reagent Preparation					
Truck Unloading Hydrogen Peroxide	Kiggavik (1)	24-hr operation	-	88.9	McClean Lake Measurements

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Lime Delivery Pressure Release	Kiggavik (1)	24-hr operation; max. 2 min/hr	-	121.1	McClean Lake Measurements
Truck at Idle in Loading Bay	Kiggavik (1)	24-hr operation	119.1	113.8	(Beranke, L. 2006)
Tailings Thickener					
Thickener Pumphouse Fan	Kiggavik (1)	24-hr operation	-	81.5	McClean Lake Measurements
Vent on Thickener Galleyway	Kiggavik (1)	24-hr operation	-	83.5	McClean Lake Measurements
Oxygen Plant					
Oxygen Plant Interior	Kiggavik Oxygen Plant	24-hr operation	-	91.3	McClean Lake Measurements
Oxygen Plant Process Exhaust	Kiggavik (2)	24-hr operation	-	103.6	McClean Lake Measurements
Oxygen Plant Louver	Kiggavik (1)	24-hr operation	-	104.1	McClean Lake Measurements
Air Cooled Condenser Fan	Kiggavik (10)	24-hr operation	-	92.4	McClean Lake Measurements
Oxygen Plant Rooftop Ventilator	Kiggavik (2)	24-hr operation	-	93.0	McClean Lake Measurements
Acid Plant					
Acid Plant Interior	Kiggavik Acid Plant	24-hr operation	-	82.8	McClean Lake Measurements
Acid Plant Steam Release	Kiggavik (1)	24-hr operation	-	115.8	McClean Lake Measurements
Acid Plant Wall Exhaust	Kiggavik (1)	24-hr operation	-	95.3	McClean Lake Measurements
CX Plant Wall Exhaust	Kiggavik (1)	24-hr operation	-	92.1	McClean Lake Measurements
CX Plant Stack	Kiggavik (1)	24-hr operation	-	116.7	McClean Lake Measurements
Acid Plant Cooling Tower	Kiggavik (1)	24-hr operation	-	96.9	McClean Lake Measurements
Backfill Plant					
Backfill Plant Interior	Sissons Backfill Plant	24-hr operation	-	97.0	SENES Database
Airstrip					
Tractor Trailer	Mill to Pointer Lake Airstrip (2)	60 km/hr; 24-hr operation at part power	119.1	113.8	(Beranke, L. 2006)

