AREVA

Kiggavik Project
Final Environmental Impact Statement

Tier 2 Volume 4:
Atmospheric Environment

Part 2 – Noise and Vibration

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

Foreword

The enclosed document forms part of the Kiggavik Project Final Environmental Impact Statement (FEIS) submission, presenting potential environmental and social impacts to determine if the Project should proceed and if so, under what terms and conditions. The submission has been prepared for the Nunavut Impact Review Board by AREVA Resources Canada Inc. to fulfill the requirements of the “Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.’s Kiggavik Project (NIRB File No. 09MN003)”, to include new material or clarity provided during the review of the Draft Environmental Impact Statement, and to address company commitments and direction from the Nunavut Impact Review Board as outlined in the “Preliminary Hearing Conference Decision Concerning the Kiggavik Project (NIRB File No. 09MN003)”.

The FEIS submission consists of a number of documents, as shown in the attached road map. These documents have been categorized into tiers, as follows:

- **Tier 1** document (Volume 1) provides a plain language summary of the Final Environmental Impact Statement.

- **Tier 2** documents (Volumes 2 to 10) contain technical information and provide the details of the assessments of potential Project environmental effects for each environmental compartment. Tier 2 Volume 11 contains executive, popular, and volume summaries in Inuktitut.

- The Tier 2 documents each have a number of technical appendices, which comprise the **Tier 3** supporting documents. These include the environmental baseline reports, design reports, modelling reports and details of other studies undertaken to support the assessments of environmental effects. Management plans are provided as Tier 3 documents.

Volume 1 Main Document

Volume 2 Project Description and Assessment Basis

- Governance and Regulatory Oversight
- Project Description
- Assessment Basis

2A Alternatives Assessment
2B Drilling and Blasting Design
2C Explosives Management Plan
2D Design of Ore and Mine Rock Pads and Ponds
2E Water Diversion and Collection Design
2F Design of Andrew Lake Dewatering Structure
2G Kiggavik-Sissons Road Report
2H Ore Storage Management Plan
2I Water Management Plan
2J Marine Transportation
2K Winter Road Report
2L All-Season Road Report
2M Roads Management Plan
2N Borrow Pits and Quarry Management Plan
2O Mine Site Airstrip Report
2P Occupational Health and Safety Plan
2Q Radiation Protection Plan
2R Preliminary Decommissioning Plan
2S Waste Management Plan
2T Environmental Management Plan
2U Hazardous Materials Management Plan
2V Mine Geotechnical Reports

Volume 3 Public Engagement and Inuit Qaujimajatuqangit

Part 1
- Public Engagement

Part 2
- Inuit Qaujimajatuqangit

3A Public Engagement Documentation
3B Inuit Qaujimajatuqngit Documentation
3C Community Involvement Plan

Volume 4 Atmospheric Environment

Part 1
- Air Quality and Climate Change

Part 2
- Noise and Vibration

4A Climate Baseline
4B Air Dispersion Assessment
4C Air Quality Monitoring Plan
4D Baker Lake Long-Term Climate Scenario
4E Noise and Vibration Assessment
4F Noise Abatement Plan

Volume 5 Aquatic Environment

- Surface Hydrology
- Hydrogeology
- Water and Sediment Quality
- Aquatic Organisms
- Fish and Fish Habitat

5A Hydrology Baseline
5B Geology and Hydrogeology Baseline
5C Aquatics Baseline
5D Groundwater Flow Model
5E Prediction of Water Inflows to Kiggavik Project Mines
5F Mine Rock Characterization and Management
5G Thermal and Water Transport Modelling for the Waste Rock Piles and Tailings Management Facilities
5H Waste Rock Water Balance
5I Hydrology of Waste Rock Piles in Cold Climates
5J Tailings Characterization and Management
5K Historical and Climate Change Water Balance
5L Kiggavik Conceptual Fisheries Offsetting Plan
5M Aquatics Effects Monitoring Plan
5N Hydrology Assessments
5O Sediment and Erosion Control Plan
5P Technical Assessments of Water Withdrawal Locations and Baker Lake Dock Site

Volume 6 Terrestrial Environment

- Terrain
- Soils
- Vegetation
- Terrestrial Wildlife

6A Surficial Geology and Terrain Baseline
6B Vegetation and Soils Baseline
6C Wildlife Baseline
6D Wildlife Mitigation and Monitoring Plan

Volume 7 Marine Environment

- Marine Water and Sediment Quality
- Marine Mammals
- Marine Fish

7A Marine Environment Baseline
7B Underwater Acoustic Modelling

Volume 8 Human Health

- Occupational Dose Assessments
- Human Health Risk Assessment

8A Ecological and Human Health Risk Assessment
8B Radiation Protection Supporting Document

Volume 9 Socio-Economic Environment and Community

Part 1
- Socio-Economic Environment

Part 2
- Heritage Resources

9A Socio-Economic Baseline
9B Archaeology Baseline
9C Human Resources Development Plan
9D Archaeological Resource Management Plan

Volume 10 Accidents, Malfunctions and Effects of the Environment on the Project

- Risk Assessments
- Effects of the Environment on the Project

10A Transportation Risk Assessment
10B Spill Contingency and Landfarm Management Plan
10C Emergency Response Plan

Volume 11 Executive, Popular and Volume Summaries Translated into Inuktitut

KEY:

- **Tier 1 Document** — Main Documents
- **Tier 2 Document** — Environmental Effects Assessment Report
- **Tier 3 Document** — Technical Appendices, Baseline Reports, Technical Development and Management Plans

Executive Summary – Noise and Vibration

As per the guidelines issued by the Nunavut Impact Review Board (NIRB 2011), AREVA has prepared an Environmental Impact Statement (EIS) which includes the assessment of the potential human health effects relating to noise and vibration levels that are associated with the Kiggavik Project (Project).

Scope of the Assessment

The Nunavut Impact Review Board (NIRB) developed the scope of the assessment for the Project based on input from Inuit, government, and other interested stakeholders. Issues related to noise and vibration were identified through this consultation, as well as through engagement activities undertaken directly by AREVA. These issues included a general concern with elevated noise levels and the impact the Project activities may have on the local noise environment in Baker Lake. In particular, the following items were identified:

- General concerns were raised about the process of evaluating noise and vibration impacts in relation to the Project and the need to ensure that appropriate studies were completed to assess potential effects (EN-KIV OH 2009[1]; EN-CH NIRB 2010[2]; EN-CI NIRB 2010[3]; EN-RB NIRB 2010[4]; EN-AR OH 2012[5]);

- There was a concern that there was a lack of noise regulations in Nunavut (EN-BL NIRB 2010[6]); and

- Noise from helicopter flyovers was identified as an area of particular concern, especially in light of the existing helicopter traffic from other operators in Baker Lake (EN-BL EL 2012[7]; EN-BL CLC 2013[8]).

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[1] EN-KIV OH 2009: *General concern regarding if and how the environmental effects will be assessed.*

[2] EN-CH NIRB 2010: *Would like fellow Inuit to be employed and earning a living, as well as the environment should be taken care of at the same time.*

[3] EN-CI NIRB 2010: Chesterfield Inlet will be largely affected by the project because of the shipping routes… Noise pollution is a concern.

[4] EN-RB NIRB 2010: *Concerned over who will be conducting the study and environmental monitoring. It is important that the study is complete before the mine is in operation.*

[5] EN-AR OH 2012: *Will the impacts on the environment be big during operation? Will the effects be reversible when the operation stops?*

[6] EN-BL NIRB 2010: *Would like to see strict regulations in place for noise, environment, air pollution, etc. before this project goes ahead and would like to see these even for the exploration activities.*

[7] EN-BL EL 2012: *Helicopters are very noisy every day in the spring and summer.*

The comments and concerns raised by the Inuit and other stakeholders were integrated into the broader study design and are discussed throughout this report. Many of the comments provided were addressed in the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011), including identification of valued ecosystem components (VECs) and issues that should be considered in the environmental impact statement (EIS). For example, young adults "… believe the impact assessment should consider the potential effects of the Project during all seasons…" (IQ-RIYA 2009[9]).

Although the Nunavut Department of Environment's Environmental Protection Division regulates activities that have the potential to affect noise and vibration (via the Act) there are currently no environmental noise or vibration regulations, guidelines or criteria have been established in Nunavut. In the absence of Territorial noise and vibration guidelines, Federal, Provincial and International standards and guidelines were used in the assessment of Human Health effects.

Existing Environment

In an effort to characterize the existing noise environment within the Project area, an analysis of noise monitoring from AREVA's McClean Lake Operations and noise and vibration effects assessments submitted to NIRB was completed to identify appropriate baseline levels. With consideration to the above information, an Leq (energy equivalent sound level) of 35 dBA was selected for daytime (16-hour), night-time (eight-hour) and 24-hour sound levels. The Leq of 35 dBA was used as the baseline value for assessing the relevance of potential changes in sound levels as a result of Project activities. No information was available to establish baseline vibration within the Project area. It is expected that vibration levels are not perceptible (i.e., less than 0.1 mm/s).

Effects of Project-Related Activities Noise and Vibration

During each Project phase (construction, operation, final closure and post-closure), activities will occur which have the potential to increase noise and vibration levels within the local and regional environments. A summary of Project activities which may result in effects to noise and vibration is provided below.

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[8] EN-BL CLC 2013: *It's not only AREVA's choppers but there are a lot of other companies' choppers.*

[9] IQ-RIYA 2009: *Young adults have heard about damage to the environment that has been caused by mines, and believe the impact assessment should consider the potential effets of the Project during all seasons, and that a priority should be given to considering the potential effects of the Project on caribou migration routes.*

Construction/Final Closure

The potential environmental effects associated with in-water and on-land construction and supporting activities that could result in increased ambient sound levels include:

- Continuous airborne noise produced by heavy equipment used in the site preparation and decommissioning, quarry operations and in the construction of the Mill complex;
- Semi-continuous airborne noise produced by air traffic and pile driving (i.e., building foundations); and
- Impulsive groundborne noise produced by blasting.

Operation

The potential environmental effects associated with mining, milling, tailings management, water management, waste management, general services, transportation, and on-going exploration that could result in increased ambient sound levels include:

- Continuous airborne noise produced by heavy equipment associated with open pit mining and underground mining activities;
- Continuous airborne noise produced by mill operations, including crushing, screening, yellowcake processing, water/wastewater treatment and power generation;
- Continuous airborne noise produced by the Dock and Storage Facility operations, including offloading and heavy equipment usage;
- Semi-continuous airborne noise produced by truck traffic (along haul roads and access roads), air traffic and exploration drilling; and
- Impulsive groundborne noise produced by blasting.

Mitigation and Project Design

In general, the Project will employ standard operating procedures for equipment/machinery and ensure that regular maintenance is performed in accordance with good engineering practices or as recommended by suppliers such that the equipment is kept in good operating condition. As well, the Project proponent will adhere to conditions outlined in all permits, authorizations and/or approvals. Procedures will also be developed to address community complaints.

Residual Project Effects to Noise and Vibration

Construction/Operation/Final Closure

Noise and Vibration were identified as VECs because of the potential for noise and vibrations from Project activities to generate human health effects in the residential areas of Baker Lake and at semi-permanent hunting camps surrounding the Mine Development Area. Potential human health effects include changes in annoyance and sleep disturbance. The predicted residual noise effects are not expected to be significant. A potential measurable change in noise levels was noted in Baker Lake during some short term construction and operational activities associated with the dock and storage facility. However, the overall predicted receptor noise levels during construction, operation and final closure were below the Project effects criteria (50 dBA day and 45 dBA night), and in many cases are below the threshold of perception (i.e., would not be heard in relation to background noise). The predicted change in community annoyance (percent highly annoyed) was also well below the Project effects criteria (6.5%) at all sensitive receptors evaluated and was considered negligible during all phases of the Project. The predicted ground-borne noise levels from blasting was predicted to be below Project effects criteria (120 dB) at the nearest sensitive receptor. Similarly, the predicted residual vibration effects were not considered significant. In all cases, the overall predicted vibration levels were well below the Project effects criteria and are below the threshold of perception at all receptor locations.

Residual Cumulative Effects

A list of Future projects that may overlap with the proposed Project was screened for potential cumulative effects with the identified residual Project effects. Noise and vibration effects are generally restricted to the localized area surrounding the Project and decrease rapidly with distance. The main Project sites and any proposed Project activity areas within the RAA are expected to be of sufficient distance apart so that there would be no cumulative noise and vibration effects at the sensitive receptors.

Mitigation Measures

Since there were no predicted human health effects associated with the Project no specific noise and vibration mitigation measures were considered necessary.

Recommended Monitoring and Follow-Up

Given that the noise and vibration effects were considered negligible and would not generate a human health effect, no specific monitoring programs were considered necessary. However, Human health effects relating to noise and vibration would be monitored using a complaints/response procedure. If the community raises any specific concerns the need for a detailed noise and vibration monitoring program will be reassessed.

ᓇᐃᓈᖅᓯᒪᔪᖅ – ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓵᔪᕋᕐᓛᖅᑐᑦ

ᒪᓕᒃᑕᐅᔭᕆᐊᓕᒃᑎᒍᑦ ᓴᖅᑭᑕᐅᔪᑦ ᓄᓇᕗᒻᒥ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᕿᒥᕐᕈᔾᔪᓄᑦ (NIRB 2011), ᐊᕼᐅᒃᑯᑦ ᐋᕿᒃᓱᐃᓚᐅᖅᑐᑦ ᐊᑭᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᒥᑦ (EIS), ᐃᓚᐅᐸᓗᓂ ᖃᐅᔨᓴᐃᓂᖅ ᐊᒃᑐᖅᓯᓂᐅᔪᙳᖅᑐᖅ ᐃᓄᐃᑦ ᐋᓐᓂᐊᕐᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᖃᓄᐃᙱᓕᖅᑎᑦᑎᓂᐅᔪᙳᖅᑐᑦ ᐱᔾᔪᑎᓕᙵᓄᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓵᔪᕋᕐᓛᖅᑐᓄᑦ ᐊᒃᑐᐊᓂᕐᑲᖅᑐᑦ ᑮᓪᓚᕝ ᐱᓕᕆᐊᒧᑦ (ᐱᓕᕆᐊᖅ).

ᑕᐅᑦᑯᓪᓗᒍ ᖃᐅᔨᓴᐃᓂᖅ

NIRB-ᑯᑦ ᓴᖅᑭᑦᑎᓚᐅᖅᑐᑦ ᓇᓅᓐᓂᕆᔭᕆᓂᒃ ᖃᐅᔨᓴᐃᓂᖅ ᐱᓕᕆᐊᒧᑦ ᐊᑐᖅᓗᒋᑦ ᐅᖃᐅᓯᐅᔪᑦ ᐃᓄᙵᓄᑦ, ᒐᕙᒪᒃᑯᓐᓄᑦ ᐊᒻᒪ ᐊᓯᙵᓐᓄᑦ ᐱᖃᖃᑕᐅᔪᓄᑦ. ᐱᔾᔪᑕᐅᔪᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓵᔪᕋᕐᓛᖅᑐᓄᑦ ᐃᓕᑕᕆᔭᐅᓚᐅᖅᑐᑦ ᐅᖃᖃᑎᖃᑦᑕᐅᑎᓂᒃᑯᑦ, ᐊᒻᒪ ᐱᓕᕆᖃᑎᖃᕐᓂᒃᑯᑦ ᐊᕼᐅᒃᑯᑦ ᐋᕿᒃᑕᕐᒐᒍᑦ. ᐱᔾᔪᑕᐅᔪᓂᑦ ᐃᓚᐅᔪᑦ ᐃᓱᒫᓘᑎ ᓂᐱᖃᕐᓂᖅᓴᐅᓕᕐᓂᕐᒧᑦ ᐊᒻᒪ ᐊᒃᑐᖅᓯᓂᖅ ᐱᓕᕆᐊᑉ ᖃᓄᐃᓕᐅᕐᓂᕆᔭᕆᓐᓄᑦ ᓂᐱᖃᕐᓂᖅ ᖃᒪᓂᑦᑐᐊᕐᒥᑦ. ᐱᑐᐊᖅᑐᒥᑦ, ᐅᑯᐊ ᐃᓕᑕᕆᔭᐅᔪᑦ:

- ᐃᓱᒫᓘᑏᑦ ᐅᖃᐅᓯᐅᓚᐅᖅᑐᑦ ᐱᕙᓪᓕᐊᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓂᕐᒥᒃ ᓂᐱᖃᕐᓂᕐᒥᒃ ᐊᒻᒪ ᓵᔪᕋᕐᓛᖅᑐᓂᒃ ᐊᒃᑐᖅᓯᓂᐅᔪᑦ ᐱᓕᕆᐊᒥᙳᕕᖅᑐᓂᒃ ᐊᒻᒪ ᖃᐅᔨᓴᐃᓃᑦ ᑕᒪᒃᑯᓄᙵ ᐱᐊᓂᓚᐅᖅᑐᑦ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᖃᓄᐃᙱᓕᖅᑎᑦᑎᓂᐅᑐᐃᓐᓇᕆᐊᓕᕐᓄᑦ (EN-KIV OH 2009[10]; EN-CH NIRB 2010[11]; EN-CI NIRB 2010[12]; EN-RB NIRB 2010[13]; EN-AR OH 2012[14]);

- ᐃᓱᒫᓘᑕᐅᓚᐅᖅᑐᖅ ᓂᐱᖃᕐᓂᕐᒧᑦ ᒪᓕᒐᖅᑕᖃᙱᑐᐊᕐᓂᙱᓂᒃ ᓄᓇᕗᒻᒥᑦ (EN-BL NIRB 2010[15]); ᐊᒻᒪ

- ᖁᓕᒥᒎᓕᕐᓂᑦ ᓂᐱᖃᕐᓂᖅ ᐃᓕᑕᕆᔭᐅᓚᐅᖅᑐᖅ ᐃᓱᒫᓘᑕᐅᓂᕐᒧᑦ, ᐱᑐᐊᖅᑐᒥᑦ ᐊᓯᙵᑦ ᖁᓕᒥᒎᓖᑦ ᐃᙵᕋᔭᖃᑕᐅᑎᓪᓗᒋᑦ ᖃᒪᓂᑦᑐᐊᕐᒥᑦ (EN-BL EL 2012[16]; EN-BL CLC 2013[17]).

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[10] EN-KIV OH 2009: ᐃᓱᒫᓗᑎ ᐊᕙᑎᒧᑦ ᖃᓄᐃᙱᓕᖅᑎᑦᑎᓂᖅ ᖃᐅᔨᓴᖅᑕᐅᓂᐊᕐᒪᙶᑦ ᐊᒻᒪ ᖃᓄᖅ.

[11] EN-CH NIRB 2010: ᐃᓄᐃᑦ ᐱᓕᕆᑎᑕᐅᕐᑯᔭᙱᑦ ᑮᓇᐅᔭᓕᐅᕐᓗᑎᒡᓗ, ᐊᒻᒪ ᐊᕙᑎ ᒥᐊᓂᕆᔭᐅᔭᕆᐊᓗᓂᑦᑕᐅᖅ.

[12] EN-CI NIRB 2010: ᐃᒡᓗᓕᒎᕐᔪᒃ ᐊᒃᑐᖅᑕᐅᓂᖃᕐᓂᐊᖅᑐᖅ ᐱᓕᕆᐊᒧᑦ ᐊᐅᓚᖅᑎᓂᕐᒧᑦ ᐊᑉᕐᑯᑕᐅᔪᓄᑦ... ᓂᐱᖃᕐᓂᖅ ᐃᓱᒫᓗᑕᐅᔪᖅ.

[13] EN-RB NIRB 2010: ᐃᓱᒫᓗᑎ ᑭᑐᑦ ᖃᐅᔨᓴᐃᓂᖃᕐᓂᐊᕐᒪᙶᑕ ᐊᒻᒪ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒥᒃ. ᐱᒻᒪᕆᐅᔪᖅ ᖃᐅᔨᓴᐃᓂᖅ ᐱᐊᓂᒃᑕᐅᓂᖓ ᐅᔭᕋᙱᓂᐊᖅᑐᓕᕆᓂᖅ ᐊᐅᓛᓕᕐᓂᐊᖅᐸᖅᑎᓪᓗᒍ.

[14] EN-AR OH 2012: ᐊᒃᑐᖅᓯᓃᑦ ᐊᕙᑎᒧᑦ ᐊᖏᓂᐊᖅᐸᑦ ᐊᐅᓛᖅᑎᓪᓗᒍ? ᖃᓄᐃᙱᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐅᑎᕈᙵᕐᓂᐊᖅᐸᑦ ᐊᐅᓛᕐᓂᖅ ᓄᖅᑲᖅᐸᑦ?

[15] EN-BL NIRB 2010: ᒪᓕᒐᒃ ᑕᑯᔪᒪᔪᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ, ᓯᓚᒨᖅᑐᓄᑦ, ᑕᒪᒃᑯᓐᓇᒐᕋᓗᒃ ᐱᓕᕆᐊᖅ ᑲᔪᓯᓂᐊᕐᕕᖅᑎᓪᓗᒍ ᕿᓂᖅᓴᐃᓂᖅᑕᖃᕐᓂᐊᕐᕕᖅᑎᓪᓗᒎᓃᑦ.

[16] EN-BL EL 2012: ᖁᓕᒥᒎᓖᑦ ᓂᐱᖁᖅᑐᔪᒪᓕᐊᓗᐃᑦ ᖃᐅᑖᓪᑦ ᐅᐱᕐᙶᖁᑦ ᐊᒻᒪ ᐊᐅᔭᒃᑯᑦ.

[17] EN-BL CLC 2013: ᐊᕼᐅᒃᑯᑦ ᖁᓕᒥᒎᓕᕆᑐᐃᓐᓇᐅᕆᑦᑐᑦ ᑭᓯᐊᓂ ᐊᒥᓱᑦ ᐊᓯᙵᑦ ᑲᒡᐸᓂᐅᔪᑦ ᖁᓕᒥᒎᓕᕆᑦ.

