APPENDIX 4-E

Noise and Vibration Impact Assessment

4.E-1 INTRODUCTION

Agnico Eagle Mines Limited – Meadowbank Division (Agnico Eagle) is planning to develop Whale Tail Pit (the Project) as a satellite to its existing Meadowbank Mine. The Project has the potential to affect both ambient noise levels and vibration levels in the environment. Therefore, a noise and vibration impact assessment (NIA) was completed for the Project. Supporting information for the Project NIA is presented in this technical appendix to the Final Environmental Impact Statement (FEIS) Amendment. The results of the Project NIA are presented in Volume 4, Section 4.4 of the FEIS Amendment.

4.E-2 PROJECT DESCRIPTION AND EMISSIONS SOURCES

The Project will consist of the Whale Tail Pit itself, along with an associated power plant, ore crushing facility, and water treatment plant. All ore extracted from the Whale Tail Pit will be hauled to Meadowbank Mine for processing and so the Project will include a 62 km haul road connecting Whale Tail Pit to existing processing and tailings infrastructure at Meadowbank Mine.

As described in the FEIS Amendment effects pathways table (Volume 3, Appendix 3-C, Table 3-C-1), the Project NIA was focused on the three Project activities for which primary effects pathways were identified:

- haul road construction;
- pit operations; and
- haul road operations.

Project activities for which secondary effects pathways were identified (i.e., Whale Tail Pit construction, Whale Tail Pit decommissioning, and haul road decommissioning) were not assessed in the Project NIA, since Project noise and vibration emissions associated with these activities are expected to be comparable or less than Project noise and vibration emissions during activities with primary effects pathways. The additional three years of processing and use of supporting infrastructure at the Meadowbank Mine that will result from the Project were not assessed in the Project NIA, as they were assessed as a secondary effects pathway. Noise emissions from the Meadowbank Mine have already been characterized as part of an earlier regulatory process (Cumberland 2005a, b), will not change as a result of the Project and are currently monitored. The Project NIA was focussed on those activities for which Project noise and vibration effects are expected to be highest.

4.E-2.1 Haul Road Construction

The 62 km Project haul road will be constructed by improving the existing exploration road. In other words, the Project haul road will not forge a new route from Meadowbank Mine to the Whale Tail Pit; instead, the Project haul road will follow the same route used by the existing exploration road.

Haul road construction will require use of mobile heavy machinery - conventional noise sources, like loaders, excavators, and dozers - to widen and otherwise improve the existing exploration road. Use of conventional noise sources during haul road construction is not expected to result in any vibration effects in the environment and so the Project NIA only assessed the potential for these sources to affect ambient noise levels.

Haul road construction is not currently expected to involve explosive blasting. However, depending on conditions encountered once construction begins, some blasting may be required. In case blasting were to prove necessary, the Project NIA assessed potential noise and vibration effects associated with blasting as part of haul road construction.

4.E-2.1.1 Conventional Noise Sources

Estimated noise emissions from conventional noise sources associated with haul road construction used a combination of:

- vendor noise specifications for comparable equipment;
- empirical formulae from acoustics handbooks (Crocker 2007; Bies and Hansen 2003; DEFRA 2005); and
- professional experience assessing noise from similar facilities.

Table 4-E-1 present noise emissions used in the Project NIA to represent haul road construction. Noise emissions are presented in the form of octave-band sound power levels per unit. For mobile equipment, the noise emission values include the contribution from a back-up alarm - with a suitable penalty applied to account for the tonal nature of this source (ISO 2003). For each source, Table 4-E-1 also presents the quantity and usage factor assumed in the Project NIA. The quantity and usage factor for each source were calculated using information provided by Agnico Eagle.

Table 4-E-1: Haul Road Construction - Noise Emissions for Road Construction Sources

Source	Quantity	Usage Factor [%]	Octave-Band Sound Power Level[a] [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Loader	1	40	102.0	104.0	118.0	116.0	107.0	115.5	105.0	98.0	90.0	117.0
Dozer	2	40	92.8	97.8	113.8	110.8	106.8	115.6	102.8	97.8	89.8	116.5
Excavator	2	40	104.0	103.0	116.0	106.0	108.0	113.2	105.0	99.0	94.0	114.9
Roller / Compactor	1	20	118.4	118.2	113.1	105.6	109.2	102.0	96.8	94.0	90.1	108.9
Pickup Truck	2	40	68.0	79.4	98.6	85.9	84.0	82.2	77.8	70.3	63.1	87.9

[a] Sound power levels are presented per unit and, where appropriate, include the contribution of a tonal back-up alarm.

dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

4.E-2.1.2 Blasting Noise and Vibration Sources

The Project NIA assumed that if blasting is required for haul road construction it will be similar to the blasting associated with construction of the Meliadine all-weather access road, as described in the Phase 1 environmental assessment for this activity (Agnico Eagle 2011). In particular, the Project NIA assumed that each blasting event for haul road construction will require detonation of a single 45 kilograms (kg) explosive charge.