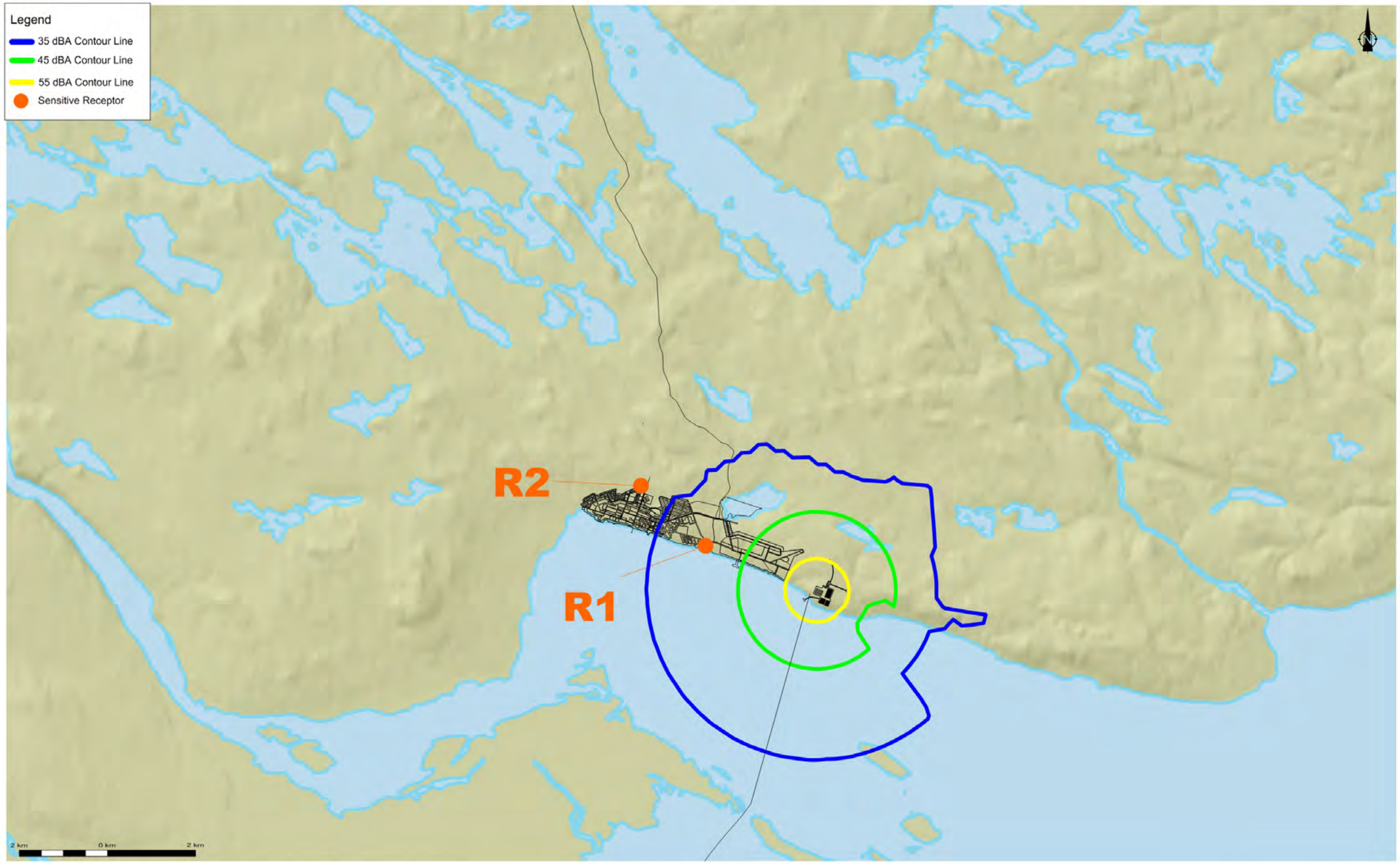
Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
Aircraft transportation (S1.2 take-off)	Pointer Lake Airstrip (3 day-time & 2 night-time flights)		105.7	-	(DataKustik GmbH 2010a)
Aircraft transportation (S1.2landing)	Pointer Lake Airstrip (3 day-time & 2 night-time flights)		85.7	-	(DataKustik GmbH 2010a)
Aircraft transportation (P-MIL2 take-off)	Pointer Lake Airstrip (1 night-time flight)		109.3	-	(DataKustik GmbH 2010a)
Aircraft transportation (P-MIL2 landing)	Pointer Lake Airstrip (1 night-time flight)		100.3	-	(DataKustik GmbH 2010a)
Access Road					
B-Train Transport Truck	Winter Road	30 km/hr; 43 round trips per day	119.1	113.8	(Beranke, L. 2006)
B-Train Transport Truck	All-Season Road (Option)	70 km/hr; 22 round trips per day	119.1	113.8	(Beranke, L. 2006)
Dock Facility					
Mobile Crane	Dock and Storage Facility (1)	24-hr operation	116.7	111.3	(Beranke, L. 2006)
Tug Boat	Dock and Storage Facility (2)	24-hr operation	-	100.0	(CINOTECH Consultants Limited 2003)
Fuel Pump	Dock and Storage Facility (5)	24-hr operation	100.5	98.6	(Miller, L.N. 1981)
Shunt / Rigging Truck	Dock and Storage Facility (1)	24-hr operation	113.4	108.0	(Beranke, L. 2006)
Container Handler	Dock and Storage Facility (1)	24-hr operation	115.6	110.2	(Beranke, L. 2006)
Heavy Lift Truck	Dock and Storage Facility (1) & Barge to Dock and Storage Facility (1)	15 km/hr (site road); 24-hr operation	115.5	110.1	(Beranke, L. 2006)
Reach Stacker	Dock and Storage Facility (1)	24-hr operation	117.6	112.2	(Beranke, L. 2006)
Field Survey					
Helicopter transportation (H1.1)	Kiggavik (2 day-time flights)	10-hr work day	87.4	81.5	(DataKustik GmbH 2010a)
Exploration					
Drill Rig	Kiggavik (1)	10-hr work day	125.1	119.8	(Beranke, L. 2006)
Helicopter	Kiggavik (1)	10-hr work day	87.4	81.5	(DataKustik GmbH 2010a)