ᐅᕐᑲᐅᓯᐅᔪᑦ ᐃᓱᒫᓅᑏᓪᓗ ᐃᓄᖕᓄᑦ ᐊᓯᖏᓐᓄᓪᓗ ᐱᖃᖃᑕᐅᔪᓄᑦ ᑲᑎᑕᐅᓚᐅᖅᑐᑦ ᐊᖏᓂᖅᓴᒧᑦ ᖃᐅᔨᓴᐃᓂᕐᒧᑦ ᐊᒻᒪ ᐅᕐᑲᐅᓯᐅᕐᑲᑦᑕᖅᑰᑎᒃ ᐅᓂᑳᑉ ᐃᓗᐊᓂᑦ. ᐊᒥᓱᑦ ᐅᕐᑲᐅᓯᐅᔪᑦ ᐱᓕᕆᐊᖑᓚᐅᖅᑐᑦ NIRB-ᑯᑦ “ᒪᓕᒃᑕᐅᔪᒃᓴᖏᑦ ᐸᕐᓇᐃᓂᕐᒧᑦ ᐊᕙᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᒥᑦ ᐊᓈᕆᒃᑯᑦ ᑭᒡᒐᖁᒃ ᐱᓕᕆᐊᖑᓐᓄᑦ (NIRB ᑎᑎᖅᑲᐅᑉ ᓈᓴᐅᑎᖓ 09MN003)” (NIRB 2011), ᐃᓚᐅᑉᓗᓂ ᐃᓕᑕᖅᓯᓂᖅ ᐱᒻᒪᕆᐅᔪᓂᒃ ᐱᕈᖅᑐᐃᑦ ᐃᓚᖏᑦ (VECs) ᐊᒻᒪ ᐱᔾᔪᑕᐅᔪᑦ ᐃᓱᒪᒋᔭᐅᕐᑲᑕᐅᔭᕆᐊᕐᑲᖅᑐᑦ ᐊᕙᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᒥᑦ (EIS)-ᒥᑦ. ᐆᒃᑐᑎᒋᓗᒍ, ᒪᒃᑯᒃᑐᑦ ᐃᓐᓇᒃᓴᔭᐃᑦ “.... ᐅᒃᐱᕆᓱᒃᑐᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᕐᑲᐅᔨᓴᐃᓂᖅ ᐃᓱᒪᒋᔭᐅᔭᕆᐊᕐᑲᖅᑐᖅ ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᑐᐃᓐᓇᕆᐊᓖᑦ ᐱᓕᕆᐊᒥᑦ ᐅᑭᐅᑉ ᐃᓗᐊᓂᓗᒃᑖᖅ....” (IQ-RIYA 2009[18]).

ᓄᓇᕗᒻᒥ ᐊᕙᑎᓕᕆᔨᒃᑯᑦ ᐊᕙᑎᒥᒃ ᒥᐊᓂᖅᓯᓂᕐᒧᑦ ᒪᓕᒐᕐᑲᖅᑐᑦ ᕐᑲᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᐊᒃᑐᖅᓯᓂᕐᑲᑐᐃᓐᓇᕆᐊᓕᖕᓄᑦ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᓄᑦ (ᐱᕐᑯᔭᑎᒍᑦ) ᒫᓐᓇᐅᔪᖅ ᐊᕙᑎᒧᑦ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᓴᔪᕋᓛᕐᓂᕐᒧᓪᓗ ᒪᓕᒐᖅᑕᕐᑲᙱᑦᑐᖅ, ᒪᓕᒃᑕᐅᔪᒃᓴᓅᖓᔪᑦ ᑕᐃᒪᙵᖅᑎᑕᐅᓚᐅᖅᑐᑦ ᓄᓇᕗᒻᒥᑦ. ᒪᓕᒐᖅᑕᕐᑲᙱᑎᓪᓗᒍ ᓄᓇᕗᒻᒥ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᓴᔪᕋᓛᖅᑐᓄᓪᓗ, ᑲᓇᑕᒥᑦ, ᓄᓇᓕᖕᓂᑦ ᐊᕕᒃᑐᖅᓯᒪᔪᓂᑦ ᐊᒻᒪ ᓄᓇᕐᔪᐊᕐᒥᑦ ᐊᑐᖅᑕᐅᔪᑦ ᒪᓕᒃᑕᐅᔪᒃᓴᐃᓪᓗ ᐊᑐᖅᑕᐅᓚᐅᖅᑐᑦ ᕐᑲᐅᔨᓴᐃᓂᕐᒧᑦ ᐃᓄᐃᑦ ᐋᓐᓂᐊᕐᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓄᑦ.

ᒫᓐᓇᐅᔪᖅ ᐊᕙᑎ

ᓇᓗᓇᐃᔭᐃᔭᕋᓱᒡᓗᒍ ᒫᓐᓇᐅᔪᖅ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᐊᕙᑎ ᐱᓕᕆᐊᑉ ᐃᓂᖓᓂᑦ, ᕐᑲᐅᔨᓴᐃᓂᖅ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᕐᑲᐅᔨᒋᐊᕐᑲᑦᑕᕐᓂᖓᑦ ᐊᓈᕆᒃᑯᑦ McClean ᑕᓯᕐᒥᑦ ᐊᐅᓚᓐᓂᖓᑦ ᐊᒻᒪ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᓴᔪᕋᓛᖅᑐᓄᓪᓗ ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓄᑦ ᕐᑲᐅᔨᓴᐃᓃᑦ ᑐᓂᔭᐅᔪᑦ NIRB-ᑯᓐᓄᑦ ᐱᐊᓂᒃᑕᐅᓚᐅᖅᑐᖅ ᐃᓕᑕᖅᓯᓂᕐᒥᑦ ᑭᒡᓕᒋᔭᐅᔪᑦ ᓇᓐᓂᖕᒋᓐᓄᑦ. ᐃᓱᒪᒋᐸᓗᒋᑦ ᑖᒃᐸᒃᑯᐊ ᑐᑭᓯᐅᒪᔾᔪᐃᓐᑦ, Leq (ᐅᒻᒪᖅᑯᑎᑑᖅᑐᖅ ᓂᐱᐅᑉ ᓇᓐᓂᓕᔾᖓ) 35-ᓂᒃ dBA ᓂᕈᐊᖅᑕᐅᓚᐅᖅᑐᖅ ᐅᐸᓗᒃᑯᒧᑦ (16-ᓄᑦ ᐃᑲᕐᕋᓄᑦ), ᐅᓐᓄᒃᑯᑦ (8-ᓄᑦ ᐃᑲᕐᕋᓄᑦ) ᐊᒻᒪ 24-ᓄᑦ ᐃᑲᕐᕋᓄᑦ ᓂᐱᕐᑲᕐᓂᐅᑉ ᓇᓐᓂᖓᓄᑦ. Leq of 35 dBA ᐊᑐᖅᑕᐅᓚᐅᖅᑐᖅ ᑭᒡᓕᐅᔪᒧᑦ ᓈᓴᐅᑎᒧᑦ ᕐᑲᐅᔨᓴᐃᓂᕐᒧᑦ ᐊᓯᐊᖑᕐᓂᐅᔾᖓᖅᑐᓄᑦ ᓂᐱᕐᑲᕐᓂᐅᑉ ᓇᓐᓂᓕᔾᖓᓄᑦ ᐱᓕᕆᐊᒥᑦ ᕐᑲᓄᐃᓕᐅᕐᓂᖏᓐᓄᑦ. ᑐᑭᓯᐅᒪᔾᔪᑎᓂᒃ ᐱᑕᕐᑲᙱᑦᑐᖅ ᑭᒡᓕᓕᐅᓕᓂᕐᒧᑦ ᓴᔪᕋᓛᖅᑐᓄᑦ ᐱᓕᕆᐊᑉ ᐃᓂᖓᓄᑦ. ᓂᓕᐅᑎᔭᐅᔪᖅ ᓴᔪᕋᓛᕐᓂᕐᒧᑦ ᓇᓐᓂᐅᔪᑦ ᐅᔾᔨᕐᓇᙱᓐᓂᖏᓐᓄᑦ (ᓲᕐᓗ, ᒥᑭᓂᖅᓴᖅ 0.1 mm/s-ᒥᐊᖓᓂᑦ).

ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓈᑦ ᐱᓕᕆᐊᒨᖓᔪᓂᒃ ᕐᑲᓄᐃᓕᐅᕐᓂᐅᔪᓂᒃ ᓂᐱᕐᑲᕐᓂᖅ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᑦ

ᐱᓕᕆᐊᖅ ᓇᓐᓂᓗᒃᑖᖏᓐᓂᑦ (ᓴᓇᔭᐅᑎᓪᓗᒍ, ᐊᐅᓚᖅᑎᓪᓗᒍ, ᑭᖑᓪᓕᖅᐹᒃᑯᑦ ᐅᒃᑯᐊᖅᑎᓪᓗᒍ ᐊᒻᒪ ᐅᒃᑯᐊᖅᓯᒪᓕᖅᑎᓪᓗᒍ), ᕐᑲᓄᐃᓕᐅᕐᓂᐅᔪᖅᑕᕐᑲᕐᓂᐊᖅᑐᖅ ᐊᖏᓪᓕᒋᐊᖅᑎᑦᑎᔾᖓᖅᑐᓂᒃ ᓂᐱᕐᑲᕐᓂᐅᑉ ᓴᔪᕋᓛᕐᓂᐅᑉᓗ ᓇᓐᓂᓕᔾᖏᓐᓄᑦ ᕐᑲᓂᑦᑐᒥᑦ ᐊᒻᒪ ᐅᖓᓯᖕᓂᖅᓴᒥᑦ. ᓇᐃᓈᖅᓯᒪᔪᖅ ᐱᓕᕆᐊᒧᑦ ᕐᑲᓄᐃᓕᐅᕐᓂᐅᔪᓄᑦ ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓂᕐᑲᑐᐃᓐᓇᕆᐊᕐᑲᖅᑐᑦ ᓂᐱᕐᑲᕐᓂᕐᒧᑦ ᓴᔪᕋᓛᕐᓂᕐᒧᓪᓗ ᐊᑖᓃᖅᑐᖅ.

18 IQ-RIYA 2009: ᒪᒃᑯᒃᑐᑦ ᐃᓐᓇᒃᓴᔭᐃᑦ ᑐᓴᖅᓯᒪᔪᑦ ᓱᕐᑲᓯᒪᓂᖓ ᐊᕙᑎᐅᑉ ᐅᔭᕋᖕᓂᐊᖅᑐᓕᕆᓂᐅᔪᓂᑦ, ᐊᒻᒪ ᐅᒃᐱᕆᓱᒃᑐᑦ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᕐᑲᐅᔨᓴᐃᓂᖅ ᐃᓱᒪᔭᕆᐊᕐᑲᕐᓂᖓᓂᒃ ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔾᖓᖅᑐᓂᒃ ᐱᓕᕆᐊᒥᑦ ᐅᑭᐅᓗᒃᑖᒧᑦ, ᐱᓕᕆᐊᖑᖅᑲᐅᑕᐅᔭᕆᐊᕐᑲᕐᓂᖓᓗ ᕐᑲᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐱᓕᕆᐊᒥᑦ ᑐᒃᑐᐃᑦ ᓅᓐᓂᕐᒧᑦ ᐊᑦᕐᑯᑎᒋᔭᕆᐊᖓᓄᑦ.

ᓴᓇᔭᐅᓂᖅ/ᑭᖑᓪᓕᖅᐹᒃᑯᑦ ᐅᑯᐊᕐᓂᖓ

ᐊᕙᑎᒥᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᑐᐃᓐᓇᕆᐊᖃᖅᑐᑦ ᐊᒃᑐᐊᓂᖃᖅᑐᑦ ᐃᒪᕐᒥᑦ ᓄᓇᒥᓪᓗ ᓴᓇᕙᓪᓕᐊᓂᖅ ᐊᒻᒪ ᐃᑲᔪᐃᓂᖃᖅᑐᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᓂᒃ ᐊᖏᒃᓕᒋᐊᖅᑎᑦᑎᔾᔪᓇᖅᑐᑦ ᓂᐱᐅᑉ ᓇᓐᓂᓈᔾᔨᓐᓂᒃ ᐃᓚᐅᔪᑦ:

- ᓯᓚᒥᑦ ᓂᐱᖃᐃᓐᓇᐅᔭᕐᓂᖅ ᓄᓇᒃᑰᕈᑎᕝᔪᐊᑦ ᐊᑐᖅᑕᐅᑎᓪᓗᒋᑦ ᐃᓂᒃᓴᓕᐅᓇᑎᓪᓗᒋᑦ ᐊᒻᒪ ᐊᑐᕈᙵᖅᑎᑦᑎᕙᓪᓕᐊᑎᓪᓗᒋᑦ, ᐃᓗᑦᑐᖅᑎᖅᓯᒪᔪᓂᒃ ᐊᐅᓛᖅᑎᑦᑎᓂᖅ ᓴᓇᔭᐅᓂᖓᓗ ᓯᖃᓪᓕᑎᓇᖁᒃᓴᖅ;
- ᓯᓚᒥᑦ ᓂᐱᖃᕐᓂᖅ ᖃᖓᑕᑉᓗᑎᒃ ᐃᖏᕐᕋᓂᒃᑯᑦ ᓄᓇᒃᑰᕈᑎᒃᑯᑦ (ᖂᕐᓗ, ᐃᒡᓗᕝᔪᐊᑦ ᑐᙵᕗᒃᓴᖏᑦ); ᐊᒻᒪ
- ᓂᐱᖃᐃᓐᓇᐅᔭᕐᓂᖅ ᓄᓇᒥᑦ ᖄᖅᑎᓇᓂᕐᒧᑦ.

ᐊᐅᓛᕐᓂᖅ

ᐊᕙᑎᒥᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᑐᐃᓐᓇᕆᐊᖃᖅᑐᑦ ᐊᒃᑐᐊᓂᖃᖅᑐᑦ ᐅᔭᕋᙱᐊᕐᓂᕐᒧᑦ, ᓯᖃᓪᓕᑎᓇᓂᕐᒧᑦ, ᕿᒪᒃᑎᑦᑐᓕᓇᓂᕐᒧᑦ, ᐃᒪᓕᓇᓂᕐᒧᑦ, ᐊᒃᑕᑯᓕᓇᓂᕐᒧᑦ, ᐱᔨᑦᑎᕋᐃᓂᕐᒧᑦ, ᐃᖏᕐᕋᔪᓕᓇᓂᕐᒧᑦ, ᐊᒻᒪ ᕿᓂᖅᓴᐃᖏᓐᓇᐅᔭᕐᓂᕐᒧᑦ ᐊᖏᒃᓕᒋᐊᖅᑎᑦᑎᔾᔪᓇᖅᑐᑦ ᓂᐲᑦ ᓇᓐᓂᓈᔾᔨᓐᓄᑦ ᐃᓚᐅᔪᑦ:

- ᑲᔪᓯᔪᒥᒃ ᓯᓚᒥᑦ ᓂᐱᖃᐃᓐᓇᐅᔭᕐᓂᖅ ᓄᓇᒃᑰᕈᑎᕝᔪᐊᑦ ᐊᑐᖅᑕᐅᑎᓪᓗᒋᑦ ᐅᒃᑯᐃᖓᔪᓄᑦ ᒪᓂᖅᑲᒥᑦ ᐅᔭᕋᙱᐊᖅᑐᓕᓇᓂᕐᒧᑦ,
- ᑲᔪᓯᔪᒥᒃ ᓯᓚᒥᑦ ᓂᐱᖃᐃᓐᓇᐅᔭᕐᓂᖅ ᓯᖃᓪᓕᑎᓇᓂᕐᒧᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᓯᖃᓪᓕᑎᓇᓂᕐᒨᖓᔪᓗᒃᑖᑦ;
- ᑲᔪᓯᔪᒥᒃ ᓯᓚᒥᑦ ᓂᐱᖃᐃᓐᓇᐅᔭᕐᓂᖅ ᐃᒃᓴᕝᕕᖓᓐᒧᑦ ᑐᖅᑯᖅᓯᓯᒪᕗᕕᖓᓐᒧᓪᓗ ᐊᐅᓛᕐᓂᕐᒧᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᐅᓯᖏᔭᐃᓃᑦ ᐊᒻᒪ ᓄᓇᒃᑰᕈᑎᕝᔪᐊᑦ ᐊᑐᖅᑕᐅᓂᖏᑦ;
- ᓯᓚᒥᑦ ᓂᐱᖃᐃᓐᓇᐅᔭᕐᓂᖅ ᓄᓇᒃᑰᕈᑏᑦ ᐃᖏᕐᕋᔭᕐᓂᖏᓐᓄᑦ (ᐊᑦᕐᑯᑎᓂᑦ), ᖃᖓᑕᔭᒃᑐᓄᑦ ᐊᒻᒪ ᕿᓂᖅᓴᐃᓂᕐᒧᑦ ᐃᑰᑕᕐᓂᕐᓄᑦ; ᐊᒻᒪ
- ᓄᓇᒥᑦ ᓂᐱᖃᐃᓇᐅᔭᕐᓂᖅ ᖄᖅᑎᓇᓂᕐᒧᑦ.

ᐊᖏᓗᐊᖏᒋᐊᖅᑎᑦᑎᓂᖅ ᐊᒻᒪ ᐱᓕᕆᐊᑉ ᖃᓄᐃᙶᓂᖓ

ᐱᓕᕆᐊᖅ ᐊᑐᕐᓂᐊᖅᑐᖅ ᐊᑐᖅᑕᐅᕙᒃᑐᓂᒃ ᐊᐅᓛᕐᓂᕐᒧᑦ ᒪᓕᒃᑕᐅᖃᑦᑕᖅᑐᓂᒃ ᒪᓕᒡᓗᒋᑦ ᐃᑯᒪᓕᓇᓂᕐᒧᑦ ᐊᑐᖅᑕᐅᖃᑦᑕᖅᑐᑦ ᐅᕙᓘᓐᑦ ᐱᖁᔭᐅᓂᕐᒋᑦᑎᒍᑦ ᐱᖁᑎᑖᕝᕕᐅᖃᑦᑕᖅᑐᓄᑦ ᑕᒪᒃᑯᐊ ᐃᑯᒪᖃᖅᑐᑦ ᐊᐅᓛᑦᑎᐊᕐᒋᓇᖅᑑᖁᐸᓗᒋᑦ. ᐊᒻᒪ, ᐱᓕᕆᐊᒨᕐᒐᔪᖅ ᒪᓕᖃᑦᑕᕐᓂᐊᖅᑐᖅ ᖃᓄᐃᓕᐅᕆᐊᖃᖁᔭᐅᓂᐅᔪᓂᒃ ᐱᔪᕐᓇᖅᑎᑕᐅᓂᕐᒧᑦ (permits) >ᒥᑦᓃᑐᓗᒃᑖᓂᑦ, ᐱᒋᐊᕈᕐᓇᖅᑎᑕᐅᓂᑦ ᐊᒻᒪ/ᐅᕙᓘᓐᑦ ᓈᒻᒪᒋᔭᐅᓂᒃᑯᑦ. ᒪᓕᒃᑕᐅᔭᓇᐊᖅᑐᓂᒃ ᓴᖅᑭᑎᓂᐊᕐᒥᔪᑦ ᐱᓕᕆᐊᓇᓂᐊᕐᓗᒋᑦ ᓄᓇᓕᖕᒥᑦ ᐅᖃᐅᓯᐅᔪᑦ.