Because of the high-energy and short-duration nature of explosive blasting, the Project NIA characterized potential noise and vibration effects associated with Project blasting using widely-accepted empirical formulae (ISEE 1998; DFO 1998). A detailed explanation of the empirical formulae used to characterize Project blasting is provided in Section 4.E-3.4.2 of this technical appendix.

4.E-2.2 Whale Tail Pit Operations

Whale Tail Pit operations will require the use of mobile and stationary heavy machinery (e.g., excavators, loaders, trucks, and electrical generators), which will emit noise continuously 24 hours per day. Use of these conventional noise sources during pit operations is not expected to result in any vibration effects in the environment and so the Project NIA only assessed the potential for these sources to affect ambient noise levels.

Pit operations will also involve explosive blasting. In contrast to conventional noise sources, which operate continuously 24 hours per day, blasting is an extremely short-duration activity that will occur periodically. In particular, information provided by Agnico Eagle indicates a maximum of two blasting events per day, each of which will last only a few seconds. Blasting activities associated with pit operations have the potential to affect both ambient noise levels and vibration levels in the environment, and so both blasting noise and blasting vibration were assessed in the Project NIA.

4.E-2.2.1 Conventional Noise Sources

Noise emissions were estimated from conventional noise sources associated with pit operations using a combination of:

- vendor noise specification sheets and calculation tools for comparable equipment (CAT 2013);
- empirical formulae from acoustics handbooks (Crocker 2007; Bies and Hansen 2003); and
- professional experience assessing noise from similar facilities.

Table 4-E-2 through Table 4-E-6 present noise emissions used in the Project NIA to represent Whale Tail Pit operations. In particular:

- Table 4-E-2 presents noise emissions for sources that will operate within the pit itself;
- Table 4-E-3 presents noise emissions for sources that will operate on the short access road between the pit and adjacent waste piles;
- Table 4-E-4 presents noise emissions for sources associated with the power plant;
- Table 4-E-5 presents noise emissions for sources associated with the ore crushing facility; and
- Table 4-E-6 presents noise emissions for sources associated with the water treatment plant.

In all cases, noise emissions are presented in the form of octave-band sound power levels per unit. For mobile equipment, the noise emission values include the contribution from a back-up alarm - with a suitable penalty applied to account for the tonal nature of this source (ISO 2003). For each source, Table 4-E-2 through Table 4-E-6 also present the quantity and usage factor (i.e., the percentage of time that a given source will operate) assumed in the Project NIA. The quantity and usage factor for each source were calculated using information provided by Agnico Eagle.

Table 4-E-2: Whale Tail Pit Operations - Noise Emissions for In-Pit Sources

Source	Quantity	Usage Factor [%]	Octave-Band Sound Power Level[(a)] [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Excavator - Terex RH120	2	83	121.8	122.7	124.5	120.1	118.1	117.0	112.9	106.9	100.9	121.3
Track Dozer - CAT D9T	4	83	101.2	104.2	122.2	112.2	110.2	115.8	106.2	100.2	91.2	117.5
Wheel Loader - CAT 992G	2	83	102.0	104.0	118.0	116.0	107.0	115.5	105.0	98.0	90.0	117.0
Wheel Dozer - CAT 834H	1	83	92.8	97.8	113.8	110.8	106.8	115.6	102.8	97.8	89.8	116.5
Water Truck - CAT 773D	1	33	118.8	119.8	123.8	116.8	109.8	112.0	106.8	100.8	99.8	116.2
Motor Grader	3	83	101.0	103.0	116.0	112.0	110.0	112.8	105.0	100.0	95.0	115.1
Excavator - CAT 390DL	1	83	104.0	103.0	116.0	106.0	108.0	113.2	105.0	99.0	94.0	114.9
Production Drill - ATLAS DM45	4	83	103.9	111.9	119.9	104.9	105.9	106.9	105.9	102.9	100.9	112.6
Excavator - CAT 345D	2	83	114.3	112.4	113.0	106.9	100.5	112.1	91.1	83.0	85.1	112.6
Mining Truck - CAT 777F	11	42	113.0	118.0	120.0	111.0	106.0	106.0	104.0	99.0	88.0	111.6
Dewatering Pump	2	100	99.3	100.7	102.0	103.3	103.3	105.7	103.3	99.7	93.3	109.7