Summary Table of Noise Sources, Assumptions and Sound Power Levels

Source Description	Assumed Equipment Quantity and Location(s)*	Assumed Operation	NOISE DATA		
			Overall		Reference
			dB	dBA	
NOTES: * Equipment quantities are based on the Project Description and communications with AREVA staff. Assume that all equipment can be at either site at any given time NA = not applicable Hr = hour					

Attachment B Preferred Option: Noise contour Plots



Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE C-1

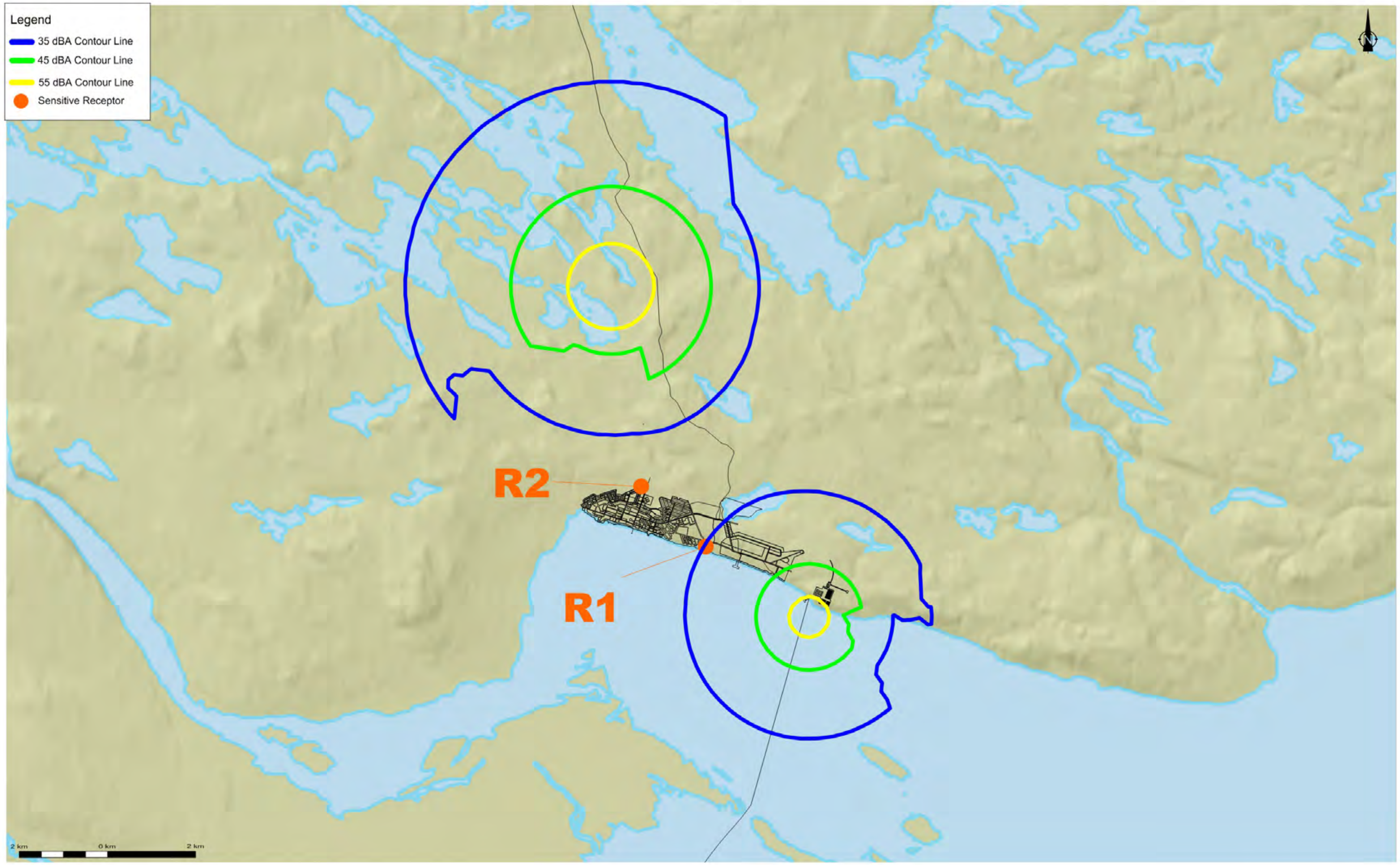
DOCK AND STORAGE FACILITY CONSTRUCTION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