ᕿᒪᒃᑎᑦᑐᑦ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓃᑦ ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᑦ

ᓴᓇᔭᐅᑎᓪᓗᒍ/ᐊᐅᓛᕐᓂᖅ/ᑭᖑᓪᓕᖅᐹᒃᑯᑦ ᐅᒃᑯᐊᕐᓂᖅ

ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᑦ ᐃᓕᑕᓇᔭᐅᔪᑦ VEC-ᑐᑦ ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᑦ ᐱᓕᕆᐊᒥᙵᖅᑐᓄᑦ ᐃᓄᐃᑦ ᐋᓐᓂᐊᖃᖅᑕᐃᓕᒪᓂᕐᓂᐊᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᖃᒪᓂᑦᑐᐊᕐᒥᑦ ᐊᒻᒪ

ᒪᖅᑲᐃᑦᑕᕆᐅᔭᓂᑦ ᓄᓇᓕᐊᓛᓂᑦ ᐅᔾᕋᓐᓂᐊᕿᓕᐅᖅᑕᐅᕝᓪᓕᐊᔪᑉ ᓯᓚᑖᓂᑦ. ᐃᓄᐃᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔭᓂᑦ ᐃᓚᐅᔪᑦ ᐊᓯᐊᒍᕐᓃᑦ ᐃᓄᐃᓂᖓ ᐊᒻᒪ ᓯᓂᖕᓂᖏᓐᓄᑦ. ᓇᓚᐅᑖᖅᑕᐅᔪᖅ ᕿᒪᒃᑎᑦᑐᓄᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓃᑦ ᐊᖏᕐᔫᖏᓐᓇᓯᒋᔭᐅᔪᑦ. ᐆᒃᑐᕋᖅᑕᐅᔪᖕᓇᖅᑐᑦ ᐊᓯᐊᖑᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᑦ ᓂᐱᖃᕐᓂᐅᑉ ᓇᓅᓐᓂᓇᔾᖓᓄᑦ ᐅᖃᐅᓯᐅᓚᐅᖅᑐᑦ ᖃᒪᓂᑦᑐᐊᕐᒥᑦ ᐊᑯᓂᐅᖏᑦᑐᖅ ᓴᓇᔪᖃᖅᑎᓪᓗᒍ ᐊᒻᒪ ᐊᐅᓛᕐᓂᖃᖅᑎᓪᓗᒍ ᐃᒃᓴᕿᖏᒥᑦ ᑐᖅᑯᖅᓯᓯᒪᕚᖏᒥᓗ. ᑭᓯᐊᓂ, ᓇᓚᐅᑖᖅᑕᐅᔪᓗᒃᑖᑦ ᐱᔪᓄᑦ ᓂᐱᖃᕐᓂᕐᒥᒃ ᓇᓈᓐᓂᓇᔾᖓᓂᒃ ᓴᓇᔭᐅᑎᓪᓗᒍ, ᐊᐅᓛᖅᑎᓪᓗᒍ ᑮᒍᓪᓕᖅᐹᒃᑯᑦ ᐅᒃᑯᐊᖅᑎᓪᓗᒍ ᐊᑦᑎᖕᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓄᑦ (50 dBA ᐅᐸᓗᒃᑯᑦ ᐊᒻᒪ 45 dBA ᐅᓐᓄᒃᑯᑦ), ᐊᒻᒪ ᐊᒥᓱᑦ ᐊᑦᑎᖕᓂᖅᓴᐅᐸᓗᑎᒃ ᓈᓴᐅᑎᒥᒃ ᐱᔪᓄᑦ (ᓲᕐᓗ, ᑑᓴᐅᓇᔮᖅᑎᑦᑐᖅ ᐅᖓᓯᒃᑐᒥᑦ ᓂᐱᖃᕐᓂᖅ). ᓂᕆᐅᒋᔭᐅᔪᑦ ᐊᓯᐊᖑᕐᓂᐅᔪᑦ ᓄᓇᓕᖕᒥᑦ ᐃᓄᐃᓵᕆᓂᖅ (ᖁᑦᑎᒃᑐᖅ ᐃᓄᐃᓗᑕᖅ) ᐊᑦᑎᒃᑑᓚᐅᕐᒥᔪᖅ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓄᑦ (6.5%) ᐱᔪᓗᒃᑖᓄᑦ ᖃᐅᔨᓴᖅᑕᐅᔪᓂᑦ ᐊᒻᒪ ᐃᓱᒪᒋᔭᐅᐸᓗᓂ ᐃᓱᒪᒋᔭᒃᓴᐅᖏᓐᓂᖓᓄᑦ ᑕᒪᐃᓂᓗᒃᑖᖅ ᐱᓕᕆᐊᑉ ᐊᐅᓛᕐᓂᕆᔭᖓᓂᑦ. ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᓄᓇᒥᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓅᓐᓂᐅᔪᓄᑦ ᖄᖅᑎᕆᓂᕐᒧᑦ ᐊᑦᑎᒃᑑᓂᐊᕐᓂᖓᓄᑦ (120 dB) ᖃᓂᓛᒥᑦ ᐱᔪᒧᑦ. ᐊᔾᔨᐸᓗᖓ, ᓂᕆᐅᒋᔭᐅᔪᖅ ᕿᒪᒃᑎᑦᑐᓄᑦ ᓴᔪᕋᓛᖅᑐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᕐᓄᑦ ᐊᖏᓗᐊᔾᔫᖏᓐᓇᓯᒋᔭᐅᔪᖅ. ᑕᒪᐃᓂᓗᒃᑖᖅ, ᓇᓚᐅᑖᖅᑕᐅᔪᑦ ᓴᔪᕋᓛᖅᑐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᕐᓄᑦ ᓇᓅᓐᓂᐅᔪᑦ ᐊᑦᑎᒃᑑᓚᐅᖅᑐᑦ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓄᑦ ᐊᒻᒪ ᐊᑦᑎᖕᓂᖅᓴᐅᐸᓗᓂ ᓈᓴᐅᑎᓄᑦ ᐱᔪᓄᑦ ᑕᒪᐃᓂᑦ ᐱᔪᑦ ᐃᓂᖏᓐᓄᑦ.

ᕿᒪᒃᑎᑦᑐᑦ ᑲᑎᑉᐸᓪᓕᐊᓂᕐᒧᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓃᑦ

ᑎᑎᕋᖅᓯᒪᔪᑦ ᓯᕗᓂᕐᒥᑦ ᐱᓕᕆᐊᒃᓴᓄᑦ ᐊᑕᐅᑎᒃᑰᕐᓂᖅᑲᕈᖕᓇᖅᑐᑦ ᐱᓕᕆᐊᒧᑦ ᕿᒥᕐᕈᔭᐅᓚᐅᖅᑐᖅ ᑲᑎᑉᐸᓪᓕᐊᓂᕐᒧᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓄᑦ ᐃᓕᑕᕆᔭᐅᔪᓄᑦ ᕿᒪᒃᑎᑦᑐᓄᑦ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᕐᓄᑦ. ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᓄᓪᓗ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓃᑦ ᖃᓂᑦᑐᕝᒪᔪᒃᑐᑦ ᐱᓕᕆᐊᑉ ᐊᒻᒪ ᐱᑕᖃᕈᓐᓂᑲᐅᑎᕆᐸᓗᑎᒃ ᐅᖓᓯᒃᓯᔭᕌᖓᑕ. ᐱᓕᕆᐊᑉ ᐃᓂᖓ ᐊᒻᒪ ᐱᓕᕆᐊᒥᑦ ᖃᓄᐃᓕᐅᕈᑕᐅᔪᒪᔪᑦ RAA-ᒥᑦ ᓂᕆᐅᒋᔭᐅᔪᑦ ᓈᒻᒪᒃᑐᒥᒃ ᐅᖓᓯᖕᓂᖅᑲᕐᓂᐊᕐᓂᖕᒋᓐᓄᑦ ᑕᐃᒪᓐᓇᒧᑦ ᑲᑎᑉᐸᓪᓕᐊᔪᓂᒃ ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᓄᓪᓗ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᓈᒻᒪᒃᑐᖅ.

ᐊᖏᓗᐊᖏᒋᐊᖅᑎᑦᑎᓂᕈᖓᔪᑦ

ᓇᓚᐅᑖᖅᑕᐅᔪᓂᒃ ᐃᓄᐃᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᖅᑕᖅᑲᖏᓐᓂᖓᓄᑦ ᐱᓕᕆᐊᒥᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᓄᑦ ᐊᖏᓗᐊᖏᒋᐊᖅᑎᑦᑎᓃᑦ ᐊᑐᖅᑕᐅᔭᕆᐊᖃᖏᑦᑐᑦ.

ᖃᐅᔨᒋᐊᖃᑦᑕᕐᑯᔭᐅᓂᖅ

ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ ᐅᔾᔨᕐᓇᖏᓐᓂᖏᓐᓄᑦ ᐊᒻᒪ ᐃᓄᐃᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᖏᓐᓂᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᖅᑳᖏᓐᓂᖏᓐᓄᑦ, ᖃᐅᔨᒋᐊᖅᑲᑦᑕᕐᓂᖏᑦ ᑐᕌᖓᔪᓂᒃ ᐱᑦᑲᓇᐊᖅᑲᖏᑦᑐᖅ. ᑭᓯᐊᓂ, ᐃᓄᐃᑦ ᐋᓐᓂᐊᖅᑲᖅᑕᐃᓕᒪᓂᖏᓐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐱᔾᔪᑎᖅᑲᖅᑐᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᒻᒪ ᓴᔪᕋᓛᖅᑐᓄᑦ ᖃᐅᔨᒋᐊᖅᑕᐅᖃᑦᑕᕐᓂᐊᖅᑐᖅ ᐊᑐᕐᓗᓂ ᐅᖃᐅᓯᐅᔪᓂᒃ/ᑭᐅᔾᔪᑕᐅᔪᓂᒃ. ᓄᓇᓕᒃ ᐃᓱᒫᓘᑎᒥᒃ ᓴᖅᑭᑦᑎᒃᐸᑕ ᖃᐅᔨᒋᐊᑲᓐᓂᕐᓂᖅ ᖃᐅᔨᓴᖅᑕᐅᑲᓐᓂᕐᓂᐊᖅᑐᖅ.

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Attachments

1 Introduction – Noise and Vibration

1.1 Background

The Kiggavik Project (Project) is a proposed uranium ore mining and milling operation located in the Kivalliq region of Nunavut approximately 80 km west of the community of Baker Lake (Figure 1.1-1). The Project is operated by AREVA Resources Canada Inc. (AREVA), in joint venture partnership with JCU (Canada) Exploration Co., Ltd. and Daewoo International Corp.

Within the Kiggavik Project there are two general site areas referred to herein as the Kiggavik site and the Sissons site. The two sites are located approximately 17 km apart. Three uranium ore deposits will be mined at the Kiggavik site: East Zone, Centre Zone and Main Zone. A uranium mill, related facilities, main accommodations, and landing strip will also be located at the Kiggavik site. The Sissons site has two uranium ore deposits to be mined: Andrew Lake and End Grid. Open pit mining will be used to extract the ore from the three Kiggavik deposits as well as the Andrew Lake deposit. Mining of End Grid ore will require underground methods.

All ore extracted from the mine sites will be processed through the Kiggavik mill. Mined out pits at the Kiggavik site will sequentially be used as tailings management facilities (TMFs) with East Zone being the initial TMF. The uranium product will be packaged and transported via aircraft to southern transportation networks. Initially, mill reagents, fuel and other supplies will be transported by barge to Baker Lake and then by truck to the mine site over a winter access road. An all-season road between Baker Lake and the Kiggavik Site is carried as a secondary option proposed as a contingency in case the winter road cannot adequately support the Project over its life-span.

Decommissioning of the Project will include demolition of site facilities, clean up and reclamation of any disturbed areas, closure of the TMFs and reclamation of mine rock piles to promote vegetative growth and to provide wildlife access.

Projection: NAD 1983 UTM Zone 14N
Creator: CDC
Date: 8/21/2014 Scale: 1:16,000,000
File:
Data Sources: *Natural Resources Canada, Geobase®, Nation Topographic Database, Geological Survey of Canada, AREVA Resources Canada Inc.*

FIGURE 1.1-1
GENERAL LOCATION OF PROPOSED KIGGAVIK PROJECT IN CANADA

ENVIRONMENTAL IMPACT STATEMENT VOLUME 4

Kiggavik Project

AREVA

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

The Kiggavik Project is subject to the environmental review and related licensing and permitting processes established by the Nunavut Land Claims Agreement (NLCA) (NIRB [Nunavut Impact Review Board] 2011), and to the licensing requirements of the Canadian Nuclear Safety Commission (CNSC). The Minister of Indian and Northern Affairs Canada (now Aboriginal Affairs and Northern Development Canada; AANDC) referred the Kiggavik Project to the NIRB for a Review under Part 5 of Article 12 of the NLCA in March of 2010.

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. AREVA submitted the Draft Environmental Impact Statement in December 2011 and again in April 2012 with the NIRB determining that the submission successfully conformed to the EIS guidelines in May 2012. Two review periods followed with the Information Request stage completed in January 2013 and the Technical Review stage completed in May 2013. An in-person technical meeting was hosted in Rankin Inlet, Nunavut by the NIRB in May 2013 with a Community Roundtable and a Pre-Hearing Conference (PHC) hosted in Baker Lake, Nunavut shortly after in June 2013. Following the Pre-Hearing Conference the NIRB issued the "Preliminary Hearing Conference Decision Concerning the Kiggavik Project (NIRB File No. 09MN003)" in July 2013.

1.2 Nunavut Impact Review Board Guidelines for the Environmental Impact Statement and Preliminary Conference Decision

The DEIS, including this volume, was determined by the NIRB on May 4, 2012 to have adequately addressed relevant sections of the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc.'s Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011).

Greater clarity, consistency and, in some cases, additional design or assessment were provided within AREVA's responses to information requests in January 2013 and technical comments in May 2013. AREVA commitments for the preparation of the FEIS and regulatory review requirements are listed in the NIRB PHC Decision dated July 2013. Changes from the draft to final EIS including the location of information related to information requests, technical comments, and PHC requirements is noted in the Final Environmental Impact Statement (FEIS) conformity table (Tier 1, Volume 1, Technical Appendix 1A.

1.3 Purpose and Scope

The purpose of this document is to describe the Project components and activities that have the potential to interact with the atmposheric In particular, the extent of any noise and vibration impacts on human health. The overall objective of the environmental effects assessment is to identify the potential residual environmental effects resulting from the Project, inform appropriate mitigation measures and monitoring, and to determine the significance of such effects.

The FEIS has been prepared to fulfil the intent of the NIRB Guidelines and PHC Decision, ultimately providing the information required to confidently proceed with an environmental assessment determination. The assessment has been influenced and reflects input provided from Inuit, Land Claim, Government, community, and other interested stakeholders.

1.4 Report Content and related documents

In addition to this introduction (Section 1), this volume consists of the following sections.

- Section 2: An overview of the Project
- Section 3: A description of the assessment approach and methodology used to assess potential effects of the Project
- Section 4: A description of the scope of assessment and the methodology used for the Environment and Social Assessment (ESA)
- Section 5: A summary of the existing noise and vibration environment
- Section 6: An assessment of noise effects and cumulative effects of the Project
- Section 7: An assessment of vibration effects and cumulative effects of the Project

Tier 3 documents are appended to this Volume to provide further details and supporting information. The Technical Appendices pertaining to this volume are as follows:

- Technical Appendix 4E: Noise and Vibration Assessment

2 Overview – Noise and Vibration

2.1 Project Fact Sheet

Location	• Kivalliq Region of Nunavut, approximately 80 km west of Baker Lake. • The Project includes two sites: Kiggavik and Sissons (collectively called the Kiggavik Project). • The Kiggavik site is located at approximately 64°26'36.14"N and 97°38'16.27"W. • The Sissons site is located approximately 17 km southwest of Kiggavik at 64°20'17.61"N and 97°53'14.03"W. • The Kiggavik and Sissons sites are composed of 37 mineral leases, covering 45,639 acres.
Resources	• The total quantity of resources is currently estimated at approximately 51,000 tonnes uranium (133 million lbs U3O8) at an average grade of 0.46% uranium.
Life of Mine	• Approximately 12 years of production, based on studies to date. It is anticipated that pre-operational construction will require three years while remaining post-operational decommissioning activities will require ten years. • Date of Project construction will be influenced by favorable market conditions, completion of detailed engineering, and successful completion of licensing and other Project approvals.
Mining	• There are five individual mines proposed for the Project: East Zone, Center Zone and Main Zone at the Kiggavik site; End Grid and Andrew Lake at the Sissons site. • The three Kiggavik deposits and the Andrew Lake deposit will be mined by truck-shovel open pit, while End Grid will be an underground mine.
Mine Rock	• Mine rock will be segregated into material suitable for use in construction (Type 1), non-acid generating (Type 2), and potentially problematic material (Type 3). • Type 1, Type 2 and Type 3 rock will be managed in surface stockpiles during operation. • Upon completion of mining, Type 3 mine rock will be backfilled into mined-out pits.
Mill	• The ore will be processed in a mill at the Kiggavik site to produce 3,200 to 3,800 tonnes uranium (8.3 to 9.9 million lbs U3O8) per year as a uranium concentrate, commonly referred to as yellowcake.
Tailings	• The mill tailings will be managed at in-pit tailings management facilities constructed using the mined-out East Zone, Centre Zone and Main Zone open pits at the Kiggavik site. • Administrative and action levels will be used to control and optimize tailings preparation performance for key parameters.
Water Management	• A purpose-built-pit will be constructed at the Kiggavik site to optimize water management, storage, and recycling. • All mill effluent, tailings reclaim, and site drainage will be treated prior to discharge to meet the Metals Mining Effluent Regulations and site-specific derived effluent release targets. • Administrative and action levels will be used to control and optimize water treatment plant performance for key elements.
Site Infrastructure	• Power will be supplied by on-site diesel generators. • The operation will be fly-in/fly-out on a 7 to 14 day schedule with on-site employees housed in a permanent accommodations complex.

Access	• Access to the site will be provided by a winter road between Baker Lake and Kiggavik. An all-season road is assessed as an option should the winter road be unable to adequately support the Project. Supplies will be shipped to a dock facility at Baker Lake during the summer barge season and trucked to Kiggavik via the road. • An airstrip will be constructed and operated at site for transportation of personnel and yellowcake.
Environment	• Site-specific environmental studies have been on-going since 2007 • Public engagement and collection of Inuit Qaujimajatuqangit has been on-going since 2006; this information is integrated into the environmental effects assessment reports • AREVA's approach has been to integrate environmental assessment and decommissioning requirements into the Project design cycle to enhance mitigation of effects by design and to support the development of management, mitigation, and contingency plans to protect the environment
Benefits	• AREVA is negotiating an Inuit Impact Benefit Agreement with the Kivalliq Inuit Association • The total taxes and royalties to be paid on the Kiggavik project would be approximately $1 billion, payable to Nunavut Tunngavik Inc., Government of Nunavut, and Government of Canada. • The Project is expected to employ up to 750 people during construction and 400 to 600 people during operation.

The economic feasibility of the Kiggavik Project depends on 1) the production cost for the uranium concentrate including construction, operation and decommissioning costs and 2) the market value of the final product. The latest feasibility study completed for the Kiggavik Project was in November 2011. The study assessed the technical and economic viability of developing and operating a uranium mine and mill site in the Kiggavik area and estimated the capital cost of the Project at $2.1 billion and the operating cost at $240 million per year. This initial feasibility study will be updated and refined prior to a development decision. The market price for uranium concentrate over the last years has been within the range needed for a reasonable return on investment to its owners, however at the time of FEIS preparation was below the threshold needed for Project advancement. AREVA believes future opportunities are strong enough to encourage Project advancement with the intent of development that will coincide with viable future markets.

2.2 Assessment Basis

To ensure that the potential environmental and socioeconomic effects of the Kiggavik Project are adequately considered in this environmental assessment, it was determined that it would be advantageous to develop a clear "assessment basis" for the Project. The purpose of the assessment basis is to clearly and consistently define how the design parameters detailed in Tier 2 Volume 2 Project Description encompass the more conservative values for various design features and options. It is consistent with the precautionary principle to assess potential environmental effects conservatively to improve confidence that the Project can be realized within the predicted effects and approved environmental assessment.

The assessment basis is summarized in Table 2.2-1 and presented with greater detail in Tier 2 Volume 2 Section 20. For biophysical and some socio-economic effects, the range value with the greatest potential to result in an adverse effect is used. In the case of socio-economic benefits, the range value resulting in the lowest benefit is used.

Table 2.2-1 Project Assessment Basis

Project Activities/Physical Works	Parameter	Units	Parameter / Assumption Values	
			Base Case (PD)	Assessment Case
Overall	Production Rate	Tonnes U per year	3,200 – 3,800	3,200 - 4,000
	Mill Feed Rate	Kilotonnes per year	71 - 977	1,000
	Project Operating Life	Years	2 years pre-production 12 years production	25
	Project Footprint	Hectares (ha)	938	1,102
	Access Road Route	Not Applicable	Winter Road	Winter Road All-Season Road
	Dock Site Location	Not Applicable	Site 1	Sites 1,2, Agnico Eagle's Meadowbank Dock Site
Milling	Flowsheet	Not Applicable	Resin in Pulp (RIP)	Resin in Pulp (RIP), possibly solvent extraction (SX) and / or calciner
	Final Product	Not Applicable	Non-calcined uranium concentrate	Non-calcined or calcined uranium concentrate
Tailings Management	Containment volume	Million cubic metres (Mm^3)	28.4	30.0
	Total tailings volume (un-consolidated)	Million cubic metres (Mm^3)	21	30.0
	Design		Natural surround, no drain	Various design contingencies
Water Management	Freshwater requirements – no permeate or site drainage recycle	Cubic metres per day (m^3/day)	7,910	8,000
	Freshwater requirements – permeate and site drainage recycle	Cubic metres per day (m^3/day)	2,000	8,000
	Freshwater requirements - Sissons	Cubic metres per day (m^3/day)	60	60
	Treated effluent discharge at base quality – Kiggavik	Cubic metres per day (m^3/day)	2,707	3,000
	Treated effluent discharge – Sissons	Cubic metres per day (m^3/day)	1,700	1,700
Power Generation	Kiggavik peak load	megaWatt (MW)	13.0	13.0 – 16.8
	Sissons peak load	megaWatt (MW)	3.8	0 – 3.8
Logistics & Transportation	Number of barge trips – 5000t & 250 containers	Barge trips / year	9 - 31	31
	Number of barge trips – 7500t & 370 containers	Barge trips / year	7 - 22	22
	Number of truck trips – 56,000L & 48t	Truck trips / year	328 – 3,233	3,300
	Number of truck trips – 70,000L & 60t	Truck trips / year	243 – 2,405	2,500
	Number of yellowcake flights	Flights / year	310 - 350	355
Decommissioning	Period	Years	10	10

3 Assessment Methodology – Noise and Vibration

3.1 Introduction

This section describes the methods used in the assessment of environmental and socio-economic effects associated with the Kiggavik Project. The methods meet the applicable regulatory requirements while focusing the assessment on the matters of greatest environmental, social, cultural, economic and scientific importance. The methodological approach also recognizes the iterative nature of project-level environmental assessment, considering the integration of engineering design and mitigation and monitoring programs into comprehensive environmental management planning for the life of the Project.

The environmental effects assessment method is based on a structured approach that:

- considers the factors that are required under Nunavut Land Claim Agreement;
- focuses on issues of greatest concern;
- affords consideration of all territorial and federal regulatory requirements for the assessment of environmental effects;
- considers issues raised by the Inuit, regulators, government agencies and public stakeholders; and
- integrates Project design and programs for mitigation and monitoring into a comprehensive environmental planning.