[a] Sound power levels are presented per unit and, where appropriate, include the contribution of a tonal back-up alarm.
dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

Table 4-E-3: Whale Tail Pit Operations - Noise Emissions for Sources on Pit-to-Waste Pile Road

Source	Quantity	Usage Factor [%]	Octave-Band Sound Power Level [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Water Truck - CAT 773D	1	33	118.8	119.8	123.8	116.8	109.8	112.0	106.8	100.8	99.8	116.2
Mining Truck - CAT 777F	9	42	113.0	118.0	120.0	111.0	106.0	106.0	104.0	99.0	88.0	111.6

[a] Sound power levels are presented per unit and, where appropriate, include the contribution of a tonal back-up alarm.
dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

Table 4-E-4: Whale Tail Pit Operations - Noise Emissions for Power Plant Sources

Source	Quantity	Usage Factor [%]	Octave-Band Sound Power Level[a] [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Open Bay Door	2	100	107.3	112.1	112.3	111.2	113.2	114.3	118.0	118.5	114.1	123.6
Engine Inlet	2	100	87.0	87.0	85.0	92.3	91.5	88.2	94.9	116.6	115.2	119.2
Open Man Door	2	100	102.0	106.8	107.0	105.9	107.9	109.0	112.7	113.2	108.8	118.3
Cooling Fan	2	100	112.4	114.0	125.8	116.1	113.8	110.8	108.0	105.4	104.0	117.3
Ventilation Louver	4	100	99.0	102.8	103.0	100.9	102.9	103.0	106.7	106.2	100.8	111.9
Building Roof	1	100	120.3	119.1	113.3	108.2	108.2	96.3	99.0	92.5	88.1	108.2
Building Wall	4	100	114.5	113.3	107.5	102.4	102.4	90.5	93.2	86.7	82.3	102.4
Engine Exhaust	2	100	112.4	94.7	79.9	75.3	78.3	83.7	92.2	94.3	92.3	98.6
Air Handling Unit	2	100	97.3	96.9	96.5	93.0	93.8	93.4	89.1	83.7	73.5	97.1

[a] Sound power levels are presented per unit.

dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

Table 4-E-5: Whale Tail Pit Operations - Noise Emissions for Ore Crushing Sources

Source	Quantity	Usage Factor [%]	Octave-Band Sound Power Level[a] [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Jaw Crusher	2	83	117.2	119.5	121.8	119.9	113.5	113.8	111.7	111.0	105.3	119.5
Wheel Loader - CAT 992G	2	83	102.0	104.0	118.0	116.0	107.0	115.5	105.0	98.0	90.0	117.0

[a] Sound power levels are presented per unit and, where appropriate, include the contribution of a tonal back-up alarm.

dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

Table 4-E-6: Whale Tail Pit Operations - Noise Emissions for Waste Water Treatment Plant Sources

Source	Quantity	Usage Factor [%]	Octave-Band Sound Power Level[a] [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Open Bay Door - Large	1	100	99.5	97.2	98.0	99.0	100.0	102.6	101.2	98.3	94.3	107.2
Open Bay Door - Small	1	100	96.4	94.1	94.9	95.9	96.9	99.5	98.1	95.2	91.2	104.1
Air Handling Unit	1	100	97.3	96.9	96.5	93.0	93.8	93.4	89.1	83.7	73.5	97.1
Open Man Door	2	100	88.9	86.6	87.4	88.4	89.4	92.0	90.6	87.7	83.7	96.6
Building Roof	1	100	114.0	105.7	100.5	97.5	96.5	86.1	83.7	73.8	69.8	96.1
Ventilation Louver	2	100	88.7	85.4	86.2	86.2	87.2	88.8	87.4	83.5	78.5	93.3
Building Wall - Large	2	100	108.0	99.7	94.5	91.5	90.5	80.1	77.7	67.8	63.8	90.1
Building Wall - Small	2	100	106.0	97.7	92.5	89.5	88.5	78.1	75.7	65.8	61.8	88.1

