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VOLUME 4 - ATMOSPHERIC ENVIRONMENT

Whale Tail Pit Project Meadowbank Division

Submitted to:
Nunavut Impact Review Board
Nunavut Water Board

REPORT

Report Number: 1541520

EXECUTIVE SUMMARY – VOLUME 4 ATMOSPHERIC ENVIRONMENT

Volume 4 of the Final Environmental Impact Statement for the Whale Tail Pit and Haul Road Project (the Project) addresses Guidelines issues by the Nunavut Impact Review Board, specifically those relating to effects to the Atmospheric Environment, including climate and meteorology, air quality, and noise and vibration. The effects assessment evaluates all Project phases, including construction, operations, and closure.

Climate

The Climate and Meteorology section included a review of relevant documents, as well as Inuit Qaujimajatuqangit (IQ) observations from Inuit from Baker Lake. Climate change is a concern for Elders and land users because the unpredictability of weather conditions has resulted in a lack of confidence in using traditional knowledge to predict weather. Inuit are also concerned about the potential effects of climate change to vegetation, wildlife, fish, and other traditional resources.

Greenhouse gas (GHG) emissions from Nunavut are low due to its low population and low intensity of urban/industrial activities. Total average emissions from Nunavut from 2007 to 2011 were 434 kilotonnes of carbon dioxide equivalents per year (kt CO_{2e}/yr). Development of the Whale Tail Pit and emissions from traffic along the haul road to Meadowbank Mine are predicted to result in a 56% increase in GHG emissions for Nunavut. However, when compared to Canada's national emissions (714,000 kt CO_2e/yr), the Project contributes to a less than 0.05% increase in national GHG emissions.

The short duration of the proposed Project means that climate change related effects to the Project are likely negligible.

Air Quality and Dust

Inuit depend upon their local environment for their social, cultural, and economic well-being, they are aware of changes to their environment, including air quality. Inuit have documented recent changes to air quality, and are concerned about the potential effects of these changes on their traditional land use activities and resources. Inuit Qaujimajatuqangit highlighted concerns about the effects of dust deposition on vegetation and the sensitivity of caribou, muskox, and other traditional resources to these potential effects. Potential effects of the Project on air quality and atmospheric deposition of dust were predicted and compared to national and territorial air quality guidelines as there are no standards that can be drawn explicitly from IQ.

Local Inuit requested that emissions of fugitive road dust be mitigated through the use of road watering and the application of chemical dust suppressants, and that the accumulation of dust be monitored. Agnico Eagle conducts local meteorology, air quality, and dustfall monitoring at their existing Meadowbank Mine and mitigation and monitoring opportunities at the proposed Project are similar to those at the existing Meadowbank Mine.

The dispersion model-predicted ground level concentrations of carbon monoxide (CO), NO_2, and sulfur dioxide (SO_2) were very low compared to the baseline and to their relevant ambient air quality standards. Predictions of $PM_{2.5}$ adjacent to the haul road were below Nunavut ambient air quality guidelines within 50 to 75 metres (m) from the haul road. Maximum annual TSP concentrations are predicted to exceed the ambient air quality standard (60 micrograms per cubic metre [$\mu g/m^3$]) within the first 100 to 300 m from the haul road. Predicted dust deposition rates are predicted to be below the BC dustfall standard within 300 m of the haul road. Annual dust deposition is predicted to be below the Ontario dustfall standard within 25 m from the haul road. These standards are considered to be the strictest dust deposition standards in Canada.

The effects of fugitive dust emissions on air quality adjacent to the haul road are limited in spatial extent and occur primarily on dry windy days in the summer. These effects are reversible in that fugitive dust will no longer affect air quality once the Whale Tail Pit is decommissioned and the haul road becomes inactive.

The effects of mining activities at the Whale Tail Pit on regional air quality are limited in spatial extent and occur primarily on dry windy days in summer. These effects are reversible in that emissions will no longer affect air quality once the Whale Tail Pit is decommissioned and the haul road become inactive. Based on an extrapolation of the monitoring results, the effects of an extension to the operations of the Meadowbank Mill and camp on regional air quality are considered low. Any potential effects are considered reversible in that emissions will no longer affect air quality once the Whale Tail Pit and Meadowbank Mill are decommissioned.