The environmental assessment focuses on specific environmental components called Valued Environmental Components (VECs) or Valued Socio-economic Components (VSECs) that are of particular value or interest to Inuit, regulators, government agencies and stakeholders. The term Valued Components (VECs) refers collectively to VECs and VSECs. Valued Components are selected based on regulatory issues and guidelines, consultation with Inuit, regulators, government agencies and stakeholders, field studies, and professional judgment of the study team. Where a VEC has various sub-components that may interact in different manners with the Project, the environmental assessment may consider the environmental effects on individual Key Indicators (KIs).

The term “environmental effect” is used throughout the Application and broadly refers to the response of the biophysical or human system or a component of these systems to a disturbance from a Project action or activity or other regional actions (i.e., projects and activities).

The environmental assessment methods address Project-related and cumulative environmental effects. Project-related environmental effects are changes to the biophysical or socio-economic environment that are caused by the Project or activity arising solely because of the proposed principal works and activities, as defined by the Scope of the Project. This includes consideration of the environmental effects of malfunctions or accidents that may occur in connection with the Project. Cumulative environmental effects are changes to the biophysical or socio-economic environment that are caused by an action of the Project in combination with other past, present and future projects and activities.

In this assessment, Project-related environmental effects and cumulative environmental effects are assessed sequentially. The mechanisms through which a Project-specific environmental effect may occur are discussed first, taking into account Project design measures and mitigation that help to reduce or avoid environmental effects. The residual environmental effect is then characterized taking into account planned mitigation. At a minimum, all Project environmental effects are characterized using specific criteria (e.g., magnitude, geographic extent, duration) that are defined for each VEC.

A cumulative environmental effects screening is then conducted to determine if there is potential for the Project residual environmental effect to act in a cumulative manner with similar environmental effects from other projects and activities. If there is potential for the Kiggavik Project to contribute to cumulative environmental effects, the environmental effect is assessed to determine if it has the potential to shift a component of the natural or socio-economic environment to an unacceptable state.

The environmental effects assessment approach used in this assessment involves the following steps:

- **Scoping**: Scoping of the overall assessment, which includes: issues identification; selection of VECs (and KIs, if required); description of measurable parameters; description of temporal, spatial, administrative and technical boundaries; definition of the parameters that will be used to characterize the Project-related environmental effects and cumulative environmental effects; and identification of the standards or thresholds that will be used to determine the significance of environmental effects.
- **Assessment of Project-related environmental effects**: The assessment of Project-related environmental effects, which includes: description of the mechanism(s) by which an environmental effect will occur; mitigation and environmental protection measures to reduce or eliminate the environmental effect; and evaluation and characterization of the residual environmental effects (i.e., environmental effects remaining after application of mitigation measures) of the Project on the biophysical and socio-economic environment for each development phase.
- **Evaluation of cumulative environmental effects**: The evaluation of cumulative environmental effects, which involves two tasks: screening for potential cumulative environmental effects and, if there is potential for cumulative environmental effects, assessment of cumulative environmental effects. Where an assessment of potential cumulative environmental effects is required, the residual cumulative environmental effects of the Project are evaluated in combination with other past, present and future projects and activities.

- **Determination of significance**: The significance of Project-related and cumulative residual environmental effects is determined using standards or thresholds that are defined for each VEC.
- **Monitoring**: Several different types of monitoring may be required to confirm compliance with mitigation measures or Project design features, address uncertainties or verify environmental effects predictions and/or assess the effectiveness of mitigation measures.
- **Summary**: The last step of the assessment of environmental effects on a VEC is the development of summaries on Project and cumulative environmental effects (including combined Project environmental effects and combined cumulative environmental effects), mitigation measures and Project design features, and monitoring.

3.2 Scope of the Assessment

3.2.1 Valued Components, Indicators and Measurable Parameters

Valued Components are defined as broad components of the biophysical and socio-economic environments, which if altered by the Project, would be of concern to regulators, Inuit, resource managers, scientists, and public stakeholders.

VECs for the biophysical environment typically represent major components or aspects of the physical and biological environment that might be altered by the Project, and are widely recognized as important for ecological reasons.

Criteria for selection of VECs include:

- Do they represent a broad environmental, ecological or human environment component that may be altered by the Project?
- Are they vulnerable to the environmental effects of the Project and other activities in the region?
- Have they been identified as important issues of concerns of Inuit or stakeholders, or in other assessments in the region?
- Were they identified by the Nunavut Impact Review Board (NIRB), Inuit organizations or departments within the territorial or federal government?

Key indicators (KIs) are species, species groups, resources or ecosystem functions that represent components of the broader VECs. They are selected using the same criteria as described above for VECs. For practical reasons, KIs are often selected where sufficient information is available to assess the potential Project residual environmental effects and cumulative environmental effects.

For each VEC or KI, one or more measurable parameters are selected to quantitatively or qualitatively measure the Project environmental effects and cumulative environmental effects. Measurable parameters provide the means of determining the level or amount of change to a VEC or KI. The degree of change in the measurable parameter is used to characterize project-related and cumulative environmental effects, and evaluate the significance of these effects. Thresholds or standards are identified for each measurable parameter, where possible, to assist in determining significance of the residual environmental effect.

3.2.2 Key Issues

Issues identification focuses the assessment on matters of greatest importance related to the Project, and assists in determining which factors and the scope of those factors that will be considered in the assessment.

Issues and concern about the possible biophysical or socio-economic effects of the Project have been identified from a variety of sources, including:

- the regulatory requirements applicable to the Project;
- discussions with technical experts from various territorial and federal government agencies;
- input from Inuit and public stakeholders during engagement activities in relation to the Project;
- existing regional information and documentation regarding environmental components found near the Project;
- baseline and assessment studies conducted in the area of the Project, and
- the professional judgment of the assessment team, based on experience with similar projects elsewhere and other mining project and activities in Nunavut.

Key Project-related issues are summarized in the scoping section for each discipline considered in the assessment.

3.2.3 Project – Environment Interactions and Environmental Effects

Key Project-related activities that are likely to result in environmental effects are considered for each VEC. A matrix of Project activities and environmental components is provided in the scoping section for each discipline to identify where interactions are likely to occur based on the spatial and temporal overlap between Project activities and the VEC. Each interaction is ranked according to the potential for an activity to cause an environmental effect. The interactions are ranked according to the following:

- If there is no interaction or no potential for substantive interaction between a Project activity and the VEC to cause a potential environmental effect, an assessment of that environmental effect is not required. These interactions are categorized as 0, and are not considered further in the EA. The environmental effects of these activities are thus, by definition, rated not significant.

- If there is likely to be a potential interaction between a Project activity and a VEC but not likely to be substantive in light of planned mitigation, the interaction is categorized as 1. Such interactions are well understood and are subject to prescribed mitigation or codified practices. These interactions are subject to a less detailed environmental effects assessment and are rated as not significant. Justification is provided and the mitigation is described for such categorizations. Such interactions can be mitigated with a high degree of certainty with proven technology and practices.
- If a potential interaction between a Project activity and a VEC could result in more substantive environmental effects despite the planned mitigation, if there is less certainty regarding the effectiveness of mitigation, or if there is high concern from regulatory agencies, Inuit or stakeholders, the interaction is categorized as 2. These potential interactions are subject to a more detailed analysis and consideration in the environmental assessment in order to predict, mitigate and evaluate the potential environmental effects.

The ranking takes a precautionary approach, whereby interactions with a meaningful degree of uncertainty are assigned a rank of 2 to ensure that a detailed analysis of the potential environmental effect is undertaken.

Justification for ranking the Project-environmental interactions considered for each VEC is provided in the scoping section for each discipline.

3.2.4 Assessment Boundaries

Boundaries of the assessment are defined for each VEC to allow for a meaningful analysis of the significance of environmental effects. The assessment boundaries are described in terms of temporal, spatial and administrative and technical boundaries.

3.2.4.1 Spatial Boundaries

Spatial boundaries are established for assessing the potential Project-related environmental effects and cumulative environmental effects on each VEC. The primary consideration in establishing these boundaries is the probable geographical extent of the environmental effects (i.e., the zone of influence) on the VEC.

Spatial boundaries represent the geographic extent of the VEC, as they pertain to potential Project-environment interactions. Spatial boundaries are selected for each VEC to reflect the geographic extent over which Project activities will or are likely to occur, and as such, they may be different from one VEC to another depending on the characteristics of the VEC. For this assessment, the spatial boundaries are referred to as ‘assessment areas’ to differentiate the areas from the local and regional study areas referred to in many baseline studies.

Three assessment areas are defined for each VEC.

The ***Project Footprint*** is the most immediate area of the Project. The Project Footprint includes the area of direct physical disturbance associated with the construction or operation of the Project.

The ***Local Assessment Area*** (LAA) is the maximum area within which Project-related environmental effects can be predicted or measured with a reasonable degree of accuracy and confidence. The LAA includes the Project Footprint and any adjacent areas where Project-related environmental effects may be reasonably expected to occur.

The **Regional Assessment Area** (RAA) is a broader area within which cumulative environmental effects on the VEC may potentially occur. This will depend on physical and biological conditions (e.g., air sheds, watersheds, seasonal range of movements, population unit), and the type and location of other past, present or reasonably foreseeable projects or activities. For the socio-economic environment, the RAA may be much broader (planning areas, regions, territories etc.) based on the potential geographic extent over which socio-economic effects are likely to occur. It is also the area where, depending on conditions (e.g., seasonal conditions, habitat use, more intermittent and dispersed Project activities), Project environmental effects may be more wide reaching.

3.2.4.2 Temporal Boundaries

The temporal boundaries for the assessment are defined based on the timing and duration of Project activities and the nature of the interactions with each VEC. Temporal boundaries encompass those periods during which the VECs and KIs are likely to be affected by Project activities.

For the Kiggavik Project, temporal boundaries include the following Project phases.

- construction;
- operations;
- final closure; and
- post closure.

The operations phase includes consideration of maintenance, planned exploration and temporary closure (care & maintenance) of the Project. The final closure phase considers decommissioning and reclamation, and post-closure phase includes management of restored sites.

In some cases, temporal boundaries are refined to a specific period of time beyond simply limiting them to a specific phase of the Project. This is carried out as necessary within each environmental effects analysis section. Temporal boundaries for the assessment may reflect seasonal variations or life cycle requirements of biological VECs, long-term population cycles for some biological VECs, or forecasted trends for socio-economic VSECs.

3.2.4.3 Administrative and Technical Boundaries

Administrative and technical boundaries are identified and justified for each VEC or KI, as appropriate. Administrative boundaries include specific aspects of provincial, territorial and federal regulatory requirements, standards, objectives, or guidelines, as well as regional planning initiatives that are relevant to the assessment of the Project's environmental effects on the VEC. Administrative boundaries may be selected to establish spatial boundaries.

Technical boundaries reflect technical limitations in evaluating potential environmental effects of the Project, and may include limitations in scientific and social information, data analyses, and data interpretation.

3.2.5 Environmental Effects Criteria

Where possible, the following characteristics are described quantitatively for each VEC to assist in the assessment of residual environmental effects. Where these residual environmental effects cannot be defined quantitatively, they are described using qualitative terms. If qualitative descriptions are used, definitions are provided for each VEC or KI, as appropriate, in the scoping section of the environmental assessment for that VEC or KI.

- ***Direction***: the ultimate long-term trend of the environmental effect (e.g., positive, neutral or adverse)
- ***Magnitude***: the amount of change in a measurable parameter or variable relative to the baseline case (i.e., low, moderate, high)
- ***Geographical Extent***: the geographic area within which an environmental effect of a defined magnitude occurs (site-specific, local, regional, territorial, national, international)
- ***Frequency***: the number of times during the Project or a specific Project phase that an environmental effect may occur (i.e., once, sporadically, regular, continuous)
- ***Duration***: this is typically defined in terms of the period of time that is required until the VEC returns to its baseline condition or the environmental effect can no longer be measured or otherwise perceived (i.e., short term, medium term, long term, permanent)
- ***Reversibility***: the likelihood that a measurable parameter for the VEC will recover from an environmental effect (i.e., reversible, irreversible)
- ***Ecological or socio-economic context***: the general characteristics of the area in which the Kiggavik Project is located (i.e., undisturbed, disturbed, urban setting)

3.2.6 Standards or Thresholds for Determining Significance

Where possible, threshold criteria or standards for determining the significance of environmental effects are defined for each VEC or KI to represent that limit beyond which a residual environmental effect would be considered significant. In some cases, standards or thresholds are also defined for specific environmental effects on a VEC or KI.

Standards are recognized federal and territorial regulatory requirements or industry objectives that are applicable to the VEC, and that reflect the limits of an acceptable state for that component. Where standards, guidelines or regulatory requirements do not specifically exist, thresholds are defined for the measurable parameters for an environmental effect on a VEC based on resource management objectives, community standards, scientific literature, or ecological processes (e.g., desired states for fish or wildlife habitats or populations).

Potential changes in a measurable parameter or VEC resulting from residual Project or cumulative environmental effects are evaluated against these standards or thresholds. Environmental effects are rated as either *significant* or *not significant*.

3.2.7 Influence of Engagement on the Assessment

Engagement undertaken to date with regulators, Inuit and public stakeholders in relation to the Project is described in Volume 3. Issues raised during these engagement activities and Inuit Qaujimajatuqangit (IQ) sessions were documented, and were reviewed for consideration in each discipline-specific assessment, including scoping of baseline data collection, selection of VEC and KIs, use of TEK and IQ in the environmental effects assessment, mitigation and monitoring.

3.3 Assessment of Project Environmental Effects

3.3.1 Existing Conditions

The existing conditions for each VEC are described according to the status and characteristics of the VEC within its defined spatial and temporal assessment boundaries. This is based on a variety of sources, including:

- information from past research conducted in the region;
- Inuit Qaujimajatuqangit (IQ); and
- knowledge gained from the collection of baseline data through literature review, qualitative and quantitative analyses and field programs carried out as part of the environmental assessment.

In general, the description of existing conditions is limited to information directly relevant to the potential VEC interactions with the Project to support the environmental effects analysis.

3.3.2 Project Effect Linkages

The mechanisms or linkages through which the Project components and activities could result in an environmental effect on a VEC, and the spatial and temporal extent of this interaction is described based on the existing conditions of the VEC. Because the assessment focuses on residual environmental effects, effects prior to mitigation are not characterized or quantified and the significance of the effect is not determined.

3.3.3 Mitigation Measures and Project Design

Where Project activities are likely to cause an environmental effect on a VEC, mitigation measures are identified to minimize or avoid environmental effects of the Project. This includes measures or strategies that are technically and economically feasible and that would reduce the extent, duration or magnitude of the environmental effect.

Mitigation includes Project design features to change the spatial or temporal aspect of the Project, specialized mitigation, environmental protection measures and protocols, and compensation (habitat compensation, replacement or financial compensation).

Where mitigation is identified, a brief discussion of how the measure(s) will help to minimize the residual environmental effect on the VEC is provided. Where possible, this includes a description of how effective the measure is expected to be in minimizing the change in the measurable parameters for the environmental effect.

3.3.4 Residual Project Effects Assessment

Taking into account the mitigation and expected effectiveness of the measure(s), the residual environmental effects of the Project are described according to their probable magnitude, geographic scope, duration, frequency, reversibility and ecological context, where appropriate. The residual effect is characterized in the context of the existing condition for the measureable parameter(s) and how it is likely to change as a result of the Project environmental effect. For some residual environmental effects, the change in the measurable parameter is described relative to each Project phase.

Where possible, the magnitude, geographic extent and duration of the residual environmental effect are quantified. If a residual effect cannot be quantified, qualitative terms are used to describe the attributes of the effect.

3.3.5 Significance of Residual Project Environmental Effects

Significance of a residual Project environmental effect is determined based on standards or thresholds that are specific to the VEC, KI and/or the measurable parameters used to assess the environmental effect. Determination of whether a residual environmental effect is considered to be significant or not significant is based on a comparison of the predicted change in the VEC or measurable parameter to the defined threshold or standard. This includes an indication of the likelihood that a significant residual environmental effect on a VEC will occur based on probability of occurrence (i.e., based on past experience) and level of scientific uncertainty.

Determination of significance also includes a discussion of the confidence of the prediction with respect to:

- the characterization of environmental effects, and
- the success of Project design features, mitigation measures, and environmental protection measures in effectively reducing the environmental effect.

Prediction confidence for the environmental effect and the success of mitigation measures is ranked as low, moderate or high.

3.3.6 Monitoring of Residual Project Environmental Effects

Based on analysis of the residual Project environmental effect, it may be necessary to conduct a monitoring program. Monitoring is recommended in cases where there is a need to address Project-related issues of public concern, test the accuracy of the assessment predictions, verify the success of the mitigation measures, or gain additional scientific knowledge related to prediction of the Project environmental effect.

Two types of monitoring are considered: compliance and follow-up environmental monitoring.

Compliance monitoring is undertaken to confirm that Project design features, mitigation measures, environmental protection measures, or benefit agreements are being effectively implemented.

Biophysical and socio-economic monitoring programs are used to:

- verify predictions of environmental effects;
- determine the effectiveness of mitigation measures, environmental protection measures or benefits agreements in order to modify or implement new measures where required;
- support the implementation of adaptive management measures to address previously unanticipated adverse environmental effects; and

- support environmental management systems used to manage the environmental effects of projects.

Where a monitoring program for a specific VEC or KI is identified, the following aspects of the program are defined:

- parameters to be measured;
- methods and equipment to be used;
- location and timing of surveys; and
- how the results of the monitoring will be applied, including consideration of an adaptive management approach.

3.4 Assessment of Cumulative Environmental Effects

3.4.1 Screening for Potential Cumulative Effects

Cumulative environmental effects are only assessed if the following criteria are met for the residual Project effect under consideration:

- The Project will result in a measurable, demonstrable or reasonably-expected residual environmental effect on a component of the biophysical or socio-economic environment,
- The Project-specific residual environmental effect on the component will likely act in a cumulative fashion with the environmental effects of other past or future projects or activities that are likely to occur (i.e., Is there overlap of environmental effects?), and
- There is a reasonable expectation that the Project's contribution to cumulative environmental effects will be substantive, measurable or discernible such as that it will affect the viability or sustainability of the resource.

If, based on these criteria, there is potential for cumulative environmental effects, the effect is assessed further to determine if it is likely to shift the component to an unacceptable state. Where there is no potential for the environmental effect of the Project to spatially or temporally overlap with similar effects of other project and activities, justification for not carrying these environmental effects forward to the assessment of cumulative environmental effects is provided.

3.4.2 Project Inclusion List

The project inclusion list includes all past, present and reasonable foreseeable projects, activities and actions in the region of the Kiggavik Project. Only projects and activities that overlap with the Project residual environmental effects both spatially and temporally are considered in the assessment of potential cumulative environmental effects.

The specific projects, activities and action considered for each environmental effect are described in the assessment for the VEC or KI.

3.4.3 Description of Cumulative Environmental Effects

The first step in the assessment of cumulative environmental effects involves describing the environmental effect, the mechanisms by which the Project environmental effect may interact cumulatively with other projects and activities in the RAA (from the Project Inclusion List), and the geographic and temporal scope of the cumulative environmental effect.

For this assessment, cumulative environmental effects are described for four cases. A more detailed description of the assessment cases is provided within the Project Inclusion List (Volume 1, Appendix 2).

- ***Base Case***: the current status of the measurable parameters for the environmental effects at baseline (i.e., prior to the Project). Baseline includes all past and present projects and activities in the RAA that may result in similar environmental effects to the Project environmental effect, including ongoing mineral exploration. Existing projects include projects that have received environmental approval and are in some form of planning, construction and/or commissioning.
- ***Project Case***: the status of the measurable parameters for the environmental effect with the Project in place, over and above the Base Case. This is usually assessed using the peak environmental effect of the Project or maximum active footprint for the Project.
- ***Future Case***: the status of the measurable parameters for the environmental effect because of the Project Case, in combination with all reasonable foreseeable projects, activities and actions. Reasonably foreseeable projects are defined as future projects, activities and actions that will occur with certainty, including projects that are in some form of regulatory approval or have made a public announcement to seek regulatory approval.

For this assessment, future projects include proposed mines that are currently under NIRB review:

- Meadowbank;
- Doris North 1;
- Doris North 2;
- Meliadine;
- Mary River;
- Hackett River;
- Back River;
- Hackett River; and
- High Lake.

The combination of the Project Case with the Future Case allows determination of the Project's contribution to cumulative effects of all past, present and reasonably-foreseeable projects and activities.

- Far Future Case: the status of the measurable parameters for the environmental effect because of the Future Case, in combination with possible far future developments in the Kiggavik region.

It is recognized that exploration activities will continue in the vicinity of the Kiggavik Project, and that there is the potential for additional resources to be discovered during the life of the Project. To address such a possibility, a potential far future development scenario was developed. This scenario assumes additional deposits within a 200 km radius of the Kiggavik site, and the development of a non-uranium operation located within the Kiggavik RSA. The Meadowbank gold operation is used as the model for this. It assumes additional resources are found in the Meadowbank area, and that operation of Meadowbank continues. The following projects and activities are included in the development scenario.

Component	Locations
Uranium mines	3 mines within 200 km of Kiggavik
Uranium mills	Kiggavik mill
Gold mines	1 mine within Kiggavik RSA Meadowbank region
Gold mills	Meadowbank region Additional mill within Kiggavik RSA
Access Roads	Meadowbank region Additional mill within Kiggavik RSA
Exploration	Induced exploration near the access road(s) and in the Kiggavik area

Due to the lack of information regarding the specific details of potential future developments (i.e., footprint of projects and activities), the assessment of cumulative environmental effects under this Case is by definition qualitative and is limited to a description of how these projects, activities and actions could affect the magnitude, duration and extent of cumulative environmental effects.

3.4.4 Mitigation of Cumulative Environmental Effects

Mitigation measures that would reduce the Project's environmental effects are described for cumulative environmental effects, with emphasis on measures that should limit the interaction of environmental effects of the Project with similar environmental effects from other projects. Three types of mitigation measures are considered, where appropriate:

- Measures that can be implemented solely by AREVA;
- Measures that can be implemented by AREVA, in cooperation with other project proponents, government, Aboriginal organizations and/or public stakeholders; and
- Measures that can be implemented independently by other project proponents, government, Aboriginal Organizations and/or public stakeholders.