[a] Sound power levels are presented per unit.

dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

4.E-2.2.2 Blasting Noise and Vibration Sources

Based on information provided by Agnico Eagle, the Project NIA assumed that each blasting event during pit operations will consist of sequential detonation of 50 blast holes, and that each hole will be filled with 215 kg of explosives. The Project NIA further assumed that blast holes will be arranged into five rows of ten holes each, and that all the holes in a given row will be detonated simultaneously (i.e., simultaneous detonation of the first row of ten holes, followed by a short delay, then simultaneous detonation of the next row of ten holes, and so on until all 50 holes have detonated).

Because of the high-energy and short-duration nature of explosive blasting, the Project NIA characterized potential noise and vibration effects associated with Project blasting using empirical formulae (ISEE 1998; DFO 1998). A detailed explanation of the empirical formulae used to characterize Project blasting is provided in Section 4.E-3.4.2 of this technical appendix.

4.E-2.3 Haul Road Operations

A 62 km road will connect the Project to existing ore processing infrastructure at Meadowbank Mine. This road will primarily be used to haul ore from the Project to Meadowbank Mine, but it will also be used to transport workers, explosives, and other supplies from Meadowbank Mine to the Project.

Haul road operations will require the use of conventional noise sources, which have the potential to affect ambient noise levels but are not expected to affect vibration levels. Haul road operations will not involve any blasting or other activities that might result in vibration effects. As such, the Project NIA only assessed the potential effects of haul road operations on ambient noise levels.

4.E-2.3.1 Conventional Noise Sources

Estimated noise emissions from conventional noise sources associated with haul road operations used a combination of:

- vendor noise specifications for comparable equipment;
- empirical formulae from acoustics handbooks (Crocker 2007; Bies and Hansen 2003); and
- professional experience assessing noise from similar facilities.

Table 4-E-7 presents noise emissions used in the Project NIA to represent haul road operations. Noise emissions are presented in the form of octave-band sound power levels per unit. For each source, Table 4-E-7 also presents the expected number of trips per day and the average speed of travel assumed in the Project NIA. The trips per day and travel speeds were calculated using information provided by Agnico Eagle.

Table 4-E-7: Haul Road Operations - Noise Emissions

Source	Trips Per Day	Average Speed of Travel [km/h]	Octave-Band Sound Power Level[a] [dBZ]									Overall Sound Power Level[a] [dBA]
			31.5 Hz	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz	
Haul Truck - CAT 785D	173	29	121.9	126.9	128.9	119.9	114.9	114.9	112.9	107.9	96.9	120.5
Oversize Cargo Truck - Western Star 6900XD	4	19	124.0	124.0	117.0	107.0	107.0	104.0	103.0	95.0	90.0	110.2
Explosives Truck - Western Star 4800SB	5	38	121.0	121.0	114.0	104.0	104.0	101.0	100.0	92.0	87.0	107.2
Fuel Truck - Kenworth T800	4	39	121.0	121.0	114.0	104.0	104.0	101.0	100.0	92.0	87.0	107.2
Cargo Truck - Kenworth C500B	10	38	121.0	121.0	114.0	104.0	104.0	101.0	100.0	92.0	87.0	107.2
Crew Bus - Blue Bird Vision SL	4	38	121.0	121.0	114.0	104.0	104.0	101.0	100.0	92.0	87.0	107.2
Pickup Truck - Ford F250	26	38	68.0	79.4	98.6	85.9	84.0	82.2	77.8	70.3	63.1	87.9

[a] Sound power levels are presented per unit and, where appropriate, include the contribution of a tonal back-up alarm.

dBA = A-weighted decibel; dBZ = unweighted or linear decibels; Hz = hertz; % = percent.