The All-Weather Access Road (AWAR) between the community of Baker Lake and the Meadowbank Mine is expected to remain active for a period of up to three years after the Whale Tail Pit operations commence. The significant distance between the AWAR and the Whale Tail operations and the expected limited use of the AWAR limits the potential for combined effects of emissions resulting from the ongoing use of the AWAR and the Whale Tail Pit operations. The most recent (2015) results of the Meadowbank dustfall monitoring program indicate that even in close proximity to the project operations, all samples but 1 out of the 48 collected, compared favourably with the Alberta guidance on dustfall for recreational and residential areas.

The results of this assessment indicate particulate matter and dustfall monitoring at the Whale Tail Pit and along the haul road to the Meadowbank Mine is warranted. The monitoring program will be based on the existing air quality and dustfall monitoring conducted at the Meadowbank Mine, and the dustfall monitoring program along the Meadowbank AWAR to Baker Lake.

Both IQ and scientific monitoring suggest that road watering and the application of chemical suppressants can reduce fugitive dust emissions.

Noise and Vibration

Haul road construction noise levels for all periods are predicted to be less than the existing ambient noise level at the boundary of the Local and Regional Study Areas (LSA and RSA). The predicted values also indicate that there will be no low frequency noise (LFN) effect along the LSA boundary. Haul road operations noise levels are also predicted to be less than the existing ambient noise level in summertime and wintertime at the boundary of the RSA. Similarly, for all periods, haul road operations Project noise levels are predicted to be less than 35 A-weighted decibel (dBA) at the boundary of the LSA.

Pit Operations noise levels are predicted to be less than 30 dBA at the RSA boundary for both summertime and wintertime. Similarly, for all periods, pit operations noise levels are predicted to be less than the 30 dBA existing ambient noise level for most of the LSA boundary and are predicted to be less than 35 dBA along all areas of the LSA boundary. Summertime and wintertime pit operations cumulative noise levels are predicted to be less than the applicable AER Directive 038 PSL limit along the whole LSA boundary. There will be no LFN effect along the LSA boundary. At the LSA boundary airborne noise levels from Project blasting are predicted to be well below the NCP-119 standard.

The predicted setback distances from pit operations blasting activities required to achieve compliance with DFO peak particle velocity (vibration) and peak pressure level (noise) limits for the protection of spawning fish and fish habitat, are 700 m and 148 m for Fish Spawning areas and Fish Habitat, respectively. During pit operations, blasting will be carefully managed and monitored in the context of DFO limits and appropriate setbacks will be established so that noise and vibration from pit operations blasting do not affect fish spawning or general habitat.

Any potential effects associated with the primary pathways are captured in the assessment of potential effects to, and residual effect classifications for, other valued components, specifically in wildlife, birds, and fisheries.

Follow-up noise monitoring for the Project will be conducted in a way similar to monitoring currently being conducted as part of the Meadowbank Mine noise management plans. Annual monitoring will be conducted at four locations in the vicinity of the Project with locations being selected and adjusted as Project evolves If monitored noise levels exceed appropriate limits, Agnico Eagle will take appropriate actions to identify the specific cause of the exceedance and, if practical, to mitigate the relevant noise source.

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ᐅᖃᓕᒫᒐᖅ 4 ᑭᖑᓪᓕᖅᐸᑦᖅ ᐊᕙᑎᒥᒃ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᑎᑎᖅᑲᕐᒧᑦ Whale Tail ᐃᓗᑦᑐᖅᓯᒪᔪᕐᒧᑦ ᐊᒻᒪᓗ ᐅᓯᑲᑦᑕᕐᓂᕐᒧᑦ ᐊᑉᖁᑎᒧᑦ ᐱᓕᕆᐊᕐᒧᑦ (ᐱᓕᕆᐊᖅ) ᐱᓕᕆᐊᖃᖅᑐᖅ ᒪᓕᒃᑕᐅᔫᒃᓴᓂᒃ ᐱᔾᔪᑕᐅᔪᓂᒃ ᓄᓇᕗᒻᒥ ᐊᒃᑐᖅᓯᓂᕐᒧᑦ ᕿᒥᕐᕈᔾᔮᒃᑯᓐᓄᑦ, ᐱᔪᐊᖅᑐᒥᒃ ᐱᔾᔪᑎᖃᖅᑐᓂᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᓯᓚᐅᑉ ᓯᓚᖃᖕᒋᑦᑑᑉ ᐊᕙᑎᖓᓂᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᓯᓚ ᐊᒻᒪᓗ ᓯᓚᖃᖕᒋᑦᑐᖅ, ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖓ, ᐊᒻᒪᓗ ᓂᐱᖃᕐᓂᖅ ᐊᒪᓗ ᓴᔪᕋᖄᕐᓂᐅᔪᑦ. ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᕐᒧᑦ ᖃᐅᔨᓴᐃᓃᑦ ᕿᒥᕐᕈᔪᑦ ᑕᒪᐃᓄᓗᒃᑖᖅ ᐱᓕᕆᐊᑉ ᓇᓃᓐᓂᕆᔭᖕᒋᓐᓂᑦ, ᐃᓚᐅᑉᓗᑎᒃ ᓴᓇᔭᐅᓂᖓ, ᐊᐅᓛᖅᑎᑦᑎᓂᖅ, ᐊᒻᒪᓗ ᐅᒃᑯᐊᖅᐸᓪᓕᐊᓂᖅ.