For the latter two types of mitigation, the degree to which AREVA can or cannot influence the implementation of these measures is noted.

Mitigation measures that could assist in reducing potential cumulative environmental effects are identified for each environmental effect, including a discussion of how these measures may potentially modify the characteristics of an environmental effect.

3.4.5 Residual Cumulative Environmental Effects Assessment

Residual cumulative environmental effects are described, taking into account how the mitigation will change the environmental effect. Where possible, cumulative environmental effects are characterized quantitatively or qualitatively in terms of the direction, magnitude, duration, geographic extent, frequency and reversibility. This includes characterization of:

- The total residual cumulative environmental effects based on the Future Case (i.e., the environmental effects of all past, present and reasonably foreseeable project and activities), in combination with the environmental effects of the Project, and
- The contribution of the Project to the total residual cumulative effects (i.e., how much of the total residual cumulative effects can be attributed to the Project).

3.4.6 Significance of Residual Cumulative Environmental Effects

The significance of cumulative environmental effects is determined using standards or thresholds that are specific to the VEC, KI and/or measurable parameters used to assess the Project environmental effect. Determinations of significance are made for:

- the significance of the total residual cumulative environmental effect; and
- the significance of the contribution of the Project to the total residual cumulative environmental effect.

The determination of residual cumulative environmental effects includes a discussion of the confidence of the prediction based on scientific certainty relative to:

- quantifying or estimating the environmental effect (i.e., quality and/or quantity of data, understanding of the effects mechanisms); and
- the effectiveness of the proposed mitigation measures.

As for residual Project environmental effects, prediction confidence for the cumulative environmental effect and the success of mitigation measures is ranked as low, moderate or high.

3.4.7 Monitoring of Cumulative Environmental Effects

Based on the evaluation of residual cumulative environmental effects, it may be necessary to conduct monitoring programs. Monitoring programs are designed to:

- confirm the effectiveness of a broad range of approved mitigation techniques,
- determine whether different or an increased level of mitigation is required to achieve the mitigation or reclamation goals, and
- identify and address any cumulative effects that occur but were not predicted.

Two types of monitoring are considered:

- compliance Monitoring: to confirm that Project design features, mitigation measures, environmental protection measures, or benefit agreements are being effectively implemented.
- biophysical or Socio-economic Monitoring: to confirm the environmental effect prediction and/or effectiveness of a Project design feature, mitigation measure, environmental protection measure, or benefit agreement.

3.5 Summary of Residual Environmental Effects

Residual Project and cumulative environmental effects are briefly summarized for each VEC. This includes a discussion of the overall combined environmental effect of the Project on the VEC and its significance, as well as a discussion of the overall combined effect of all cumulative effects on the VEC and its significance. For biophysical VECs, this relates to the sustainability of the resource or populations being considered. For socio-economic VSECs, this relates to the ability of the community, the Kivalliq region and/or Nunavut to adapt to or manage the environmental effect. A discussion of the Project's contribution to the combined cumulative effect is also provided.

In addition, this summary section presents an assessment of the effects of climate change on residual Project and cumulative effects. Where possible, the effects are described quantitatively, and include a description of how likely climate changes in the region will likely influence Project and cumulative residual effects.

3.6 Assessment of Transboundary Effects

As required by the NIRB EIS Guidelines, the assessment includes consideration of transboundary effects, where residual environmental effects are likely to extend beyond the Nunavut into federal waters and/or other provincial or territorial jurisdictions. As this is based largely on the cumulative effects assessment, the transboundary effects are characterized qualitatively or semi-quantitatively.

3.7 Summary of Mitigation

A detailed description of the mitigation measures proposed to minimize or avoid project-related and cumulative effects on VECs is provided based on the scoping and effects analyses. This includes:

- relevant Project design features to reduce environmental effects;
- project policies (e.g., Inuit hiring policy);
- specialized mitigation measures to minimize environmental effects on VECs;
- social or community programs to minimize environmental effects on VSECs;
- environmental Protection plans;
- broader agreements (e.g., benefits agreements); and
- compensation.

3.8 Summary of Monitoring

Monitoring programs to address uncertainties associated with the environmental effects predictions and environmental design features and mitigation proposed for residual Project effects and cumulative effects are described in detail. This includes all compliance monitoring and environmental monitoring that may be applied during the life of the Project, and that will form the:

- Compliance Monitoring Program Framework;
- Environmental Monitoring Program Framework;
- Socio-Economic Monitoring Program Framework;
- Post-Project Analysis Program Framework; and
- Follow-up Monitoring Programs.

4 Scope of the Assessment – Noise and Vibration

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

The discussion herein focuses on noise and vibration effects from the Project as they relate to human health. The analysis of potential noise and vibration effects in the terrestrial environment is presented in Volume 6 (Terrestrial Environment). The analysis of potential changes in noise and vibration levels in the marine mammals and fish in fresh water and marine environments is presented in Volume 5 (Aquatic Environment) and Volume 7 (Marine Environment).

4.1 Issues and Concerns Identified During Inuit, Government and Stakeholder Engagement

The Nunavut Impact Review Board (NIRB) "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) incorporated advice from the public and interested parties on the proposed scope of assessment for the atmospheric environment, including identification of valued ecosystem components (VECs) and issues that should be considered in the environmental impact statement (EIS).

Specifically, the guidelines require an analysis of the environmental effects of:

- open-pit and underground mining and associated activities, including drilling, blasting, transport and stockpiling activities;
- mill operations, including crushing, screening, yellowcake processing, water/wastewater treatment and power generation;
- dock and Storage Facility operations, including offloading;
- ground transportation and associated water crossings, including mine traffic along haul roads and access roads; and
- air transportation, including the Pointer Lake airstrip and associated activities.

Project-specific issues and concerns identified during Inuit, government and stakeholder engagement broadly include

- Concerns about the process of evaluating noise and vibration impacts in relation to the Project and the need to ensure that appropriate studies were completed to assess potential effects (EN-KIV OH 2009[19]; EN-CH NIRB 2010[20]; EN-CI NIRB 2010[21]; EN-RB NIRB 2010[22]; EN-AR OH 2012[23]);
- Concern that there was a lack of noise regulations in Nunavut (EN-BL NIRB 2010[24]); and
- Particulate concern regarding noise from helicopter flyovers, especially in light of the existing helicopter traffic from other operators in Baker Lake (EN-BL EL 2012[25]; EN-BL CLC 2013[26]).

The comments and concerns raised by the Inuit and other stakeholders were integrated into the broader study design and are discussed throughout this report. Many of the comments provided were addressed in the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011), including identification of valued ecosystem components (VECs) and issues that should be considered in the environmental impact statement (EIS). For example, young adults "… believe the impact assessment should consider the potential effects of the Project during all seasons…" (IQ-RIYA 2009[27]).

[19] EN-KIV OH 2009: *General concern regarding if and how the environmental effects will be assessed.*

[20] EN-CH NIRB 2010: *Would like fellow Inuit to be employed and earning a living, as well as the environment should be taken care of at the same time.*

[21] EN-CI NIRB 2010: Chesterfield Inlet will be largely affected by the project because of the shipping routes… Noise pollution is a concern.

[22] EN-RB NIRB 2010: *Concerned over who will be conducting the study and environmental monitoring. It is important that the study is complete before the mine is in operation.*

[23] EN-AR OH 2012: *Will the impacts on the environment be big during operation? Will the effects be reversible when the operation stops?*

[24] EN-BL NIRB 2010: *Would like to see strict regulations in place for noise, environment, air pollution, etc. before this project goes ahead and would like to see these even for the exploration activities.*

[25] EN-BL EL 2012: *Helicopters are very noisy every day in the spring and summer.*

[26] EN-BL CLC 2013: *It's not only AREVA's choppers but there are a lot of other companies' choppers.*

[27] IQ-RIYA 2009: *Young adults have heard about damage to the environment that has been caused by mines, and believe the impact assessment should consider the potential effets of the Project during all seasons, and that a priority should be given to considering the potential effects of the Project on caribou migration routes.*

4.2 Regulatory Setting

4.2.1 Regulatory Criteria for Airborne Noise

4.2.1.1 Territorial

The *Nunavut Environmental Protection Act* (2010) is territorial legislation established to regulate contaminant discharges into the environment including emissions of noise and vibration. The Nunavut Department of Environment's Environmental Protection Division 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. In light of this regulatory gap and concerns raised by the Inuit and the public, the noise and vibration assessment have considered other applicable federal and international standards and guidelines to determine project effects (EN-BL NIRB 2010[28]).

4.2.1.2 Federal

In 2005, Health Canada published a draft guidance document for noise assessments under the *Canadian Environmental Assessment Act* (2010). 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 is based on Annex D of ISO standard 1996-1 Description, measurement and assessment of environmental noise (International Organization of Standards [ISO] 2003).

The sound level metric used to assess the sound levels using the Health Canada calculation is the day-night sound level (DNL), which is a 24-hour energy equivalent sound level that penalizes sounds that occur during night time hours. The rationale for the night time penalty is that people generally experience an increased annoyance to noise during the night time due to the potential for sleep disturbance. Health Canada suggests that a noise effect occurs when a project undertaking causes a change in percent highly annoyed (%Ha) of more than 6.5%.

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[28] EN-BL NIRB 2010: *Would like to see strict regulations in place for noise, environment, air pollution, etc. before this project goes ahead and would like to see these even for the exploration activities.*

The Project will require licensure by the Canadian Nuclear Safety Commission (CNSC) to construct and operate the facilities (mines and mill). The CNSC has not developed noise or vibration guidelines.

4.2.1.3 International

The World Health Organization (WHO) Guidelines for Community Noise (WHO 1999) outline a set of noise exposure guidelines 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 WHO Guidelines represent the sound pressure levels (SPLs) that affect the most exposed receiver in a specific environment. The WHO Guidelines considered for the Project are presented below.

Table 4.2-1 WHO Guidelines for Community Noise in Specific Environments

Specific Environment	Critical Health Effect(s)	Leq (dBA)	Time Base (hours)
Outdoor Living Area	Serious annoyance, day time and evening	55	16
	Moderate annoyance, day time and evening	50	16
Inside bedrooms	Sleep disturbance night time	30	8
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8
SOURCE: WHO 1999			
NOTE: Leq – energy equivalent sound level dBA – A-weighted decibel			

4.2.2 Regulatory Criteria for Ground-borne Noise and Vibration

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

4.2.2.1 Other Jurisdictions

Due to the lack of ground-borne noise and 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 peak SPL (i.e., concussion) and peak particle velocity (PPV) (i.e., vibration). For purpose of this evaluation, criteria from the Ontario Ministry of the Environment (OMOE) Noise Pollution Control

119 (NPC-119) were applied (OMOE 1978). These limits are expressed in terms of the linear peak sound pressure level (dB) and peak particle level (PPV) (millimetres per second [mm/s]). Peak or maximum velocity refers to the speed that particles oscillate and is an indicator of the magnitude of the motion. The following limits are specified by the OMOE:

- Concussion: peak SPL of 120 dB; and
- Vibration: PPV of 10 mm/s.

4.2.2.2 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 typical set of vibration levels tolerated by humans in buildings is given in the following table, which is derived from the Standards Australia standard AS 2670.2-1990 Evaluation of human exposure to whole-body vibration - Continuous and shock-induced vibration in buildings (1 to 80 hertz [Hz]) (Standards Australia 1990).

Table 4.2-2 Standards Australia Vibration Guideline Values

Specific Environment	Time Period	PPV (mm/s)[a]	
		Preferred	Maximum
Continuous Vibration - Residence	Day time	0.28	0.56
	Night time	0.20	0.40
Impulsive Vibration – Residence	Day time	8.6	17.0
	Night time	2.8	5.6
SOURCE: DECNSW 2006			
NOTE: [a] Values given for the most critical frequency range >8 Hz			

Methods for measuring, evaluating and assessing whole-body vibration and repeated shock are also given in ISO 2631-1 Mechanical vibration and shock - Evaluation of human exposure to whole-body vibration - Part 1: General requirements (ISO 1997). However, ISO 2631 does not explicitly state vibration exposure limits relating to human health.

4.3 Project–Environment Interactions and Effects

Interactions are expected to occur between the atmospheric environment and Project activities during the construction, operation, final closure and post closure Project phases. These are ranked according to the potential for an activity to interact with one or more VECs of the atmospheric environment. Ranking of each interaction were assigned as described in Section 3.

Table 4.3-1 Identification of Project-Environmental Effects Interaction – Construction

	Activities	Study Area	Component	Noise	Vibration
Economic Activities	Construction Workforce Management (hiring and training) Contracts and Taxes Advance Training of Operations Workforce			0	0
In-Water Construction	Construct freshwater diversions and site drainage containment systems (dykes, berms, collection ponds)	Site Access	Freshwater diversions	1	1
		Mine Site	Freshwater diversions Site containment dykes and berms Andrew Lake dyke Site runoff ponds Purpose built pit	1	1
	Construct in-water / shoreline structures	Site Access	Wharf construction Ferry crossing Water crossings (culverts and clear span bridges)	2	1
		Mine Site	Water crossings (culverts and clear span bridges) Intake pipelines Effluent pipelines and diffusers		
	Water transfers and discharge	Site Access	Domestic wastewater	1	1
		Mine Site	Andrew Lake dewatering Minor ponds/standing water dewatering Domestic wastewater		
	Freshwater withdrawal	Site Access	Ice flooding winter road	1	1
		Mine Site	Kiggavik site freshwater		
			Sissons site freshwater Ice flooding temporary airstrip		
On-Land Construction	Site clearing and pad construction (blasting, earth-moving, loading, hauling, dumping, crushing) Site clearing and pad construction (blasting, earth-moving, loading, hauling, dumping, crushing)	Site Access	Baker Lake port Winter road All weather road Quarry development	2	2
		Mine Site	Kiggavik, including pit stripping		
		Mine Site	Sissons, including pit stripping Airstrip		
			Quarry development		

Table 4.3-1 Identification of Project-Environmental Effects Interaction – Construction

Activities		Study Area	Component	Noise	Vibration
			Haul road and site roads		
	Construct foundations	Site Access	Baker Lake fuel tank farm	2	2
		Mine Site	Mill and powerhouse, tank farms Accommodation complex		
	Construct buildings	Site Access	Emergency shelters Warehouse	2	2
		Mine Site	Mill, powerhouse, mine shops, water treatment plants Accommodation complex and temporary camps Backfill Plant Airstrip shelter		
	Install equipment	Site Access	Generators Baker Lake facility	1	1
			Port crane and fuel off-loading		
		Mine Site	Temporary generators		
			Mill, backfill and water treatment equipment Powerhouse Utility distribution Maintenance Incinerator Communications systems		
	Install and commission fuel tanks	Site Access	Baker Lake tank farm	1	1
		Mine Site	Kiggavik site tank farm Sissons fuel tanks Airstrip jet fuel tanks		
	Mill dry commissioning (water only)	Mine Site		1	1
Supporting Activities	Transport fuel and construction materials	Site Access	Transfers, barging, trucking	2	2
		Mine Site	Transfers		
	Air transport of personnel and supplies	Mine Site		2	1
	Hazardous materials storage and use	Site Access	Baker Lake storage facility	1	1
		Mine Site	Kiggavik and Sissons		
	Explosives storage and use	Site Access		2	2
		Mine Site			

Table 4.3-1 Identification of Project-Environmental Effects Interaction – Construction

Activities		Study Area	Component	Noise	Vibration
	Waste incineration and disposal	Site Access		1	1
		Mine Site			
	Industrial machinery operation	Site Access		2	2
		Mine Site			
	Power generation	Site Access	Baker Lake storage facility	2	2
		Mine Site	Temporary generators		

Table 4.3-2 Identification of Project-Environmental Effects Interaction – Operation

Activities		Study Area	Component	Noise	Vibration
Economic Activities	Workforce Management (hiring and training)			0	0
	Employment				
	Contracts and Taxes				
Mining	Mining ore (blasting, loading, hauling)	Mine Site	East Zone, Centre Zone, Main Zone, Andrew Lake open pits	2	2
			End Grid Underground		
			Haul Road		
	Ore stockpiling	Mine Site	Kiggavik ore stockpile	2	2
			Sissons ore stockpile		
	Mining special waste (blasting, loading, hauling)	Mine Site	East Zone, Centre Zone, Main Zone, Andrew Lake open pits	2	2
			End Grid Underground		
	Special waste stockpiling		Kiggavik special waste stockpile	2	2
			Sissons special waste stockpile		
	Mining clean waste (blasting, loading, hauling)		East Zone, Centre Zone, Main Zone, Andrew Lake open pits	2	2
			End Grid Underground		
	Clean rock stockpiling	Mine Site	Kiggavik clean rock stockpile	2	2
			Sissons clean rock stockpile		
	Mine dewatering	Mine Site	East Zone, Centre Zone, Main Zone, Andrew Lake open pits	2	1
			End Grid Underground		
	Underground ventilation	Mine Site	End Grid Underground	2	1
	Backfill production and underground placement	Mine Site	End Grid Underground	2	2
Milling	Transfer ore to mill	Mine Site		2	2
	Crushing and grinding	Mine Site		2	2
	Leaching and U Recovery	Mine Site		2	1
	U Purification	Mine Site		2	1
	Yellowcake drying and packaging	Mine Site		2	1
	Tailings neutralization	Mine Site		2	1
	Reagents Preparation and Use	Mine Site		2	1
Tailings Management	Pumping and placement of tailings slurry	Mine Site	East Zone, Centre Zone, Main Zone TMFs; pipelines	2	1
	Consolidation of tailings	Mine Site	East Zone, Centre Zone, Main Zone TMFs	2	1
	Pumping of TMF supernatant	Mine Site	East Zone, Centre Zone, Main Zone TMFs; pipelines	2	1
	Create and maintain water levels	Mine Site	East Zone, Centre Zone, Main Zone TMFs	2	1

Table 4.3-2 Identification of Project-Environmental Effects Interaction – Operation

Activities		Study Area	Component	Noise	Vibration
Water Management	Freshwater withdrawal	Site Access	Ice flooding winter road	2	1
		Mine Site	Kiggavik site, potable and industrial use		
			Sissons site, potable and industrial use		
	Potable water treatment	Mine Site	Kiggavik	1	1
			Sissons		
	Collection of site and stockpile drainage	Mine Site	Site runoff ditches and ponds	1	1
			Purpose built pit		
			Snow fencing and clearing		
			Stockpile drainage collection		
	Water and sewage treatment	Mine Site	Kiggavik water treatment plant	2	1
			Sissons water treatment plant		
	Discharge of treated effluents (including grey water)	Site Access	Domestic wastewater	1	1
		Mine Site	Kiggavik treated effluent		
			Sissons treated effluent		
			Clean waste stockpile excess runoff		
Waste Management	Disposal industrial waste	Mine Site	Kiggavik and Sissons	1	1
	Management of hazardous waste	Mine Site	Kiggavik and Sissons	1	1
	Management of radiologically contaminated waste	Mine Site	Kiggavik and Sissons	1	1
	Disposal of domestic waste	Mine Site	Kiggavik and Sissons	1	1
	Incineration and handling of burnables	Mine Site	Kiggavik incinerator	2	1
	Disposal of sewage sludge	Mine Site	Kiggavik and Sissons	1	1
General Services	Generation of power	Site Access	Baker Lake Facility generator	2	1
		Mine Site	Kiggavik powerhouse		
			Sissons powerhouse		
			Power transmission lines	1	1
	Operate accommodations complex	Mine Site	Cafeteria, recreation areas, quarters	1	1
	Recreational activities	Mine Site		0	0

Table 4.3-2 Identification of Project-Environmental Effects Interaction – Operation

Activities		Study Area	Component	Noise	Vibration
	Maintain vehicles and equipment	Mine Site	Shops and wash bays	2	1
	Maintain infrastructure	Site Access	Roads, bridges, culverts, cable ferry, Baker Lake facility	1	1
		Mine Site	Site pads, roads, bridges, culverts, airstrip, buildings		
	Operate airstrip	Mine Site	Arrivals, departures, transfer materials, planes + helicopters (EN-BL EL 2012[29]; EN-BL CLC 2013[30]);	2	1
	Hazardous materials storage and handling (reagents, fuel and hydrocarbons)	Site Access	Baker Lake storage	1	1
		Mine Site	Kiggavik and Sissons		
	Explosives storage and handling	Site Access	Baker Lake storage	1	1
		Mine Site	Kiggavik and Sissons		
Transportation	Marine transportation	Site Access	Loading barges, barging, off-loading; fuel, reagents and supplies; Baker Lake and Churchill/Chesterfield; back-haul	2	1
	Truck transportation	Site Access	Fuel, reagents and supplies; winter road and/or all-weather road; cable ferry operation	2	2
	General traffic (project-related)	Site Access		2	1
		Mine Site			
	Controlled public traffic	Site Access		1	1
	Air transportation of personnel, goods and supplies	Mine Site		2	1
	Air transportation of yellowcake	Mine Site	Handling and transport of yellowcake to Points North	2	1
	General air transportation support	Mine Site	Airplanes + helicopters (EN-BL EL 2012[31]; EN-BL CLC 2013[32]); medivac, inspections, exploration, monitoring	2	1
On-going Exploration	Aerial surveys	Mine Site		2	1
	Ground surveys	Mine Site		1	1
	Drilling	Mine Site		2	2

[29] EN-BL EL 2012: *Helicopters are very noisy every day in the spring and summer.*
[30] EN-BL CLC 2013: *It's not only AREVA's choppers but there are a lot of other companies' choppers.*
[31] EN-BL EL 2012: *Helicopters are very noisy every day in the spring and summer.*
[32] EN-BL CLC 2013: *It's not only AREVA's choppers but there are a lot of other companies' choppers.*