KIGGAVIK PROJECT

AREVA

AREVA Resources Canada Inc - P.O. Box 9204 - 817 - 45th Street West - Saskatoon, SK - S7K 3XS

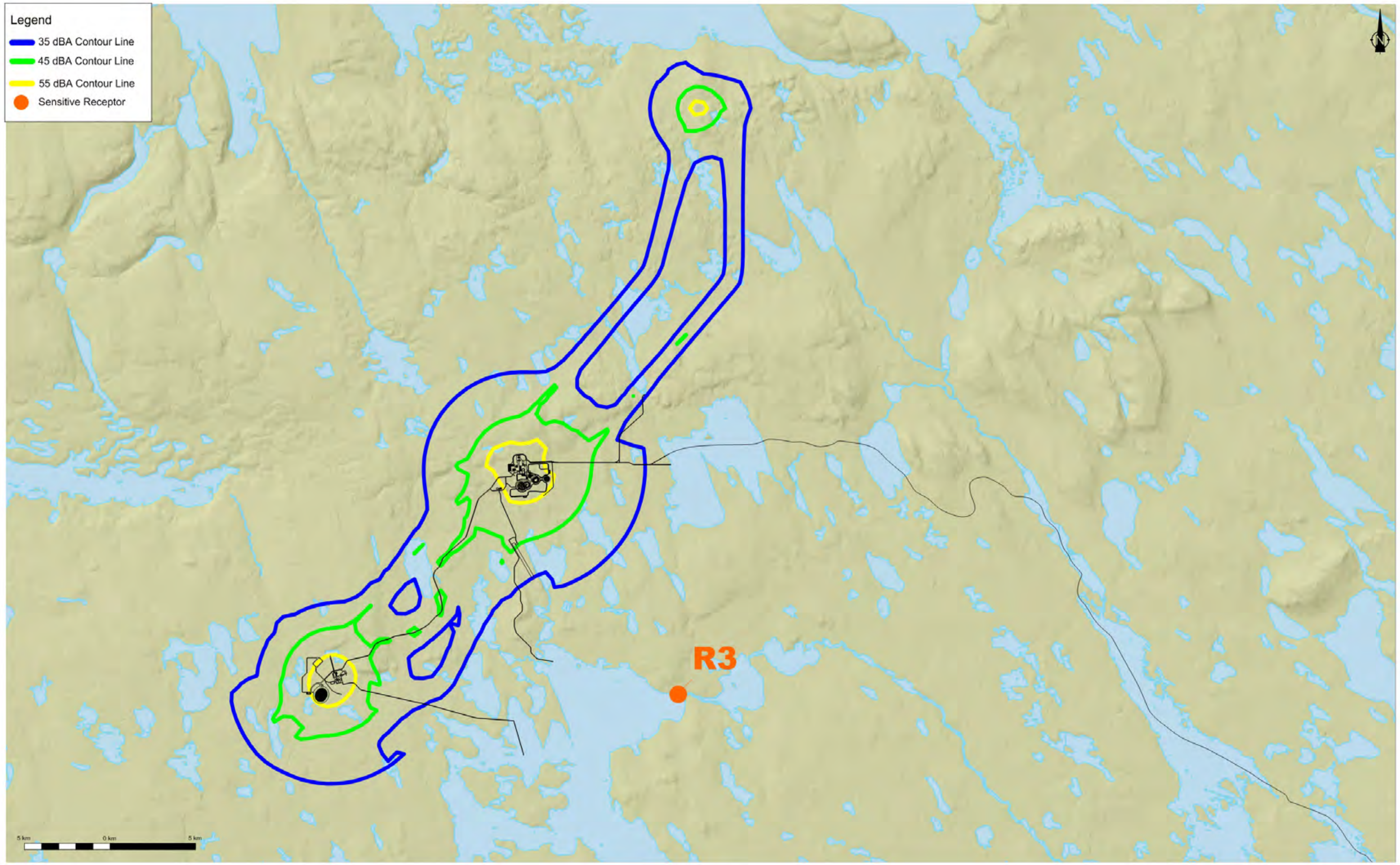


Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultant
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE C-2
WINTER ROAD CONSTRUCTION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