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ᓯᓚ ᐊᒻᒪᓗ ᓯᓚᖃᖕᒋᑦᑐᖅ ᐊᕝᒃᑐᖅᓯᒪᓂᕐᒥᑦ ᐃᓚᐅᔪᖅ ᕿᒥᕐᕈᓂᖅ ᑕᒪᑐᒨᖓ ᑎᑎᖅᑲᓂᒃ, ᐊᒻᒪᓗ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖕᒋᑦ (IQ)-ᒥᑦ ᖃᐅᔨᔭᐅᔪᑦ ᐃᓄᖕᓂᑦ ᖃᒪᓂᑦᑐᐊᕐᒥᐅᓂᑦ. ᓯᓚᐅᑉ ᐊᓯᔾᔨᕐᓂᖓ ᐃᓱᒫᓘᑕᐅᔪᖅ ᐃᓐᓇᕆᔭᐅᔪᓄᑦ ᐊᒻᒪᓗ ᓄᓇᒥᒃ ᐊᑐᖃᑦᑕᖅᑐᓄᑦ ᓇᓗᓇᕐᓂᕆᔭᖓᓄᑦ ᓯᓚᐅᑉ ᐊᓯᔾᔨᖃᑦᑕᕐᓂᖓ ᓇᓗᓂᖅᑕᖃᓕᖅᑎᑦᑎᔪᖅ ᐊᑐᖅᑕᐅᓂᖕᒋᑦ ᐱᖅᑯᓯᒃᑯᑦ ᖃᐅᔨᒪᓂᕆᔭᐅᔪᑦ ᓇᓚᐅᑦᑎᓂᕐᒧᑦ ᓯᓚᒥᒃ. ᐃᓄᐃᑦ ᐃᓱᒫᓗᑎᖃᕐᒥᔪᑦ ᖃᓄᐃᖕᒐᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓂᒃ ᓯᓚᐅᑉ ᐊᓯᔾᔨᖅᐸᓪᓕᐊᓂᖓᓄᑦ ᐱᕈᖅᑐᓄᑦ, ᓂᕐᔪᑎᓄᑦ, ᐃᖃᓗᖕᓄᑦ, ᐊᒻᒪᓗ ᐊᓯᖕᒋᓐᓄᑦ ᐱᖅᑯᓯᕆᔭᐅᔫᒃᑯᑦ ᐱᕚᐅᑲᑦᑕᖅᑐᓂᒃ.