4.E-3 ASSESSMENT APPROACH

4.E-3.1 Regulatory Guidance

4.E-3.1.1 Conventional Noise

Nunavut does not have any environmental noise regulations or guidelines and the Nunavut Impact Review Board (NIRB) does not endorse or recommend any specific noise regulation or guideline as being appropriate for assessing potential noise effects from the Project. Alberta Energy Regulator (AER) *Directive 038: Noise Control* (AER 2007) is the environmental noise regulation applicable to oil sands and coal mines in Alberta, and it is common practice to use AER Directive 038 to assess potential noise effects from existing and proposed mines in Canadian provinces and territories that lack specific noise regulations. For example, AER Directive 038 was used recently to assess potential noise effects from the Yancoal Southey Potash Mine in Saskatchewan (Yancoal 2015) and from the Dominion Diamond Jay Project in the Northwest Territories (Dominion Diamond 2014). Furthermore, an earlier version of AER Directive 038 was used to assess potential noise effects from the Meadowbank Mine (Cumberland 2005a, b) as part of the original regulatory process for this facility. In addition, AER Directive 038 has been explicitly identified by the Environmental Impact Review Board for the Inuvialuit Settlement Region as containing useful guidance for assessing potential noise effects (EIRB 2007).

Because AER Directive 038 is considered to represent best practices for environmental noise assessment and because an earlier version of this regulation was used to assess noise from the Meadowbank Mine, AER Directive 038 assessment methodologies and criteria were used in the Project NIA.

4.E-3.1.2 Blasting Noise and Vibration

Nunavut does not have any regulations or guidelines related to potential environmental noise and vibration effects from blasting and the NIRB does not endorse or recommend any specific regulation or guideline as being appropriate for assessing potential environmental effects from blasting. Ontario Ministry of Environment *Noise Pollution Control (NPC) Publication 119* (OMOE 1978) represents best practices with respect to the assessment of potential noise and vibration effects from blasting. As such, NPC-119 assessment methodologies and criteria were used in the Project NIA.

4.E-3.2 Study Areas

AER Directive 038 indicates that noise effects from new facilities should be assessed at receptors corresponding to the nearest occupied dwellings. In the absence of occupied dwellings within 1.5 km, noise effects should be assessed at 1.5 km from the facility fence line.

The Project is located in a very remote area far from any occupied dwellings and, because of its remote location, the Project will not include a formal fence line. As such, the Project NIA assessed potential noise and vibration effects across a Local Study Area (LSA) established as a buffer surrounding the Project footprint at a distance of 5 km and a Regional Study Area (RSA) established as a buffer surrounding the Project footprint at a distance of 7 km. The Project footprint was taken to include the Whale Tail Pit and associated waste piles, power plant, ore crushing facility, water treatment plant, and haul road. Project noise and vibration levels were predicted for a grid or receptors covering the LSA and RSA and for a discrete receptor corresponding to the most impacted location on the LSA boundary. These study areas are consistent with the LSA and RSA used in the noise assessment for the Meadowbank Mine (Cumberland 2005a, b).

4.E-3.2.1 Pit Operations

Figure 4.1-1 in Volume 4, Section 4.1 shows the noise and vibration LSA and RSA used to assess pit operations. Note that the north end of the Project haul road is included within the pit operations LSA and RSA, and the noise contribution from traffic on this section of the haul road was considered when assessing Whale Tail Pit operations.

4.E-3.2.2 Haul Road Operations

Haul road operations will be similar along the entire 62 km route joining the Project to the existing Meadowbank Mine. In other words, during haul road operations all vehicles (i.e., noise sources) will travel the entire length of the haul road. As such, the assessment of haul road operations focussed on a representative 5 km section of the road. The Project NIA modelled noise emissions from a 5 km section of haul road and predicted potential Project noise effects across a 5 km LSA and 7 km RSA surrounding this representative section of haul road.

4.E-3.2.3 Haul Road Construction

Haul road construction is expected to be completed by the same group of equipment (see Table 4-E-1) moving together along the length of the road. As such, the assessment of road construction focussed on a representative 140 m section of road, with the assumption that the road construction equipment from Table 4-E-1 will be spread out as much as 140 m along the route at any one time. The Project NIA predicted potential Project effects across a 5 km LSA and 7 km RSA surrounding representative construction activities.

4.E-3.3 Assessment Criteria

4.E-3.3.1 Conventional Noise: Broadband

AER Directive 038 indicates that broadband noise should be assessed by comparing cumulative noise levels, expressed in A-weighted decibels (dBA), with a mandated Permissible Sound Level (PSL). In the case of the Project NIA, cumulative noise levels consist of existing ambient noise levels added to the predicted noise contribution from the Project.