KIGGAVIK PROJECT
AREVA
AREVA Resources Canada Inc • P.O. Box 9204 • 817 - 45th Street West • Saskatoon, SK • S7K 3X5



Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultant
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE C-3
MINE DEVELOPMENT AREA CONSTRUCTION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

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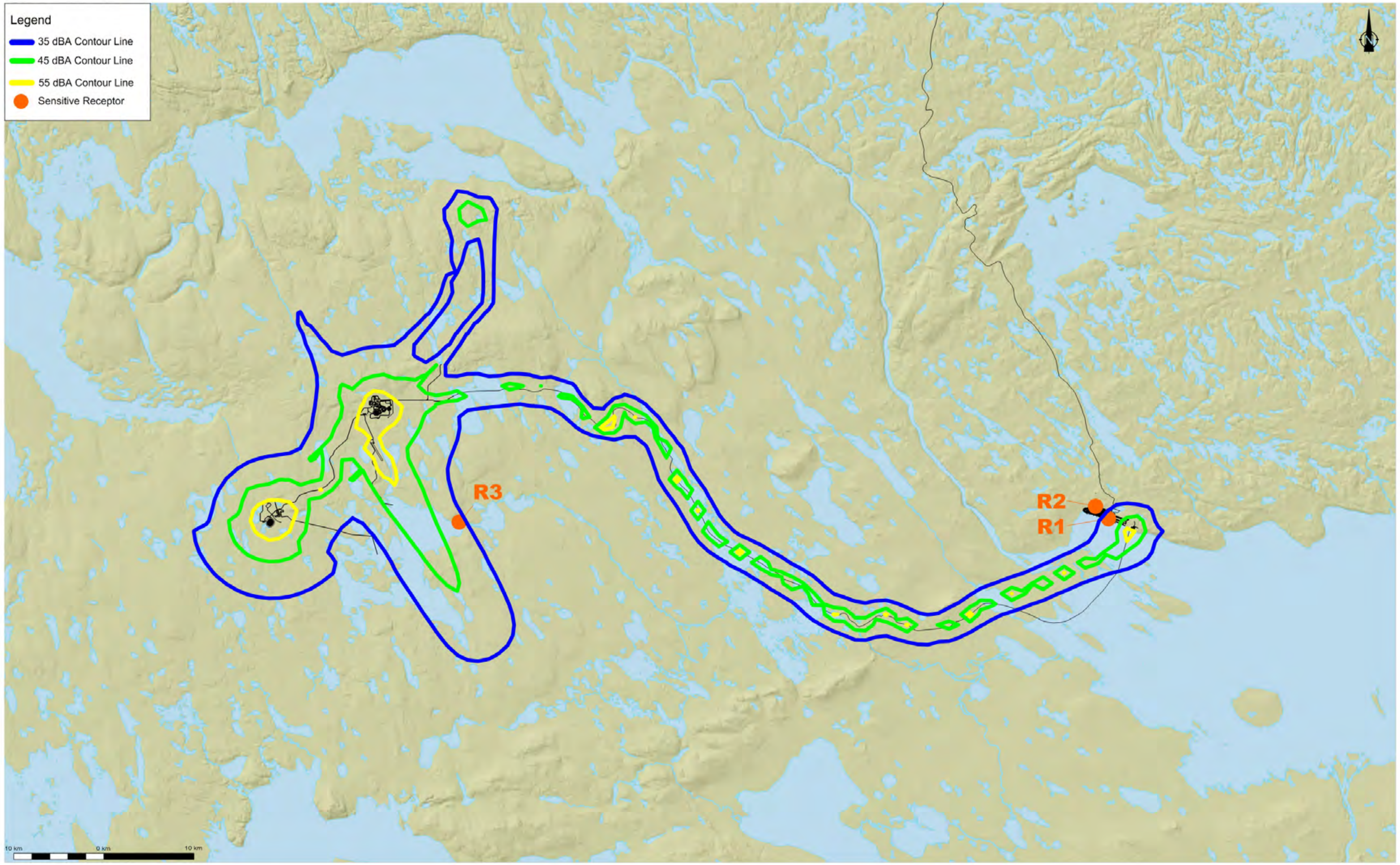