Table 4.3-3 Identification of Project-Environmental Effects Interaction – Final Closure

	Activities	Study Area	Component	Noise	Vibration
General	Decommissioning Workforce Management (hiring and training)			0	0
	Contracts and Taxes				
	Hazardous materials storage	Site Access	Storage at Baker Lake port	1	1
		Mine Site			
	Industrial machinery operation	Site Access		1	1
		Mine Site			
In-Water Decommissioning	Remove freshwater diversions; re-establish natural drainage	Mine Site	Headwater stream channel Centre Zone Andrew Lake berm	1	1
	Remove surface drainage containment	Site Access	Site runoff pond Baker Lake port	1	1
		Mine Site	Site containment dykes and berms Monitoring ponds Site runoff pond, Kiggavik, Sissons		
	Remove in-water/shoreline structures	Site Access	Wharf removal Cable ferry Water crossings (culverts) Clear span bridges	1	1
		Mine Site	Freshwater pipelines Effluent pipeline Intakes Diffusers		
	Water transfers and discharge	Site Access	Domestic wastewater	1	1
		Mine Site	Andrew Lake flooding		
			PBP flooding Domestic wastewater		
	Construct fish habitat as per FHCP	Site Access	Baker Lake	1	1
		Mine Site	In-pit		

Table 4.3-3 Identification of Project-Environmental Effects Interaction – Final Closure

	Activities	Study Area	Component	Noise	Vibration
On-Land Decommissioning	Remove site pads (blasting, earth-moving, loading, hauling, dumping)	Site Access	Baker Lake port Winter road Site roads AWR	1	1
		Mine Site	Kiggavik, including pits and stockpiles Sissons, including mines and stockpiles Airstrip Quarry development Haul road		
	Backfilling	Mine Site	Special waste into TMFs and pits Underground mine stabilization	1	1
	Contouring	Site Access	Quarries	1	1
		Mine Site	Clean waste rock piles		
	Covering	Mine Site	TMFs Landfills	1	1
	Revegetation	Site Access	Baker Lake port	1	1
			Thelon crossing Quarries		
		Mine Site	Kiggavik site pad Sissons site pad Clean waste rock piles TMFs Airstrip		
	Remove foundations	Site Access	Baker Lake fuel tank farm	1	1
		Mine Site	Mill and powerhouse buildings, Kiggavik fuel tanks		
			Sissons fuel tanks and WTP Accommodation complex		

Table 4.3-3 Identification of Project-Environmental Effects Interaction – Final Closure

Activities		Study Area	Component	Noise	Vibration
	Remove buildings	Site Access	Emergency shelters	1	1
			Warehouse		
		Mine Site	Backfill Plant		
			Kiggavik structures		
			Sissons structures		
			Airstrip shelter		
			Accommodation complex and potable WTP		
	Remove equipment	Site Access	Temporary generators - Baker Lake	1	1
			Port crane and fuel off-loading		
		Mine Site	Mill equipment		
			Power house equipment		
			Utility distribution		
			Incinerator		
	Remove fuel tanks	Site Access	Baker Lake tank farm	1	1
		Mine Site	Kiggavik site tank farm		
			Sissons fuel tanks		
			Airstrip jet fuel tanks		

Noise and vibration effects from construction and operation activities with an interaction ranking of two could potentially result in a human health effect. The potential human health effects of these activities on the VECs are the primary focus of this environmental assessment.

The construction, operation and final closure activities with an interaction ranking of one are not expected to generate substantive noise or vibration effects, would be of limited frequency and duration and/or would be overshadowed by other more substantive activities with interaction rankings of two. Activities with an interaction ranking of zero were not considered to have an interaction and were not included in the assessment.

In summary, the noise and vibration assessment for the Project addresses increased noise and vibration levels that could result in changes to human health (i.e., annoyance / disturbance). Specific issues for the two subject valued environmental components (VECs) are described in the scope of assessment for each VEC.

4.4 Valued Components, Indicators and Measurable Parameters

Criteria for selecting noise and vibration VECs included:

- Do they represent a broad human environment component that may be affected by the Project?
- Are they vulnerable to the environmental effects of the Project and other activities in the region?
- Have they been identified as important issues or concerns during Inuit, government and stakeholder engagement or in other effects assessments in the region?

Based on the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011), noise and vibration were separated into two VECs:

- VEC 1 – Noise
- VEC 2 – Vibration

Human receptors present in the assessment area may be sensitive to changes in noise and vibration levels.

4.4.1 VEC 1 – Noise

Noise was identified as a VEC because of the potential for increased noise levels from Project activities to generate human health effects in the residential areas of Baker Lake and at semi-permanent hunting camps surrounding the Mine Development Area. Potential human health effects include increased annoyance and sleep disturbance. Effects of noise on human health are assessed by determining the predicted SPLs (dBA) from Project activities. The following table lists the measurable parameters used to assess Project effects from increased noise levels and the rationale for their selection.

Table 4.4-1 Measurable Parameters for Noise

Environmental Effect	Measurable Parameter(s)	Rationale for Selection
Increased noise levels	• change in SPLs (Leq, DNL) • change in community annoyance (% Ha) • sleep disturbance	• potential to affect human health • community, government, stakeholder engagement • regulatory drivers • professional judgment

4.4.2 VEC 2 – Vibration

Vibration was identified as a VEC because of the potential for vibrations from Project activities to generate human health effects in the residential areas of Baker Lake and at semi-permanent hunting camps surrounding the Mine Development Area. Potential human health effects include changes in annoyance and sleep disturbance. Effects of vibration on human health are assessed by determining the predicted PPV levels (mm/s) from Project activities. The following table lists the measurable parameters used to assess Project effects from perceptible vibration levels and the rationale for their selection.

Table 4.4-2 Measurable Parameters for Vibration

Environmental Effect	Measurable Parameter(s)	Rationale for Selection
Perceptible vibration levels	• PPV levels • change in community annoyance • sleep disturbance	• potential to affect human health • community, government, stakeholder engagement • regulatory drivers • professional judgment

4.5 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).

4.5.1 Project Footprint

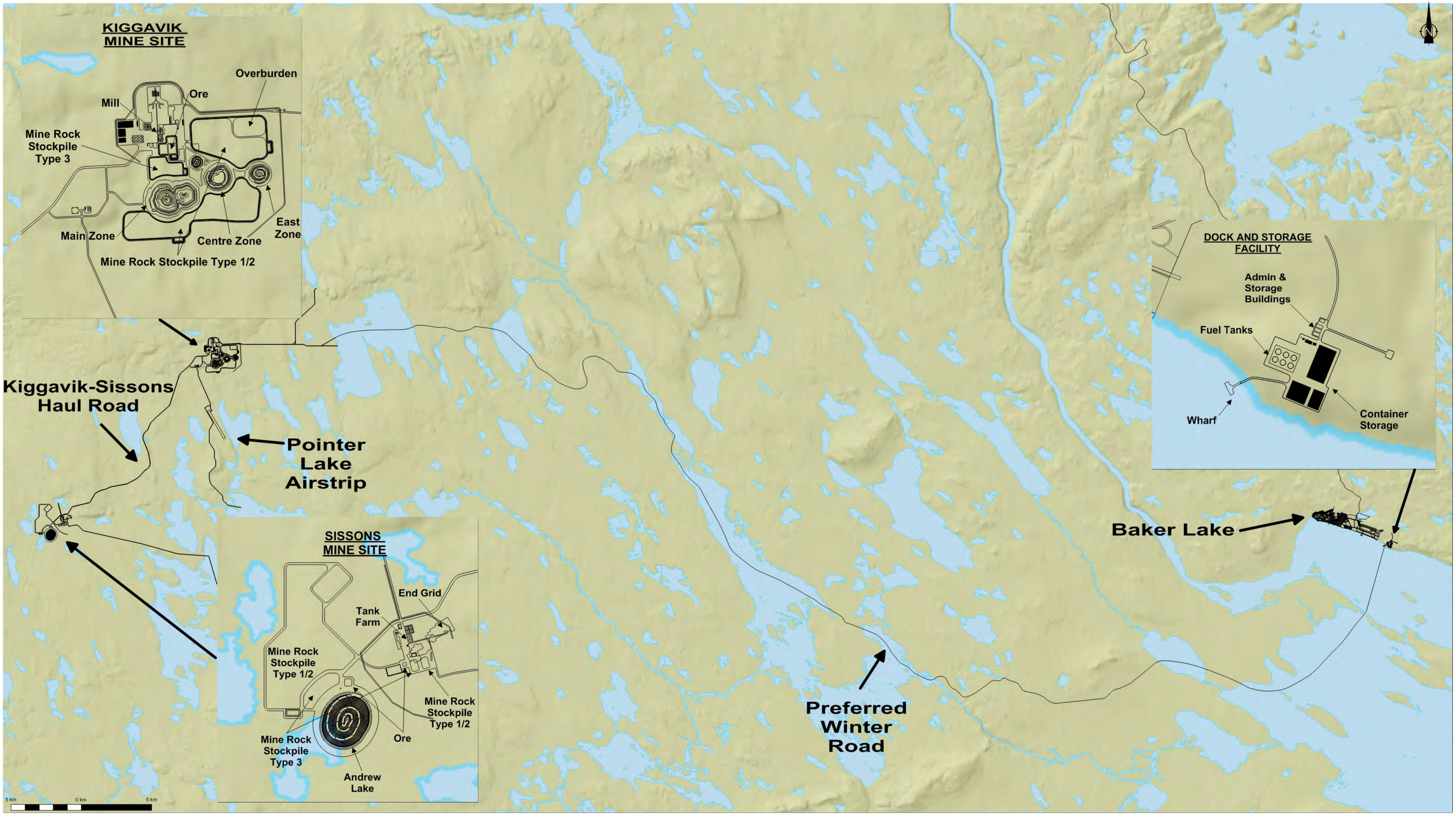
The Project footprint consists of three components: the Kiggavik and Sissons Mine Sites and interconnecting Kiggavik-Sissons Haul Road (collectively referred to as the Mine Development Area), the Dock and Storage Facility, and the access road between Baker Lake and the Mine Development Area. For the purpose of this assessment, the preferred alternate for the access road is the Winter Road. However, the All-Season Road option has also been considered in the assessment.

The Kiggavik Mine Site, located approximately 80 kilometres (km) west of the community of Baker Lake, includes three open pit mines (East Zone Pit, Center Zone Pit and Main Zone Pit), waste rock and ore stockpiles, and ore processing and auxiliary facilities. The Sissons Mine Site, located approximately 17 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 and Sissons Mine Sites are connected by a 20 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 two and a half kilometres southeast of the community of Baker Lake, will act as a transfer station between the marine and road transportation routes. The preferred option for the transportation route between the Mine Development Area and Dock and Storage Facility is the 100 km Winter Road. The Project footprint is illustrated in Figure 4.5-1.

4.5.2 Local Assessment Area

The LAA is defined by two functional areas; (1) the Mine Development Area, inclusive of the Kiggavik Mine Site, the Sissons Mine Site and the Kiggavik-Sissons Haul Road (as defined by the mineral lease boundaries), and (2) the preferred Winter Road and Dock and Storage Facility. The LAA is illustrated in Figure 4.5-2.



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 4.5-1

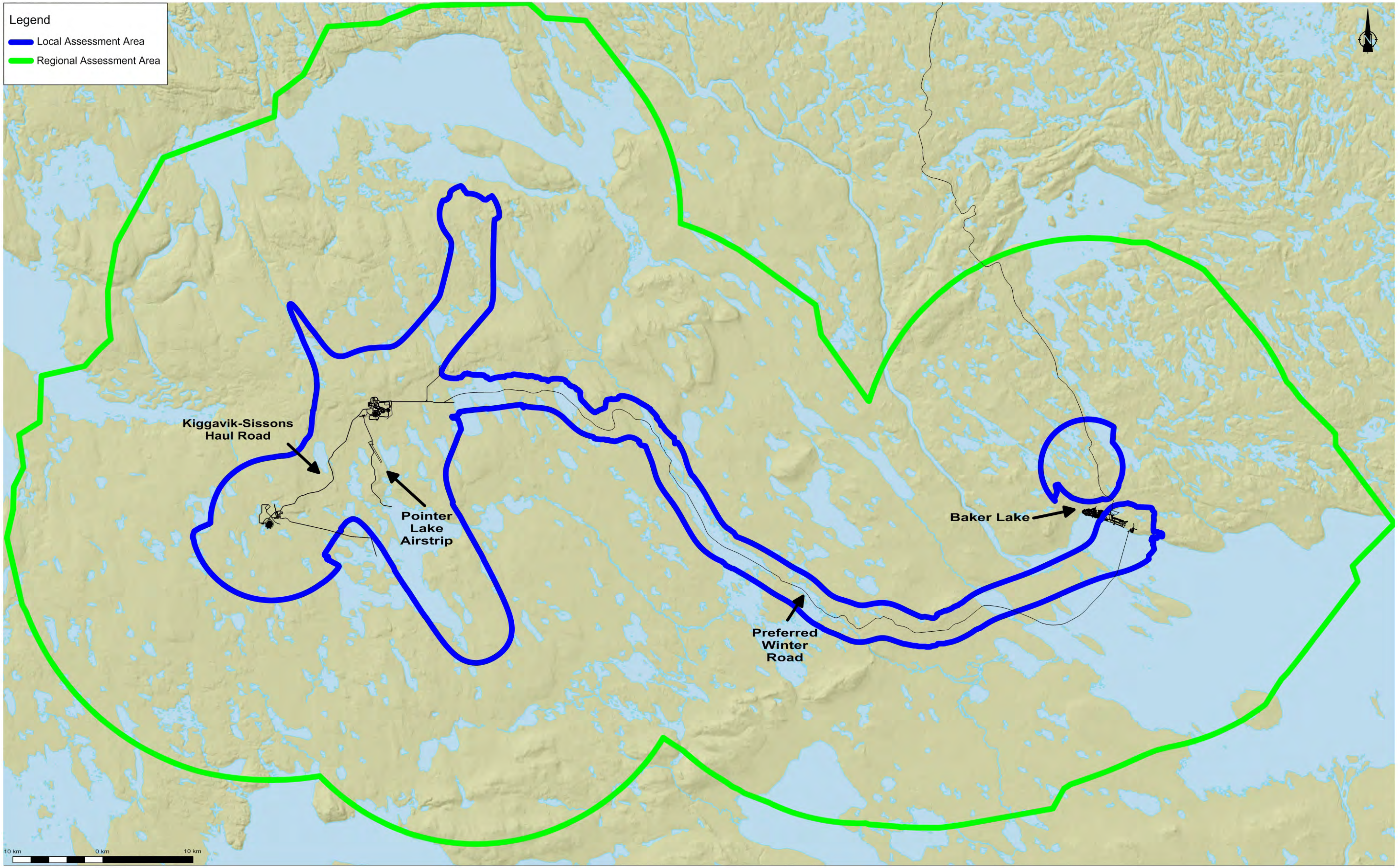
PROJECT FOOTPRINT

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT

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 4.5-2

LOCAL AND REGIONAL ASSESSMENT AREAS

ENVIRONMENTAL IMPACT STATEMENT
VOLUME 4: ATMOSPHERIC ENVIRONMENT

KIGGAVIK PROJECT

AREVA

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

4.5.3 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. Areas outside of the regional assessment area would be expected to be exposed to Project noise and vibration levels that are substantially less (EN-CI KIA 2007). For noise and vibration related effects, the RAA includes the broader area around Baker Lake inclusive of the Meadowbank All-Season Road and barge landing facility, the Baker Lake Airport, and the Project exploration and field study activities. This area is defined by a 20 km buffer area extending beyond the LAA. The RAA is illustrated in Figure 4.5-2.

4.6 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, final closure and post closure. The total life of the Project during which noise and vibration effects will occur from Project related activities is expected to be approximately 20 years. Since the level of activity from each of the Project phases differs, the extent of any related potential effects will also differ. For this reason, the assessment of potential noise and vibration effects of the Project has been considered as follows:

- Maximum Construction / Final Closure / Post Closure - The maximum construction scenario considered (1) construction of the Dock and Storage Facility, (2) simultaneous full-scale construction of the Kiggavik Mine Site and Sissons Mine Site infrastructure, and (3) construction of the Winter Road, including quarry operations. 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 and Sissons Mine Sites is not likely; however, it was considered as the most conservative bounding assumption possible for this scenario. The bounding scenario for the construction of the Winter 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. Furthermore, the maximum final closure and post closure scenarios were determined to be bounded by the maximum construction scenario.
- Maximum Operation - The maximum operation scenario was considered to be the simultaneous full-scale operation of the Mine Development Area, Winter Road, and Dock and Storage Facility. Activities for this scenario include Main Zone Pit and Andrew Lake Pit open pit mining, End Grid Ore Zone underground mining, waste rock and ore stockpiling, mill operations (ore processing, power generation, etc.), tailings management, road transportation of ore, fuel, reagents and supplies, air transportation of yellowcake and personnel, and exploration and surveying activities.

Refer to Tier 3 Technical Appendix 4E (Noise and Vibration Impact Assessment) for maximum construction and operation noise sources and assumptions.

4.7 Administrative and Technical Boundaries

The noise and vibration assessment is subject to some technical limitations due to a lack of scientific information with which to inform effects predictions. 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, 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 Technical Appendix 2B (Drilling and Blasting Design and Related Regulatory Considerations); and
- Specific vibration data for each piece of equipment that would be operating were not available. Vibration predictions for heavy equipment operations were based on published vibration information for similar equipment.

These technical limitations were overcome by using conservative estimation techniques and professional judgment. Technical Appendix 4E (Noise and Vibration Impact Assessment) provides a detailed account of assumptions that have been used in the assessment.

4.8 Environmental Effects Criteria

Project environmental effects on the atmospheric environment are typically assessed in quantitative terms through comparison to noise and vibration guidelines. Project effects criteria are based on human health effects that are associated with sleep disturbance and annoyance. For the purposes of this analysis, an impact was considered to be significant and to require mitigation if it would result in any of the following:

- Exposure of humans to, or generation of, noise levels in excess of regulatory / guidance criteria; or
- Exposure of humans to, or generation of, vibration in excess of regulatory / guidance criteria.

Project effects criteria are defined by the regulatory / guidance criteria presented below. A human health effect is evaluated by comparing the overall noise and vibration levels of the Project (including baseline) to these regulatory / guidance criteria. If the predicted noise and vibration levels (including baseline) are less than these criteria then no human health effect is anticipated. The residual effects are then assessed based on the incremental change in noise and vibration relative to baseline.

The residual effects criteria for the magnitude of these changes in noise and vibration are discussed in greater detail in Section 4.8.1.

Table 4.8-1 Summary of Airborne Noise Project Effects Criteria

Descriptor	Regulatory / Guidance Criteria		
	Day time (Leq, 16 hour)	**Night time (Leq, 8 hour)**	**24 Hour**
Continuous Noise - Disturbance / Annoyance	50 dBA	45 dBA	6.5 %Ha

Table 4.8-2 Summary of Ground-borne Noise and Vibration Project Effects Criteria

Descriptor	Regulatory / Guidance Criteria	
	PPV	**Over-pressure**
Impulsive (Blasting) Air Blast – Disturbance / Annoyance	NA	120 dB
Impulsive (Blasting) Vibration – Disturbance / Annoyance	10 mm/s	NA
Continuous Vibration – Disturbance / Annoyance	0.2 mm/s	NA
NOTE: NA – Not applicable		

4.8.1 Descriptors for Residual Effects of the Environment on Noise and Vibration

Table 4.8-3 presents the descriptors used for describing the residual effects of the Project on noise and vibration. Sections 4.8.1.1 and 4.8.1.2 provide additional details on the residual effects criteria for magnitude.

The magnitude of the change in sound levels created by the Project was ranked according to the criteria described below. The magnitude of change is addressed through comparisons of the baseline sound level to the predicted total sound level (i.e., Project Case plus Base Case) at the sensitive receptors.

Table 4.8-3 Definitions of Criteria Used in the Description of Residual Effects for Noise and Vibration

Direction	**Magnitude** (see Tables 4.8-6 and 4.8-8)	Geographic Extent	Duration	Reversibility	Frequency	Likelihood	Socio-Economic Context
Positive an improvement in noise and vibration levels Adverse a deterioration in noise and vibration levels Neutral no notable change in noise and vibration levels	Negligible an effect on noise and vibration levels that is below the threshold of perception Low an effect on noise and vibration levels that is around the threshold of perception Moderate an effect on noise and vibration levels that is above the threshold of perception and is therefore detectable, but does not pose a serious problem to human health High an effect on noise and vibration levels that is above the threshold of perception and poses a serious problem (e.g., noise levels exceeding applicable criteria)	Project footprint the effect is confined to the project footprint Local the effect occurs within the local assessment area (LSA) Regional the effect extends beyond the local assessment area (RAA)	Short Term less than 2 years in duration Medium Term between 2 and 20 years Long Term more than 20 years to a maximum of 10 years following decommissioning and abandonment Permanent effects that persist more than 10 years after decommissioning and abandonment are considered to be permanent	Reversible the VEC will recover from an environmental effect Not Reversible the VEC will not recover from an environmental effect	Once Sporadic Regular (i.e., occurs on a regular basis and at regular intervals) Continuous	L: Low probability of occurrence. M: medium probability of occurrence. H: High probability of occurrence.	Negligible: No implications to human health, well-being or quality of life Level I: No implications to human health, well-being or quality of life but some changes in annoyance / disturbance levels; potential effects on individuals within populations Level II: Implications to human health, well-being or quality of life; potential population level effects

4.8.1.1 Airborne Noise

Various government and research institutions have proposed criteria that attempt to relate changes in noise levels to community response. One commonly applied criterion for estimating response is the estimated community response to noise provided in the Bureau of Indian Standards (BIS) Assessment of Noise with Respect to Community Response (BIS 2001) as shown below. This scale relates changes in noise level to the degree of community response and allows for direct estimation of the probable response of a community to predicted changes in noise level.