Table 4-E-8 presents the PSL values applicable to the Project LSA and RSA. The summertime PSL is applicable during periods when the temperature is above 0 degrees Celsius or when the ground is free of snow or ice cover. The wintertime PSL is applicable during periods when temperature is below 0 degrees Celsius and the ground is covered by snow or ice. The daytime PSL is applicable during the period 7 am to 10 pm (i.e., daytime) and the nighttime PSL is applicable during the period 10 pm to 7 am (i.e., nighttime); daytime and nighttime periods are defined by AER Directive 038 and are not adjusted to reflect actual daylight hours.

Table 4-E-8: Applicable Permissible Sound Level Values

Area of Applicability	Permissible Sound Level [dBA]			
	Summertime		Wintertime	
	Daytime: 7 am to 10 pm	Nighttime: 10 pm to 7 am	Daytime: 7 am to 10 pm	Nighttime: 10 pm to 7 am
LSA and RSA	50	40	55	45

LSA = local study area; RSA = regional study area; dBA = A-weighted decibels.

4.E-3.3.2 Conventional Noise: Low Frequency

The AER Directive 038 indicates that a separate assessment of potential Low Frequency Noise (LFN) effects should be conducted where suitable information is available because LFN can be an issue even when broadband noise levels are otherwise acceptable. AER Directive 038 indicates that a LFN effect may exist when the following occur:

- the value of the predicted noise level, expressed in C-weighted decibels (dBC), minus the value of the predicted noise level, expressed in dBA, is greater than or equal to 20; and
- a clear tonal component exists at a frequency below 20 Hz.

Noise levels expressed in dBC have been scaled to emphasize low frequency content - as opposed to noise levels expressed in dBA, which have been scaled to reflect the frequency sensitivity of the human auditory system.

The first LFN condition can be assessed using model predictions but the second LFN condition requires high-resolution spectral data, which are not available from model predictions and can only be obtained from field measurements once Project operations have commenced. As such, the Project NIA was able to provide an assessment of potential LFN effects based on the first condition.

4.E-3.3.3 Blasting Noise and Vibration

NPC-119 establishes blasting limits for Peak Particle Velocity (PPV) associated with ground vibration and for Peak Pressure Level (PPL) associated with airborne noise. When assessing potential blasting effects, the Project NIA considered both the PPV and PPL limits from NPC-119. The Project NIA also considered blasting limits set by the Department of Fisheries and Oceans (DFO) to protect general fish habitat and areas used specifically for spawning (DFO 1998). The specific blasting limits considered in the Project NIA are presented in Table 4-E-9.

Table 4-E-9: Applicable Blasting Limits

Area of Applicability	Peak Particle Velocity Limits - Ground Vibration		Peak Pressure Level - Airborne Noise	
	NPC-119[a]	Fish Spawning[b]	NPC-119[a]	Fish Habitat[b]
LSA and RSA	10 mm/s	13 mm/s	120 dBZ	100 kPa

[a] OMOE (1978).

[b] DFO (1998).

LSA = local study area; RSA = regional study area; mm/s = millimetres per second; dBZ = unweighted or linear decibels; kPa = Kilo-Pascal.

4.E-3.4 Prediction Methodology

4.E-3.4.1 Conventional Noise

Computer noise models used in the Project NIA were developed using the CadnaA Version 4.5.151 software package. In accordance with AER Directive 038, CadnaA implements the noise propagation algorithm described in the ISO 9613-2 technical standard (ISO 1996).

The computer models were used to predict Project noise levels for a grid or receptors covering the LSA and RSA. Inputs to the computer models consisted of source emissions in the form of octave-band sound power levels (see Section 4.E-2 of this technical appendix) and environmental conditions – like ground cover, temperature, humidity, and wind conditions – that are known to affect noise propagation. A summary of model input parameters is provided in Table 4-E-10.

Table 4-E-10: Noise Model Input Parameters

Parameter	Model Setting	Description/Comments
Standard	ISO 9613-2 (ISO 1996)	models treated noise sources, noise attenuation, and noise propagation in accordance with this standard
Ground absorption	Summertime: 0.5 Wintertime: 0.0	a value of 0.5 is consistent with mixed ground (e.g., a mixture of porous/absorptive tundra and hard/reflective lakes) a value of 0.0 is consistent with hard ground (e.g., frozen lakes and ice-covered snow)
Temperature / humidity	Summertime: 10 degrees Celsius / 70% relative humidity Wintertime: -26 degrees Celsius / 69% relative humidity	summertime values are typical defaults for ISO 9613-2 intended to represent nighttime summertime conditions wintertime values are intended to represent nighttime wintertime conditions in the area
Wind conditions	1 m/s to 5 m/s downwind	wind conditions selected as per ISO 9613-2 requirements - moderate temperature inversion with all receptors downwind from all sources 100% of the time
Terrain	terrain not considered	the LSA and RSA were treated as flat - this is a conservative assumption that will tend to overestimate Project noise effects

LSA = local study area; RSA = regional study area; m/s = metre per second.