Projection: NAD 1983 UTM Zone 14N
Compiled: SENES Consultant
Date: 05/05/2014
Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE C-4
MINE DEVELOPMENT AREA / WINTER ROAD / DOCK AND STORAGE FACILITY OPERATION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

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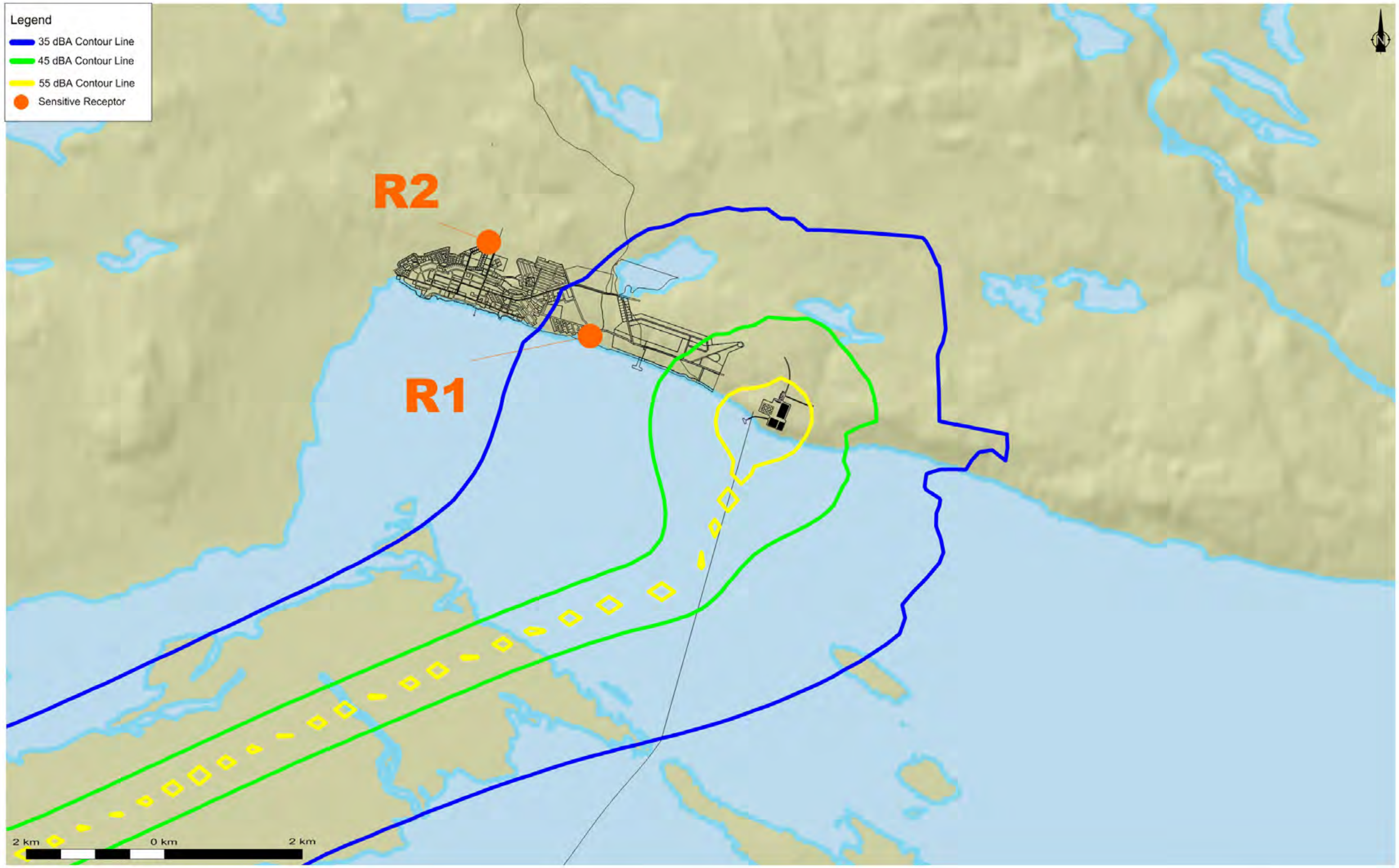

Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE C-5

DOCK AND STORAGE FACILITY / WINTER ROAD OPERATION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

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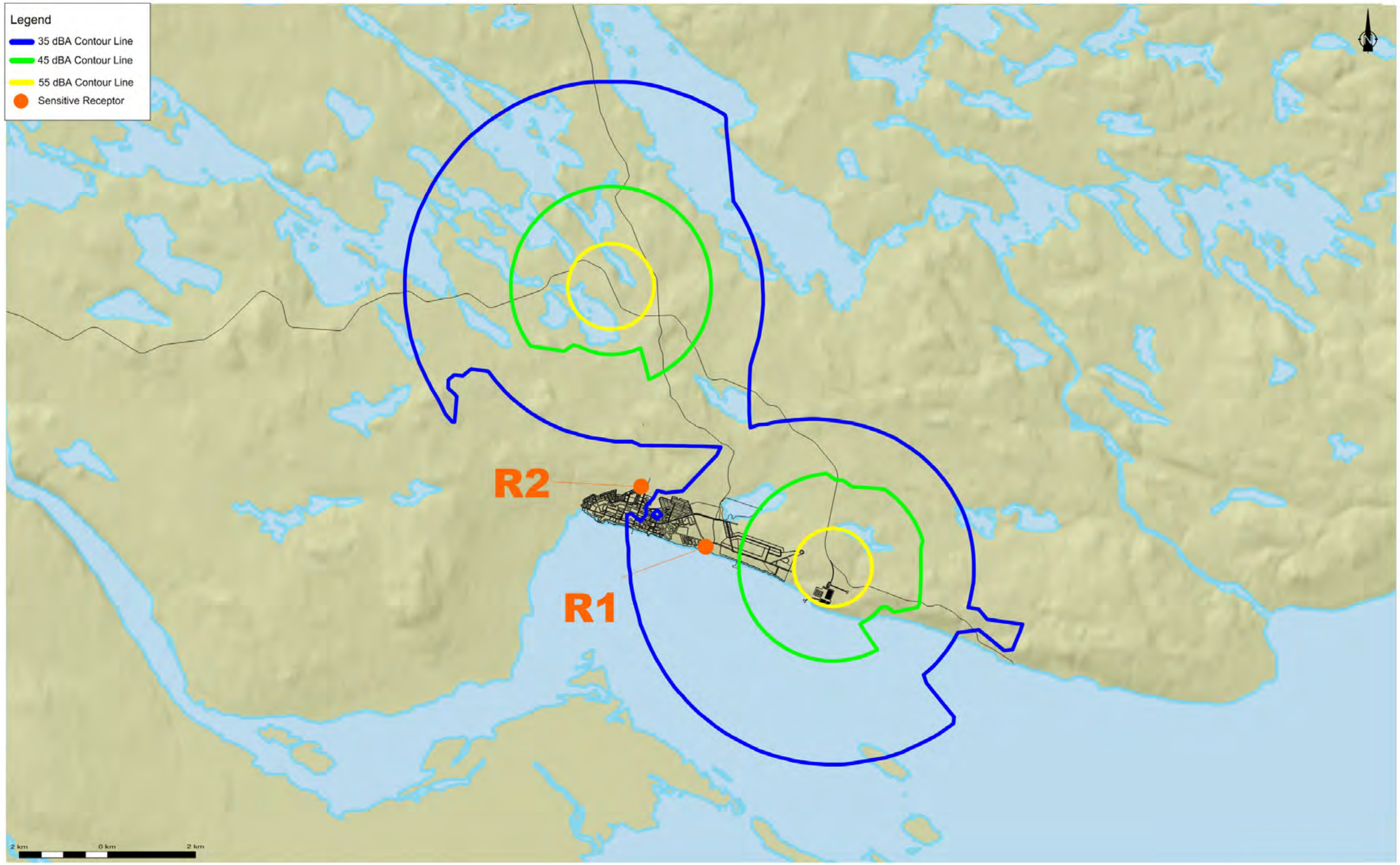
Attachment C Other Options: Noise contour Plots



Projection: NAD 1983 UTM Zone 14N
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FIGURE D-1
ALL-SEASON ROAD OPTION CONSTRUCTION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