Table 4.8-4 Estimated Community Response to Noise

Amount in dB(A) by which the Rating Sound Level L_r Exceed the Noise Criterion	Estimated Community Response	
	Category	**Description**
0	None	No observed reaction
5	Little	Sporadic complaints
10	Medium	Widespread complaints
15	Strong	Threats of community reaction
20	Very strong	Vigorous community action
SOURCE: BIS 2001		

Fundamentals and Abatement of Highway Traffic Noise prepared for the Federal Highway Administration (Bolt, Baranek and Newman, Inc. 1973) also provides a process for the assessment of the magnitude of effects and application of noise control measures as presented below.

Table 4.8-5 Human Perception of Sound

Change (dBA)	Human Perception of Sound
2-3	Barely perceptible
5	Readily noticeable
10	A doubling or halving of the loudness of sound
20	"Dramatic change"
40	Difference between a faintly audible sound and a very loud sound
SOURCE: Bolt Baranek and Neuman, Inc. 1973	

These guidelines allow for the estimation of an individual's perception of changes in noise levels. Generally, changes in noise levels less than 3 dBA are barely perceptible to most individuals, whereas a 10 dBA change is normally perceived as a doubling in loudness. Cowan (1994) states that the human ear cannot perceive increases up to 3 dB and changes in sound level from 3 dB to 5 dB may be perceived but are generally not intrusive. On the basis of the above information the following table defines the magnitude of noise effects.

Table 4.8-6 Summary of Airborne Noise Residual Effects Criteria for Magnitude

Descriptor	Residual effects criteria Magnitude (Change Relative to Baseline)			
	Negligible	Low	Moderate	High
Continuous Noise - Disturbance/ Annoyance	<3 dBA	3 to < 5 dBA	5 to 10 dBA	>10 dBA
	<1 %Ha	1 to <3 %Ha	3 to 6.5 %Ha	>6.5 %Ha
SOURCE: BIS 2001; Bolt Baranek and Neuman, Inc. 1973; Cowan 1994				

4.8.1.2 Ground-borne Noise and Vibration

Human response to ground vibration is a relatively complex phenomenon and is dependent upon a range of factors. It is recognized that the human body is very sensitive to the onset of vibration albeit very poor at distinguishing relative magnitudes. Although sensitivity to vibration varies between individuals, a person would generally become aware of vibration at levels of around 0.2 to 0.5 mm/s peak particle velocity (PPV) (Bender 1996, Wiss 1981). A summary of the average human response to ground vibration (PPV) and air overpressure (dB) is provided below.

Table 4.8-7 Summary of Magnitude of Vibration Effects

Response	PPV (mm/s)	Overpressure (dB)
Barely to distinctly perceptible	0.2 to 2.5	50 to 70
Distinctly perceptible to strongly perceptible	2.5 to 12.7	70 to 90
Strongly perceptible to mildly unpleasant	12.7 to 25.4	90 to 120
Mildly unpleasant to distinctly unpleasant	25.4 to 50.8	120 to 140
Distinctly unpleasant to intolerable	50.8 to 254	140 to 170
SOURCE: Bender (1996); Wiss (1981)		

These data allow for the estimation of an individual's perception of changes in vibration and air overpressure levels. Generally, changes in vibration levels less than 0.5 mm/s are imperceptible to most individuals, whereas a change greater than 2.5 mm/s is normally strongly perceptible.

Table 4.8-8 Summary of Groundborne Noise and Vibration Residual Effects Criteria for Magnitude

Descriptor	Residual effects criteria Magnitude (Change Relative to Baseline)			
	Negligible	**Low**	**Moderate**	**High**
Impulsive (Blasting) Air Blast – Disturbance / Annoyance	<50 dB	70 to 120 dB	120 to 140 dB	>140 dB
Impulsive (Blasting) Vibration - Disturbance / Annoyance	<0.5 mm/s	0.5 to 10 mm/s	10 to 25 mm/s	>25 mm/s
Continuous Vibration – Disturbance / Annoyance	<0.2 mm/s	0.2 to 0.5 mm/s	0.5 to 2.5 mm/s	>2.5 mm/s

4.9 Standards or Thresholds for Determining Significance

Under the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) and the Canadian Environmental Assessment Act, the environmental assessment must include a determination of the significance of environmental effects. Threshold criteria were developed for each VEC, based on the measurable parameters beyond which a residual environmental effect would be considered significant. Thresholds for effects on noise and vibration are described in Sections 6 and 7.

4.10 Influence of Inuit and Stakeholder Engagement on the Assessment

As part of the consultation process for the Kiggavik Project, AREVA has conducted a community tour, held public open houses and conducted IQ interviews in order identify Project-specific issues and concerns and to gain a better understanding of the value associated with specific VECs. Project-specific issues and concerns identified during Inuit, government and stakeholder engagement were identified in Section 4.1. Where appropriate, these concerns were considered in the noise and vibration assessment. Below, the issues and concerns have been summarized in Table 4.10-1 together with an identification of the document and where the issue is specifically addressed.

Table 4.10-1 Stakeholder Concerns Relating to Air Quality and Climate Change

Issue	Document
Concerns about the process of evaluating noise and vibration impacts in relation to the Project and the need to ensure that appropriate studies were completed to assess potential effects	Volume 4 Appendix 4E
Concern that there was a lack of noise regulations in Nunavut	Volume 4 Appendix 4E
Concern regarding noise from helicopter flyovers, especially in light of the existing helicopter traffic from other operators in Baker Lake	Volume 4 Appendix 4E

5 Summary of Existing Environment – Noise and Vibration

5.1 Noise

5.1.1 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 below.

Table 5.1-1 Ambient Monitoring Data from McClean Lake

Period	Minimum Hourly Leq (dBA)	Overall Leq (dBA)
Day time (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, as discussed in section 5.1.1 below.

5.1.2 NIRB Literature Review

An analysis of noise effects assessments submitted to NIRB was completed to identify noise and vibration levels in similar environments. The noise impact assessments considered are summarized below.

Table 5.1-2 Summary of Existing Noise Conditions in NIRB EAs

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

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 day time (16-hour) and night time (8-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 (De Beers Canada Mining Inc. 2002 and Diavik Diamond Mines Inc. 1998). The day time 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 day time). The overall L_{eq} for the monitoring period was 35 dBA. Existing hourly L_{eq}s at the Snap Lake and Diavik Diamond Mines reportedly ranged from 23 to 40 dBA (Miramar Hope Bay Ltd. 2005). 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 (Rescan, 2007) and Road and High Lake (Wolfden, 2006) noise impact assessments relied on the same data as that used for the Snap Lake and Diavik Diamond Mines. These assessments also used a L_{eq} of 35 dBA for existing sound levels.

5.1.3 Existing 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 day time (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. It should be noted that, the relative contribution of the Agnico-Eagle Meadowbank Mine (haul road) and Baker Lake Airport were assumed to be captured in the existing baseline noise levels.

5.2 Vibration

No information was available to establish baseline vibration within the Project area. It is expected that vibration levels are not perceptible (i.e., less than 0.2 mm/s). 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. However, these existing vibration sources are not expected to generate any substantive vibration impact at the nearest sensitive human receptor.

6 Effects Assessment for Noise

The effects of the Project on the noise VEC is increased ambient sound levels that could result in changes in human health (i.e., annoyance / disturbance) as determined by regulatory or health standards or guidelines.

6.1 Assessment of Changes in Ambient Sound Levels – Preferred Option

6.1.1 Analytical Methods

Environmental noise assessment requires the use of a variety of different analytical methods (e.g., computer models, manual calculations, professional judgement). The specific methods employed in this assessment are briefly described below:

- The Cadna-A predictive noise model (Datakustiks 2010a and 2010b) was used to assess noise impacts from other continuous and semi-continuous Project activities. The Cadna-A model is based upon ISO standard 9613: Attenuation of sound during propagation outdoors; Part 2: General Method of Calculation (ISO 1996). The Cadna-A visual interface allows the user to create a three-dimensional representation of the project site and surrounding area, and place a variety of source types at locations representing those where the associated work is expected to be undertaken. Calculated sound level data are applied to each source as appropriate, and the model calculates the sound level due to the distance between the source(s) and user-specified points of reception and accounts for any 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. Cadna-A calculates the individual impact of each noise source at each defined point of reception;
- A combination of measured sound level data from AREVA's McClean Lake Operation, equipment specifications and measured data contained in SENES' in-house noise database, standard noise calculation techniques, and professional judgment were used to establish sound levels emanating from sources of noise associated with the Project;
- 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 paper *"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); and

- Impulse noise from blasting (airblast overpressure) was assessed using U.S. Bureau of Mines (Siskind, et al, 1980) equations and constants.

The above data were combined into a list of "Noise Sources and Assumptions", which outlines the key assessment scenarios (operation and construction), equipment details, the quantity and location of the equipment, key assumptions, and sound power levels. Additional details are provided in the Tier 3 Environmental Assessment Report, Volume 4: Atmospheric Environment, Appendix 4E: Noise and Vibration Impact Assessment.

The criteria presented in Section 4.8 for the assessment of noise impacts on human health were applied at sensitive points of reception (PORs) within the LAA and RAA. A total of three receptors were identified as being representative of the most sensitive PORs in the vicinity of the Project. Receptors R1 and R2 are residences located in Baker Lake that would be the most exposed to construction and operation activities occurring at the Dock and Storage Facility and Winter Road, including the closest potential quarry location. Receptor R3 is a seasonal hunting camp located southeast of the Pointer Lake Airstrip at the inlet to Judge Sissons Lake and would be exposed to the Mine Development Area.

Table 6.1-1 Summary of Sensitive Points of Reception

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

NOTES:

[a] Additional seasonal hunting camps and recreational camps may be present within the RAA. This location is the closest known semi-permanent hunting camp location based on information provided by AREVA.

[b] A height of 1.5 m above grade was used to represent an average height of exposure of an individual.

6.1.2 Effect Mechanism and Linkages

The Project-environment interactions and effects described above in Section 0 and listed in Table 4.3-1 and Table 4.3-3 for the construction and operation Project phases, respectively, form the basis for the noise assessment effects mechanisms and linkages. The Project noise effects relate to equipment operating noise and groundborne blasting noise and have the potential to cause annoyance and sleep disturbance to humans.

Construction

The potential environmental effects associated with in-water and on-land construction and supporting activities that could result in increased ambient sound levels include:

- Continuous airborne noise produced by heavy equipment used in the site preparation, quarry operations and in the construction of the Mill complex;
- Semi-continuous airborne noise produced by air traffic (including helicopters) (EN-BL EL 2012[33]; EN-BL CLC 2013[34]) and pile driving (i.e., building foundations); and
- Impulsive groundborne noise produced by blasting.

Operation

The potential environmental effects associated with mining, milling, tailings management, water management, waste management, general services, transportation, and on-going exploration that could result in increased ambient sound levels include:

- Continuous airborne noise produced by heavy equipment associated with open pit mining and underground mining activities,
- Continuous airborne noise produced by mill operations, including crushing, screening, yellowcake processing, water/wastewater treatment and power generation;
- Continuous airborne noise produced by the Dock and Storage Facility operations, including offloading and heavy equipment usage;
- Semi-continuous airborne noise produced by truck traffic (along haul roads and access roads), air traffic (including helicopters) (EN-BL EL 2012[35]; EN-BL CLC 2013[36]);and exploration drilling; and
- Impulsive groundborne noise produced by blasting.

Refer to the Tier 3 Environmental Assessment Report, Volume 4: Atmospheric Environment, Appendix 4E: Noise and Vibration Impact Assessment for a more detailed description of noise sources and assumptions applied in the noise assessment.

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[33] EN-BL EL 2012: *Helicopters are very noisy every day in the spring and summer.*

[34] EN-BL CLC 2013: *It's not only AREVA's choppers but there are a lot of other companies' choppers.*

[35] EN-BL EL 2012: *Helicopters are very noisy every day in the spring and summer.*

[36] EN-BL CLC 2013: *It's not only AREVA's choppers but there are a lot of other companies' choppers.*

6.1.3 Mitigation and Project Design

In general, the Project will employ standard operating procedures for equipment/machinery and ensure that regular maintenance is performed in accordance with good engineering practices or as recommended by suppliers such that the equipment is kept in good operating condition. As well, the Project proponent will adhere to conditions outlined in all permits, authorizations and/or approvals. Procedures will also be developed to address community complaints.

6.1.4 Residual Effects

The noise effects associated with any specific activity would depend on the type of activity, the type and number of pieces of equipment in use, the noise level generated by the various pieces of equipment, the duration of the activity, the distance between the activity and sensitive receptors, and shielding effects that might result from local topography (including the development of stock piles) or buildings.

The analytical methods described above were applied to the Project for the construction and operation phases and the predicted noise levels are presented in Table 6.1-2. Table 6.1-3 shows the predicted change in annoyance (%Ha) during the maximum construction and operation scenarios.

Construction - Airborne Noise

The overall sound levels during the Dock and Storage Facility construction at R1 and R2 are 42.4 and 36.0 dBA, respectively. The incremental change in sound level at R2 is less than three dBA and would be considered negligible. However, a perceptible change of 7.4 dBA may be realized at R1. This change could be considered a moderate level of impact since it is above the threshold of perception (i.e., 3 dBA) but would not pose a serious problem to human health (i.e., less than Project effects criteria). The construction activities at the Dock and Storage Facility are not expected to last more than one year and would be considered short term.

The overall sound levels at R1 and R2 during construction of the Winter Road are 39.1 and 37.0 dBA, respectively. The incremental change in sound level at R2 remains below the threshold of perception and would be considered negligible. The incremental change in sound levels at R1 is 4.1 dBA is slightly above the threshold of perception and would be considered a low level of impact.

The predicted sound level at R3 during the construction of the Mine Development Area was 15.2 dBA, which is not unexpected given the distance from Project activities to the receptor (i.e., 15 km). As such, construction of the Kiggavik and Sissons Mine Sites would not be perceptible at this receptor location.

The predicted %Ha at R1 and R2 during the Dock and Storage Facility construction were very low (0.94 and 0.70, respectively) and yielded negligible changes (0.26 and 0.02, respectively) in %Ha. Similarly, the Winter Road and Mine Development Area construction scenarios resulted in negligible changes in %Ha (less than 0.1) at R1, R2 and R3.

It should be noted that the construction activities were located at the closest geographic location (i.e., close to the Dock and Storage Facility) that would yield the highest overall sound level at the sensitive receptors. The amount of time the receptor would be exposed to these sound levels is likely limited to a few weeks of initial road construction. As the location of the construction equipment moves further away the sound levels would decrease.

Operation - Airborne Noise

During the operation phase, the overall sound levels at R1 and R2 are 39.7 and 35.7 dBA, respectively. The incremental change in the sound level at R2 remains below the threshold of perception and would be considered negligible. A potentially measurable change of 4.7 dBA may be realized at R1 during operation, which would be considered a low level of impact since it is only slightly above the threshold of perception (i.e., 3 dBA) and would not pose a serious problem to human health.

The day time and night time overall sound levels at R3 are 39.1 and 39.8 dBA, respectively. Potentially measurable changes of 4.1 and 4.8 dBA may be realized at R3 during operations, which could be considered a low level of impact since it is only slightly above the threshold of perception (i.e., 3 dBA) and would not pose a serious problem to human health.

The predicted %Ha during the maximum operation scenario at R1 and R3 were 1.25 and 1.25, respectively. The resultant changes in %Ha at these receptors (0.57 and 0.57, respectively) are negligible and well below the 6.5% criteria. The %Ha at R2 is very low (0.74) and yielded a negligible change of 0.06 in %Ha relative to baseline conditions.

Construction and Operation - Groundborne Noise

With respect to blasting activities completed as part of construction and operation, the predicted air blast overpressure at the closest receptor, R3, is 109 dB, which is less than the Project effects criteria of 120 dB. Air blast overpressure would be perceptible at R3 during blasting; however, the overall magnitude of effect is considered low since it would only occur for a very short period of time (i.e., a single impulsive blast per day), which may or may not coincide with the typical seasonal usage of a hunting camp. Moreover, this prediction does not consider attenuation from local topography, vegetation and other structures.

Groundborne noise from blasting was not assessed for the Baker Lake receptors R1 and R2 as blasting will occur in the Mine Development Area and not in the vicinity of Baker Lake. The closest sensitive receptor to the Mine Development Area, R3, is approximately 15 kilometres from the closest mine in the Mine Development Area. The Baker Lake receptors R1 and R2 are located more than 75 kilometres from the closest mine in the Mine Development Area.

Table 6.1-2 Summary of Predicted Sound Levels During Construction and Operation

Scenario	Receptor ID	Time of Day	Baseline Sound Level (dBA)	Predicted Sound Level, Leq (dBA)	Overall Sound Level, Leq (dBA)	Project Effects Criteria, Leq (dBA)	Incremental Change[c] (dBA)
Construction – Dock and Storage Facility	R1	Day[a]	35	41.5	42.4	50	7.4
	R2	Day[a]	35	29.3	36.0	50	1.0
Construction – Winter Road	R1	Day[a]	35	36.9	39.1	50	4.1
	R2	Day[a]	35	32.8	37.0	50	2.0
Construction – Mine Development Area	R3	Day[a]	35	15.2	35	50	NC
Operations – Kiggavik Project	R1	Day	35	37.9	39.7	50	4.7
		Night	35	37.9	39.7	45	4.7
	R2	Day	35	27.3	35.7	50	0.7
		Night	35	27.3	35.7	45	0.7
	R3	Day[b]	35	36.9	39.1	50	4.1
		Night[b]	35	38.0	39.8	45	4.8

NOTES:

[a] Does not apply at night since construction occurs during day time hours

[b] Differences in the day time and night time predictions are associated with varying day time and night time aircraft operations of the Pointer Lake airstrip. Additional details are provided in Tier 3 Environmental Assessment Report, Volume 4: Atmospheric Environment, Appendix 4E: Noise and Vibration Impact Assessment - Attachment B,

[c] Incremental change is the difference between the Overall Sound Level and Baseline Sound Level.

Table 6.1-3 Summary of Predicted Changes in Annoyance During Construction and Operation

Scenario	Receptor ID[a]	Baseline (B)		Maximum including Baseline (M)		Change in %Ha[c] (M%Ha – B%Ha)
		Sound Level DNL (dBA)[b]	B%Ha	Overall Sound Level DNL (dBA)[b]	M%Ha	
Construction – Dock and Storage Facility	R1	41.0	0.68	43.5	0.94	+0.26
	R2	41.0	0.68	41.2	0.70	+0.02
Construction – Winter Road	R1	41.0	0.68	42.0	0.77	+0.09
	R2	41.0	0.68	41.4	0.72	+0.04
Construction – Mine Development Area	R3	41.0	0.68	41.0	0.68	NC
Operations – Kiggavik Project	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

NOTES:

[a] R3 was not considered is this scenario given the distance away from the Dock and Storage Facility (more than 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)[c] NC = No change in %Ha

6.1.5 Determination of Significance

There are no significant human health effects predicted at any of the sensitive receptors due to increased noise levels during Project construction and operation. In all cases, the overall predicted noise levels are below the Project effects criteria, and in many cases are below the threshold of perception. The predicted change in community annoyance (%Ha) was also well below the 6.5% Ha criteria at all sensitive receptors evaluated.

During construction, the greatest noise effects are predicted to occur at sensitive receptors in Baker Lake that are close to the proposed Dock and Storage Facility. The magnitude of the residual noise effect is expected to be moderate at the closest sensitive receptor location in Baker Lake during the construction of the Dock and Storage Facility. This effect is primarily due to noise from the movement and use of heavy equipment at the Dock and Storage Facility area. The residual noise effect is expected to be short term (i.e., limited to the amount of time required to construct the Dock and Storage Facility area) and would be geographically limited to the LAA. Construction activities at the Kiggavik and Sissons Mine Sites and during the Winter Road construction are not expected to generate any perceptible residual noise effects at the closest sensitive receptors.

Due to the remote location of the Kiggavik and Sissons Sites, the magnitude of residual noise effects at the seasonal hunting camp (R3), at Judge Sissons Lake, during the operational phase of the Project is expected to be negligible. As with the construction and decommissioning scenarios, the residual noise effects would be limited to the LAA and are expected to occur for less than 20 years (medium term) and reversible. These residual effects would primarily be associated with the Pointer Lake Airstrip and milling/mining activities in close proximity to receptors.

The Dock and Storage Facility would continue to be used for the delivery of personnel and materials as the operational phase of the Project begins. The residual noise effects at sensitive receptors in Baker Lake are expected to the less than those experienced during construction; however, the duration of these residual noise effects would be over the medium term rather than the short term. As above, the residual noise effect is limited to the LAA and is considered reversible.

6.2 Assessment of Change in Noise – Other Options

6.2.1 Access Road Options

The assessment of the site access road considered the preferred Winter Road and other option, the All-Season Road. The differences between the Winter Road and the All-Season Road include the geographic alignments as well as the reduced operating window (limited to approximately 90-days for the winter road options), resulting in higher daily traffic volumes during the operating window.

Construction –All-Season Road

The predicted sound levels for the construction of the All-Season Road were all below the day time Project effects criteria and would not cause a human health effect. The overall predicted sound levels at R1 and R2 are 43.5 and 37.9 dBA, respectively, which are higher than those predicted for the preferred option. The incremental change in sound level at R2 is less than 3 dBA and would not be considered perceptible. However, a potentially measurable change of 8.5 dBA may be realized at R1 during construction of the All-Season Road, which would be considered a moderate level of impact. This represents a slightly higher incremental change than the preferred option but would not pose a serious problem to human health.