When calculating noise levels, the ISO 9613-2 algorithm used the environmental inputs listed in Table 4-E-10 to account for four noise attenuation mechanisms:

- geometric divergence;
- atmospheric absorption;
- ground absorption; and
- screening by barriers.

Geometric divergence accounts for the fact that a given noise source radiates a finite amount of acoustic energy, and as this finite amount of energy propagates into the environment it is spread out over a larger and larger area (i.e., the surface of an ever expanding sphere). This geometric spreading means that the farther away a receptor is located from a source, the less energy will be received (i.e., the lower the observed noise level).

Atmospheric absorption accounts for the fact that acoustic energy associated with a given noise source is absorbed via interaction with molecules in the air through which it propagates. Attenuation effects associated with atmospheric absorption are most substantial at high frequencies, but can be important at lower frequencies for very large propagation distances.

Ground absorption accounts for the fact that each time the acoustic energy emitted by a noise source interacts with the ground, some of it is absorbed. The amount of energy absorbed depends on the type of ground surface – during interactions with hard ground (e.g., frozen lakes) very little energy is absorbed but during interactions with soft ground (e.g., tundra) a substantial amount of energy is absorbed. As a result, if all other factors are held constant, observed noise levels associated with sources operating in an area of hard ground will be higher than observed noise levels associated with sources operating in an area of soft ground.

Screening by barriers accounts for the fact that a physical object (either terrain-based or man-made) placed between a noise source and receptor will tend to block some of the acoustic energy and so serve to reduce observed noise levels.

4.E-3.4.2 Blasting Noise and Vibration

The Project NIA characterized potential noise and vibration effects associated with Project blasting using empirical formulae (ISEE 1998; DFO 1998). In particular, the Project NIA used empirical formulae to predict PPV and PPL values across the LSA and RSA.

The empirical formulae used to assess Project blasting –have only one input: charge mass and they do not account for specific ground conditions or atmospheric conditions in the LSA/RSA; therefore, there is substantial uncertainty associated with the specific PPV and PPL predictions obtained using these formulae. However, the empirical formulae are useful for gauging the likely magnitude of noise and vibration effects associated with blasting activities (i.e., they provide useful information about approximate setbacks required to achieve compliance with PPV and PPL limits). As such, use of empirical formulae to assess blasting is appropriate in the context of a FEIS - particularly, in the case of this Project since there are no dwellings or other sensitive receptors at which specific PPV or PPL values must be predicted.

When assessing blasting-inducted ground vibration in the context of NPC-119 limits, the Project NIA used the following empirical formula to calculate PPV in mm/s (ISEE 1998):

$$PPV = 1725\left(\frac{D}{\sqrt{M}}\right)^{-1.6}$$

where D is the distance from the explosive charge (expressed in m) and M is the mass of the explosive charge (expressed in kg).

When assessing blasting-induced airborne noise in the context of NPC-119 limits, the Project NIA used the following empirical formula to calculate PPL in dBZ (ISEE 1998):

$$PPL = 20\log_{10}\left[\left(\frac{3.28D}{\sqrt[3]{2.2M}}\right)^{-1.1}\right] + 170.75$$

where D is the distance from the explosive charge (expressed in m) and M is the mass of the explosive charge (expressed in kg).

When calculating the setback distance, D (expressed in m), required to achieve compliance with the PPV limit of 13 mm/s set by the DFO for protection of spawning fish, the Project NIA used the following empirical formula (DFO 1998):

$$D = 15.09\sqrt{M}$$

where M is the mass of the explosive charge (expressed in kg).

When calculating the setback distance, D (expressed in m), required to achieve compliance with the PPL limit of 100 kPa set by the DFO for protection of fish habitat, the Project NIA used the following empirical formula (DFO 1998):

$$D = 3.2\sqrt{M}$$

where M is the mass of the explosive charge (expressed in kg).

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