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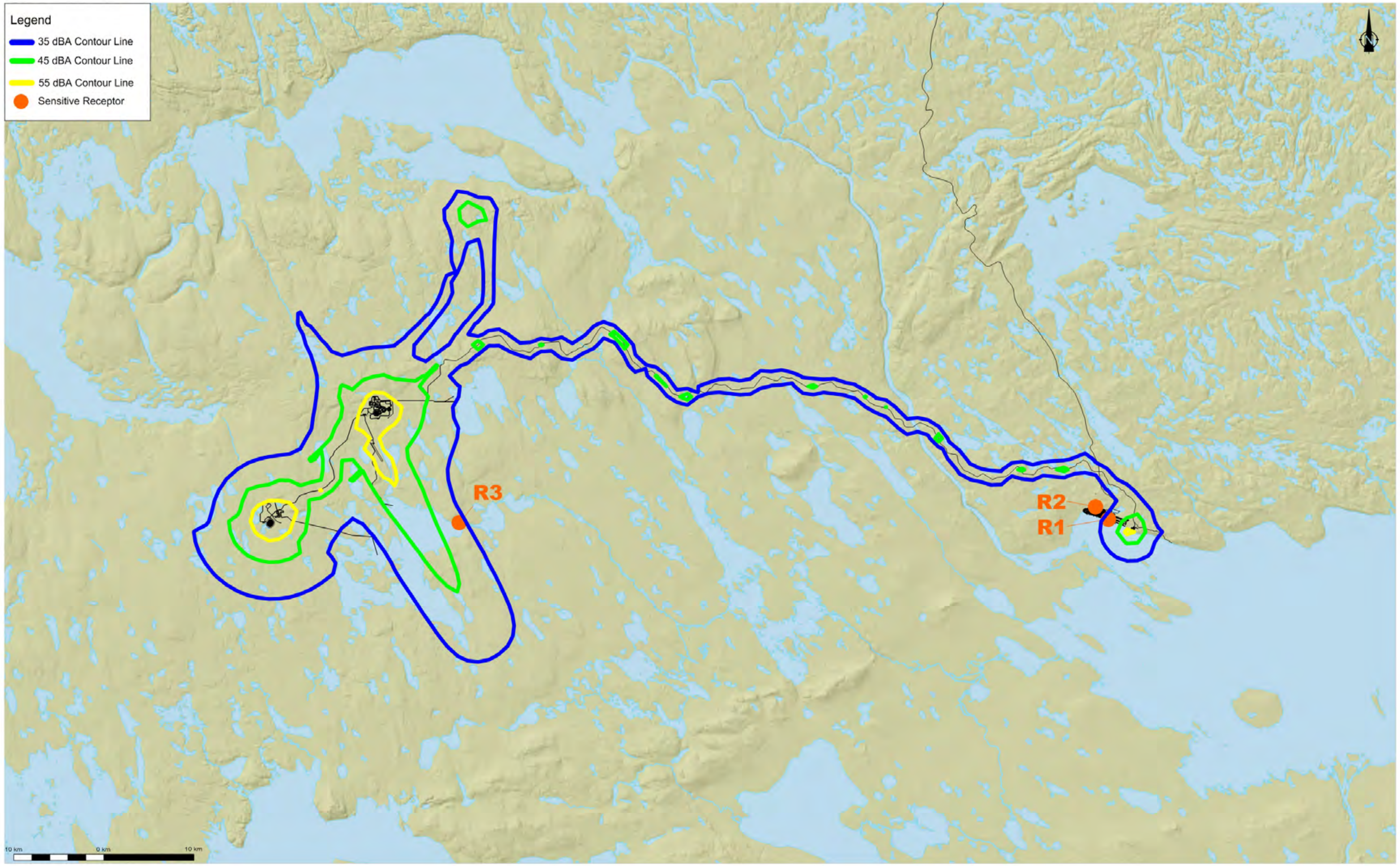

Projection: NAD 1983 UTM Zone 14N

Compiled: SENES Consultant

Date: 05/05/2014

Data Sources: Natural Resources Canada, Geobase®, Nation Topographic Database, AREVA Resources Canada Inc.

FIGURE D-2
ALL-SEASON ROAD OPTION OPERATION NOISE CONTOURS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT
TECHNICAL APPENDIX 4E: Noise and Vibration Impact Assessment

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