Note that the construction activities were located at the closest geographic location (i.e., close to the Dock and Storage Facility) that would yield the highest overall sound level at the sensitive receptors. The amount of time the receptor would be exposed to these sound levels is likely limited to a few weeks of initial road construction. As the location of the construction equipment moves further away the sound levels would decrease.

The change in %Ha during the All-Season Road construction scenario were well below the 6.5% threshold where a human health effect would occur. The %Ha during the All-Season Road construction at R1 and R2 were very low (1.01 and 0.74, respectively) and yielded negligible changes in %Ha of 0.33 and 0.68, respectively.

Operation –All-Season Road

The overall sound levels during the All-Season Road operation scenario were all below their respective day time and night time Project effects criteria and would not cause a human health effect. The overall sound levels at R1 and R2 were 39.4 and 35.6 dBA, respectively, which were lower than the preferred option. The incremental change in the sound levels at R2 remains below the threshold of perception and would be considered negligible. A potentially measurable change of 4.4 dBA may be realized at R1 during operation, which would be considered a low level of impact and would not pose a serious problem to human health.

The change in %Ha during the All-Season Road operation scenario was well below the 6.5% threshold where a human health effect would occur. The %Ha during the All-Season Road operation scenario at R1 and R2 were low (1.21 and 0.73, respectively), with negligible changes in %Ha of 0.53 and 0.05, respectively.

The overall day time and night time sound levels at R3 during the All-Season Road operation scenario were 39.1 and 39.8 dBA, respectively, which is identical to the operation of the preferred option described in section 10.1.3 above. Accordingly, the change in %Ha during the All-Season Road operation scenario were identical to the operation of the preferred option.

6.2.2 Dock and Storage Facility Options

The Dock and Storage Facility options (North Shore Site 2 and 3) are greater than six kilometres from the closest receptor in Baker Lake, whereas the preferred Dock and Storage Facility (North Shore Site 1) is approximately two and a half kilometers away. As such, it is expected that the noise would be lower than those presented for the Preferred Option.

6.2.3 Power Plant Options

Two options have been considered for power generation at the Mine Development Area; central power generation (power generation at the Kiggavik Mine Site with transmission lines to the Sissons Mine Site) and de-central power generation (power generation at both the Kiggavik and Sissons Mine Sites). The de-central power generation option is the preferred option and includes five (one standby, one maintenance) 4,190 kW generators at the Kiggavik Mine Site and five (one standby, one maintenance) 1,450 kW generators at the Sissons Mine Site. The central power generation option includes five (one standby, one maintenance) 5,570 kW generators at the Kiggavik Mine Site.

For the purpose of this assessment, the maximum power plant output and maximum overall equipment configuration were used for each Mine Site (i.e., three 5,570 kW generators operating at the Kiggavik Mine Site and three 1,450 kW generators operating at the Sissons Mine Site). This scenario was considered to conservatively bound all power plant options.

6.3 Cumulative Effects Analysis for Noise

6.3.1 Screening for Cumulative Effects Assessment

In addition to assessing the Project construction and operation scenarios, the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) also require the assessment of cumulative effects resulting from operating the Project together with other proposed projects and activities in the RAA.

Noise effects will be generally restricted to the localized area surrounding the Project and will decrease rapidly with distance from the source. The main Project sites and any future projects and activities within the RAA are expected to be of sufficient distance from the Kiggavik Project that there will be no potential for overlap of noise effects at the sensitive receptors. As such, cumulative project effects are not anticpated.

There is a possibility that localized noise levels could increase as a result of increases in truck traffic on future access roads or on one or more of the preferred or alternate roads currently considered in this assessment (i.e., if future projects utilized AREVA's road network). For comparison purposes, a doubling of truck traffic along the preferred access road would nominally increase the predicted noise levels by 3 dBA, which would still be below the Project effects criteria at the most affected receptor.

In all cases, future proposed projects, leases and exploration activities will be located more than 10 km from any of the receptors used for this assessment. However, it is difficult to determine the relative contribution of future infrastructure and facility operations to noise levels in the RAA without more detailed information on these future projects. The relative contribution of existing projects (Agnico-Eagle Meadowbank Mine and Baker Lake Airport) to noise levels were assumed to be captured in the existing baseline (Section 5.1.3).

6.4 Summary of Residual Effects on Noise

6.4.1 Project Effects

A summary of residual effects of project activities related to the maximum construction and operating scenarios are presented in Table 6.4-1. The predicted residual environmental effects will not be significant since changes in noise levels are expected to be minimal, with the exception of some short term construction activities. In all cases, the overall predicted noise levels are below the Project effects criteria, and in many cases are below the threshold of perception. The predicted change in community annoyance (%Ha) was also well below the 6.5% Ha criteria at all sensitive receptors evaluated and was considered negligible during all phases of the Project. The predicted ground-borne noise levels from blasting were below Projects effects criteria and were also considered low.

The noise and vibration effects associated with a specific activity would depend on the type of activity, the types and number of pieces of equipment in use, the noise and vibration level generated by the various pieces of equipment, the duration of the activity, the distance between the activity and any sensitive receptors, and possible shielding effects that might result from local topography (including the development of stock piles) or buildings. There are no significant human health effects predicted at any of the sensitive receptors during construction, operation and final closure. In all cases, the overall predicted noise and vibration levels are below the Project effects criteria, and in most cases are below the threshold of perception. A detailed summary of the residual effects criteria are presented in Table 6.4-1.

During construction, the greatest noise effects are predicted to occur during construction at sensitive receptors in Baker Lake that are close to the proposed Dock and Storage Facility (i.e., R1). The magnitude of the residual noise effect is expected to be moderate at one sensitive receptor location in Baker Lake during the construction of the Dock and Storage Facility. This effect is primarily due to noise from the movement and use of heavy equipment at the Dock and Storage Facility area. The residual noise effect is expected to be short term (< 1 years) and limited to the LAA. Construction activities at the Mine Development Area and during the Winter Road construction are not expected to generate any perceptible residual noise effects at the closest sensitive receptors.

Due to the remote location of the Mine Development Area, the magnitude of residual noise effects at the seasonal hunting camp, at Judge Sissons Lake, during the operational phase of the Project is expected to be negligible. As with the construction and final closure scenarios, the residual noise effects would be limited to the LAA and are expected to be less than 20 years (medium term) and reversible. The Dock and Storage Facility would continue to be used for the delivery of personnel and materials as the operational phase of the Project begins. The residual noise effects at sensitive receptors in Baker Lake are expected to the less than those experienced during construction; however, the duration of these residual noise effects would be over the medium term rather than the short term. As above, the residual noise effect is limited to the LAA and is considered reversible.

Table 6.4-1 Summary of Project Residual Environmental Effects for Noise

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Socio-Economic Context				
Change in Noise Levels – Preferred Option												
Construction – Dock and Storage Facility	Community complaint/ response procedures; Equipment maintenance; Exhaust mufflers; Other operational and administrative measures	A	M	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Construction – Winter Road	Community complaint/ response procedures; Equipment maintenance; Exhaust mufflers; Other operational and administrative measures	A	L	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Construction – Mine Development Area	Community complaint/ response procedures; Equipment maintenance; Exhaust mufflers; Other operational and administrative measures	A	N	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Operations - Kiggavik Project	Community complaint/ response procedures; Equipment maintenance; Exhaust mufflers; Other operational and administrative measures	A	L	L	L	C	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Change in Noise Levels – Other Options												
Construction – All-Season Road	Community complaint/ response procedures; Equipment maintenance; Exhaust mufflers; Other operational and administrative measures	A	M	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Operations – All-Season Road	Community complaint/ response procedures; Equipment maintenance; Exhaust mufflers; Other operational and administrative measures	A	L	L	L	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action

6.4.2 Cumulative Effects

Project activities are not predicted to contribute to cumulative effects on noise levels. .

6.4.3 Effects of Climate Change on Project

Given the duration of the Project, there are no anticipated effects from climate change that would affect Project noise levels.

6.5 Transboundary Effects

There are no anticipated transboundary noise effects associated with the Project.

6.6 Mitigation Measures

Based on the analysis above, there is no predicted human health effects associated with the Project. As such, no specific noise mitigation measures are recommended at this time. However, the following general mitigation measures may be considered to reduce construction and operation noise at the source:

- Developing a community complaint/response procedure to address noise concerns;
- Ensuring site equipment is located as far away as possible from noise sensitive receptors;
- Fitting all gas or diesel-powered equipment with intake (if appropriate) and exhaust silencers (mufflers) meeting manufacturer's recommendations, and maintaining these silencers (mufflers) in effective working condition;
- Carrying out regular maintenance on all equipment, including lubrication and replacement of worn parts, especially exhaust systems;
- Where more than one type/model of equipment or technique can be used to complete a particular job with similar efficiency, using equipment with the lowest overall sound potential;
- Limiting vehicle speeds on access, haul and intermediate roads;
- Restricting vehicle traffic to approved access routes to and from the site;
- Turning off equipment with potential to generate excessive noise when not in use, where feasible;
- Maintaining project road surfaces to reduce tire noise and truck bed/gate banging;
- To the extent possible, routing heavily-loaded trucks away from residential areas;
- To the extent possible, minimize the number of barge shipments and offloading activities. Where possible schedule barge shipments and offloading activities within day-time hours
- To the extent possible, completing activities with the highest noise potential during the day to avoid night time disturbance (i.e., blasting);

- To the extent possible, considering sequential staging of operation of equipment with the highest noise potential; and,
- To the extent possible, selecting ventilation intake/exhaust equipment with low sound levels and/or pre-packaged mitigation measures.

6.7 Compliance and Environmental Monitoring for Noise

Given that noise effects are considered low to moderate and would not generate a human health effect, no specific noise monitoring programs are recommended at this time. Noise effects would be monitored using a complaints/response procedure.

7 Effects Assessment for Vibration

7.1 Assessment of Changes in ambient Vibration Levels – Preferred Option

7.1.1 Analytical Methods

Environmental vibration assessment requires the use of a variety of different analytical methods (e.g., empirical models, manual calculations, professional judgement). The specific methods employed in this assessment are briefly described below:

- Blasting vibration were estimated using the US Bureau of Mines equations (Siskind, et al, 1989), which are based on an estimated mass of explosives and the squared scaled distances to calculate peak vibration levels (particle velocity), respectively. Ground vibration caused by blasting operations is defined as the speed of excitation of particles within the ground resulting from vibratory motion. The intensity of ground vibrations is measured in units of PPV. The bounding blasting scenario consisted of a maximum amount of explosives (kg) (see Technical Appendix 2B) and assumed that there was no attenuation of the blast vibration from nearby structures, terrain and vegetation.
- Typical semi-continuous and continuous vibration levels from key equipment were derived from empirical models. Since site-specific propagation effects are not considered in the available empirical models, an impact-distance table was generated to outline setback distances required to return to the threshold of perception.

The above data were combined into a list of “Vibration Sources and Assumptions”, which outlines the key assessment scenarios (operation and construction), key assumptions, and vibration levels. Additional details are provided in Technical Appendix 4E (Noise and Vibration Impact Assessment).

7.1.2 Effect Mechanism and Linkages

The Project-environment interactions and effects described above in Section 0 and listed in Table 4.3-1 and Table 4.3-2 for the construction and operation Project phases, respectively, form the basis for the vibration assessment effects mechanisms and linkages. The Project vibration effects relate to heavy equipment and blasting vibrations and have the potential to cause annoyance and sleep disturbance to humans.

Construction

The potential environmental effects associated with in-water and on-land construction and supporting activities that could result in perceptible vibration levels include:

- Continuous ground-borne vibrations produced by heavy equipment operations used in the site preparation, quarry operations and in the construction of the Mill complex;
- Semi-continuous ground-borne vibrations produced by pile driving; and
- Impulsive ground-borne vibrations produced by blasting.

Operation

The potential environmental effects associated with mining, milling, tailings management, water management, waste management, general services, transportation, and on-going exploration that could result in perceptible vibration levels include:

- Continuous ground-borne vibrations produced by heavy equipment operations open pit mining and underground mining activities; and
- Continuous ground-borne vibration noise produced by the Dock and Storage Facility operations, including offloading;
- Semi-continuous ground-borne noise produced by truck traffic (along haul roads and access roads) and drilling; and
- Impulsive groundborne noise produced by blasting.

Refer to the Tier 3 Technical Appendix 4E (Noise and Vibration Impact Assessment) for a more detailed description of vibration sources and assumptions applied in the vibration assessment.

7.1.3 Mitigation and Project Design

In general, the Project will employ standard operating procedures for equipment/machinery and ensure that regular maintenance is performed in accordance with good engineering practices or as recommended by suppliers such that the equipment is kept in good operating condition. As well, the Project proponent will adhere to conditions outlined in all permits, authorizations and/or approvals. Procedures will also be developed to address community complaints.

7.1.4 Residual Effects

Construction

The predicted vibration levels associated with blasting and heavy equipment operation during the construction of the Dock and Storage Facility, Winter Road and Kiggavik and Sissons Mine Sites are not expected to be perceptible. Table 7.1-1 provides a summary of the predicted vibration levels associated with blasting and various types of heavy equipment operation. The predicted PPV during blasting is less than the Project Effects criteria (10 mm/s) within 500 meters of the blast centroid and are less than 0.5 mm/s within 3 km of the blast centroid. The closest off-site receptor, R3 (hunting camp), that would be exposed to potential changes in vibration levels from blasting is over 15 kilometers from the Kiggavik and Sissons Mine Sites and would not experience any perceptible vibration from blasting. Moreover, blasting events are expected to be of limited duration and are likely to occur only a few times per day.

Groundborne vibration from blasting was not assessed for the Baker Lake receptors R1 and R2 as blasting will occur in the Mine Development Area and not in the vicinity of Baker Lake. The Baker Lake receptors R1 and R2 are located more than 75 kilometres from the closest mine in the Mine Development Area.

Similarly, heavy equipment operations during construction are not expected to generate perceptible vibration levels at any of the receptors. With the exception of pile driving activities, the predicted vibration levels are imperceptible within 100 metres of the activity. For pile driving, the predicted vibration levels are less than 0.2 mm/s within 300 metres from the activity. The closest receptor (R1) is over 2,000 metres from any heavy equipment activities and would not likely to experience any perceptible level of vibration from heavy equipment usage.

Operations

The ground-borne vibration effects during operations were considered to be the same as those presented above. The predicted vibration levels associated with blasting and heavy equipment operation during the operations are not expected to be perceptible.

Table 7.1-1 Summary of Predicted PPV From Blasting and Heavy Equipment

Distance (m)	Predicted PPV (mm/s)					
	Blasting	Pile Driver	Excavator / Large Dozer / Caisson Drilling	Small Bulldozer	Crane	Loaded Trucks
100	76.4	0.8	0.05	0.002	0.05	0.04
200	27.6	0.3	0.02	0.001	0.02	0.01
300	15.2	0.2	0.01	0.0003	0.01	0.01
400	10.0	0.1	0.01	0.0002	0.01	0.01
500	7.2	0.1	0.004	0.0001	0.004	0.004
1000	2.6	NA	NA	NA	NA	NA
3000	0.5	NA	NA	NA	NA	NA
5000	0.2	NA	NA	NA	NA	NA
7000	0.1	NA	NA	NA	NA	NA
NOTES: PPV – peak particle velocity (mm/s)						
SOURCE: Siskind, et al, 1989; Golder 2010; FTA 2006, Wiss 1981						

7.1.5 Determination of Significance

The predicted vibration levels associated with blasting and heavy equipment operation are shown in Table 7.1-1. In all cases, ground-borne vibration levels associated with blasting and heavy equipment operation during construction and operations were considered negligible. No specific human health effects associated with vibration were identified.

7.2 Assessment of Change in Vibration – Other Options

7.2.1 Access Road Options

The assessment of the site access road considered one (1) possible other option, the All-Season Road. Outside of the geographic differences in the alignments, which are described in the Project Description, the only other difference was the higher overall traffic volume and duration of operation on the All Season Road.

Based on the analysis completed above, the vibration levels are not expected to vary substantially between options. There may be a greater incidence of vibrations associated with the All-Season Road since the traffic volume is higher than the preferred Winter Road. Vibration effects are still expected to be negligible.

7.2.2 Dock and Storage Facility Options

The Dock and Storage Facility options (North Shore Site 2 and 3) are greater than six kilometres from the closest receptor in Baker Lake whereas the preferred Dock and Storage Facility (North Shore Site 1) is approximately two and a half kilometers away. As such, it is expected that the vibration levels would be lower than those presented for the preferred option.

7.3 Cumulative Effects Analysis for Vibration

7.3.1 Screening for Cumulative Effects Assessment

In addition to assessing the Project construction and operation scenarios, the NIRB "Guidelines for the Preparation of an Environmental Impact Statement for AREVA Resources Canada Inc's Kiggavik Project (NIRB File No. 09MN003)" (NIRB 2011) also require the assessment of cumulative effects resulting from operating the Project together with other proposed projects and activities in the RAA. Vibration effects will be generally restricted to the localized area surrounding the Project and will decrease rapidly with distance from the source. The main Project sites and any proposed future project activities within the RAA are expected to be of sufficient distance apart that there will be no potential for overlap of vibration effects at the sensitive receptors. In all cases, future proposed projects and leases are located more than 10 km from any of the receptors used in this assessment. However, it is difficult to determine the relative contribution of future infrastructure and facility operations to vibration levels in the RAA without more detailed information. .

7.4 Summary of Residual Effects on Vibration

7.4.1 Project Effects

A summary of residual effects of project activities related to the maximum construction and operating scenarios are presented in Table 7.4-1. The predicted residual vibration effects will not be significant since vibration levels are expected to be negligible during all phases of the Project. In all cases, the overall predicted vibration levels are well below the Project effects criteria and are below the threshold of perception at all receptor locations.

Table 7.4-1 Summary of Project Residual Environmental Effects for Vibration

Project Phase	Mitigation / Compensation Measures	Direction	Residual Environmental Effects Characteristics						Significance	Likelihood	Prediction Confidence	Recommended Follow-up and Monitoring
			Magnitude	Geographic Extent	Duration	Frequency	Reversibility	Socio-Economic Context				
Change in Vibration Levels – Preferred Option												
Construction – Dock and Storage Facility	Community complaint/ response procedures; Equipment maintenance; Other operational and administrative measures	N	N	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Construction – Preferred Winter Road	Community complaint/ response procedures; Equipment maintenance; Other operational and administrative measures	N	N	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Construction – Mine Development Area	Community complaint/ response procedures; Equipment maintenance; Other operational and administrative measures	N	N	L	S	R	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Operations - Kiggavik Project	Equipment maintenance; Other operational and administrative measures	N	N	L	L	C	R	N	N	L	H	Complaints response procedure and monitoring, if complaint history warrants action
Change in Vibration Levels – Other Options												
Construction – All-Season Road	Community complaint/ response procedures; Equipment maintenance; Operational and administrative measures	N	N	L	S	R	R	N	N	L	H	• Complaints response procedure and monitoring, if complaint history warrants action
Operations – All-Season Road	Community complaint/ response procedures; Equipment maintenance; Operational and administrative measures	N	N	L	L	C	R	N	N	L	H	• Complaints response procedure and monitoring, if complaint history warrants action

7.4.2 Cumulative Effects

Project activities are not predicted to contribute to cumulative vibration effects.

7.4.3 Effects of Climate Change on Project

Given the duration of the Project, there are no anticipated effects from climate change that would affect Project vibration levels.

7.5 Transboundary Effects

There are no anticipated transboundary vibration effects associated with the Project.

7.6 Mitigation Measures

Based on the analysis above, there are no predicted human health effects associated with the Project. As such, no specific vibration mitigation measures are recommended at this time. However, the following general mitigation measures may be considered to reduce construction and operation vibration at the source:

- Developing a community complaint/response procedure to address vibration concerns;
- Ensuring site equipment is located as far away as possible from vibration sensitive receptors;
- Carrying out regular maintenance on all equipment, including lubrication and replacement of worn parts, especially exhaust systems;
- Where more than one type/model of equipment or technique can be used to complete a particular job with similar efficiency, using equipment with the lowest overall vibration potential;
- Limiting vehicle speeds on access, haul and intermediate roads;
- Restricting vehicle traffic to approved access routes to and from the site;
- Turning off equipment with potential to generate excessive vibration when not in use, where feasible;
- Maintaining project road surfaces to reduce vibration effects;
- To the extent possible, routing heavily-loaded trucks away from residential areas;
- To the extent possible, completing activities with the highest vibration potential during the day to avoid night time disturbance (i.e., blasting); and,
- To the extent possible, considering phasing the operation of equipment with the highest vibration potential.

7.7 Compliance and Environmental Monitoring for Vibration

Given that vibration effects are considered negiligible and would not generate a human health effect, no specific vibration monitoring programs are recommended at this time. Vibration effects would be monitored using a complaints/response procedure.

8 Reference – Noise and Vibration

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Attachment A Glossary and Terms

A.1 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 (Leq)	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 (Lw)	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 (Lp)	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).

A.2 Units/Terms

CadnaA	Computer Aided Noise Abatement software
CNSC	Canadian Nuclear Safety Commission
dB	decibel
dBA	A-weighted decibel
DNL	day-night sound level
EIS	Environmental Impact Statement
%Ha	Percent highly annoyed
hp	Horsepower
Hz	hertz
IQ	Inuit Qaujimajatuqangit
km	kilometer

kW	Kilowatt
LAA	Local Assessment Area
L_{eq}	energy equivalent sound level
L_P	sound pressure level
L_W	Sound Power Level
m	Metre
mm/sec	Millimetres per second
NAD	North American Datum
NLCA	Nunavut Land Claims Agreement
Pa	Pascal
µPa	Micropascal
POR	Point of Reception

PPV	peak particle velocity (mm/s)
RAA	Regional Assessment Area
SPL	sound pressure level
t	tonnes
U	uranium
UTM	Universal Transverse Mercator (Easting and Northing)
VEC	Valued Environmental Components
VSEC	Valued Socio-Economic Components
WHO	World Health Organization