ᐱᐅᖕᒋᑦᑐᑦ ᐊᓂᐊᔪᑦ ᓯᓚᒧᑦ (GHG) ᓄᓇᕗᒻᒥᑦ ᐊᑦᑎᒃᑑᔪᑦ ᐊᒥᔫᖕᒋᓐᓂᖕᒋᓐᓄᑦ ᐃᓄᖕᒋᑦ ᓄᓇᕗᒻᒥᐅᑕᐃᑦ ᐊᒻᒪᓗ ᐊᖕᒋᓗᐊᖕᒋᕝᓗᓂ ᐱᓕᕆᕚᒡᔪᐊᖑᖃᑦᑕᖅᑐᓂᑦ ᖃᓄᐃᓕᐅᕐᓂᐅᔪᑦ. ᑲᑎᓗᒃᑖᖅᓗᒋᑦ ᐱᐅᖕᒋᑦᑐᑦ ᐊᓂᐊᔪᓄᑦ ᓈᓴᐅᑏᑦ ᓄᓇᕗᒻᒥᑦ 2007-ᒥᑦ 2011-ᒧᑦ 434 (KILOTONNES) ᑭᓗᑕᓐ-ᖑᓚᐅᖅᑐᑦ ᑳᑉᓐ ᑕᐃᔫᒃᓴᐃᑦ ᐊᔾᔨᕐᑉᓗᕐᑦ ᐅᑭᐅᒥᑦ (kt CO_{2e}/yr). ᐱᕙᓪᓕᐊᓂᖓ Whale Tail ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᐊᒻᒪᓗ ᐱᐅᖕᒋᑦᑐᑦ ᐊᓂᐊᔪᑦ ᐃᖕᒋᕐᕋᔭᖕᓂᕐᒧᑦ ᐅᓯᑲᑦᑕᓂᕐᒧᑦ ᐊᑉᖁᑎᒃᑯᑦ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ 56%-ᒥᑦ ᐊᖕᒋᓪᓕᒋᐊᕐᓂᐊᕐᓂᖓᓄᑦ GHG ᐱᐅᖕᒋᑦᑐᑦ ᐊᓂᐊᔪᑦ ᓄᓇᕗᒧᑦ. ᑭᓯᐊᓂ, ᑕᐅᑐᖕᖠᖅᓱᒍ ᑲᓇᑕᒥᑦ ᐱᐅᖕᒋᑦᑐᑦ ᐊᓂᐊᔪᑦ (714,000 kt CO_2e/yr), ᐱᓕᕆᐊᖅ ᐃᑲᔪᐃᓯᒪᔪᖅ 0.05% ᑐᖕᖠᓂᑦ ᐊᖕᒋᓪᓕᒋᐊᖅᑐᒥᒃ ᑲᓇᑕᐅᑉ GHG-ᓂᒃ ᐊᓂᐊᔪᖕᒋᓐᓄᑦ.

ᓇᐃᑦᑑᓇᔭᕐᓂᖓ ᐱᓕᕆᐊᖑᔪᒪᔪᖅ ᑐᑭᖃᖅᑐᖅ ᓯᓚᐅᑉ ᐊᓯᔾᔨᕐᓂᖓ ᐱᔾᔪᑎᖃᖅᑐᖅ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓂᒃ ᐱᓕᕆᐊᕐᒧᑦ ᐅᔾᔨᕐᓇᕋᔭᖕᒋᑦᑐᖅ.

ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖓ ᐊᒻᒪᓗ ᐊᓂᖅᓵᖅᑐᖅᑕᕗᑦ

ᐃᓄᐃᑦ ᐊᑐᖃᑦᑕᖅᑐᑦ ᖃᓂᑕᖕᒋᓐᓂᒃ ᐊᕙᑎᒋᔭᖕᒋᓐᓂᒃ ᐃᓅᖃᑎᒌᖕᓂᕐᒧᑦ, ᐱᖅᑯᓯᕐᒧᑦ, ᐊᒻᒪᓗ ᐱᕈᖅᐸᓪᓕᐊᓂᕐᒧᑦ ᖃᓄᐃᖕᒋᑦᑎᐊᕐᓂᕐᒧᑦ, ᐅᔾᔨᕈᓯᒃᑐᑦ ᐊᓯᐊᖑᕐᓂᐅᔪᓂᒃ ᐊᕙᑎᖓᓐᓄᑦ, ᐃᓚᐅᑉᓗᓂ ᐊᓂᖅᓵᖅᑐᖅᑕᖕᒋᑦᑕ ᖃᓄᐃᓐᓂᖓᑦ. ᐃᓄᐃᑦ ᖃᐅᔨᓯᒪᔪᑦ ᒫᓐᓇᓵᖅ ᐊᓯᐊᖑᕐᓂᐅᔪᓂᒃ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᕆᔭᖓᓂᑦ, ᐊᒻᒪᓗ ᐃᓱᒫᓘᑎᖃᖅᑐᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓂᒃ ᐱᖅᑯᓯᒃᑯᑦ ᓄᓇᒥᒃ ᐊᑐᖃᑦᑕᖅᑕᖕᒋᓐᓂᑦ ᐊᒻᒪᓗ ᐱᕚᕆᖃᑦᑕᖅᑕᖕᒋᓐᓂᑦ. ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖕᒋᑦ ᓇᓗᓇᐃᖅᓯᔪᑦ ᐃᓱᒫᓘᑕᐅᔪᓂᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᓂᒃ ᐳᔪᖃᑖᑉ ᒥᒃᓵᓄᑦ ᐱᕈᖅᑐᓄᑦ ᐊᒻᒪᓗ ᐃᒃᐱᒋᓴᕋᐃᓂᖕᒋᓐᓄᑦ ᑐᒃᑐᐃᑦ, ᐅᒥᖕᒪᐃᑦ, ᐊᒻᒪᓗ ᐊᓯᖕᒋᑦ ᐱᖅᑯᓯᒃᑯᑦ ᐱᕚᐅᑲᑦᑕᖅᑐᑦ ᑕᒪᒃᑯᓄᖕᖓ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓄᑦ. ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐱᓕᕆᐊᕐᒥᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᕆᔭᖓᓄᑦ ᐊᒻᒪᓗ ᓯᓚᖃᖕᒋᑦᑐᒨᖅᑐᑦ ᐳᔪᖃᑦᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᓚᐅᖅᑐᑦ ᑲᓇᑎᒥᐅᖓᓂᑦ ᐊᒻᒪᓗ ᓄᓇᕗᒻᒥᐅᖓᓂᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖕᒋᓐᓄᑦ ᒪᓕᒃᑕᐅᔫᒃᓴᐃᑦ ᐊᑐᖅᑕᐅᔪᖅᑕᖃᖕᒋᒪᑦ ᓇᓗᓇᐃᖅᑕᐅᔪᖕᓇᖅᑐᑦ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖕᒋᓐᓂᑦ.

ᓄᓇᓕᖕᒥᐅᑕᐃᑦ ᐃᓅᔪᑦ ᑐᒃᓯᕋᓚᐅᖅᑐᑦ ᐱᐅᖕᒋᑦᑐᓂᒃ ᐊᓂᐊᔪᓂᒃ ᐊᑉᖁᑎᒥᑦ ᐳᔪᖃᑖᒃ ᐊᖕᒋᓗᐊᖕᒋᕆᐊᖅᑎᑕᐅᖁᑉᓗᒍ ᐊᑐᕐᓗᑎᒃ ᐊᑉᖁᑎᒃ ᐃᒻᒥᖅᑐᐃᖃᑦᑕᕐᓂᒃᑯᑦ ᐊᑐᖅᑕᐅᖃᑦᑕᖅᑐᓂᒃ ᐳᔪᖃᑖᖃᓗᐊᖅᑕᐃᓕᑎᑦᑎᓂᕐᒥᒃ, ᐊᒻᒪᓗ ᑲᑎᑉᐸᓪᓕᐊᔪᑦ ᐳᔪᖃᑖᒃ ᖃᐅᔨᒋᐊᖅᑕᐅᖃᑦᑕᕐᓗᓂ. ᐊᓪᓃᑯᒃᑯᑦ ᓯᓚᓕᕆᖃᑦᑕᖅᑐᑦ ᐃᓂᖃᕐᕕᒋᔭᖓᓂᑦ, ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᕆᔭᖓᓂᑦ, ᐊᒻᒪᓗ ᐳᔪᖃᑖᖕᒥᒃ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒧᑦ ᑕᐃᒪᐅᔪᒥᒃ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒪᓈᓂᑦ ᐊᒻᒪᓗ ᐊᖕᒋᓗᐊᖕᒋᕆᐊᖅᑎᑦᑎᑉᓗᑎᒃ ᐊᒻᒪᓗ ᖃᐅᔨᒋᐊᖃᑦᑕᖅᓱᒋᑦ ᐱᕕᖃᕐᓂᐅᔪᑦ ᐱᓕᕆᐊᖑᔪᒪᔪᒥᑦ ᐊᔾᔨᖃᕐᓗᑎᒃ ᑕᐃᒪᐅᔪᓂᒃ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᖕᒥᑦ.

ᓯᐊᒻᒪᒃᑕᐅᓂᖓ ᐋᖅᑭᐅᒪᔪᖅ-ᓇᓚᐅᑦᑖᖅᑕᐅᔪᖅ ᓄᓇᒥᖓᔪᖅ ᑲᑎᓯᒪᔪᑦ carbon monoxide (CO), NO_2, ᐊᒻᒪᓗ sulfur dioxide (SO_2) ᐊᑦᑎᒃᑐᒻᒪᕆᐅᓚᐅᖅᑐᑦ ᑕᐅᑐᖓᖅᑯᒋᑦ ᑮᓕᒋᔭᐅᔪᑦ ᐊᒻᒪᓗ ᐊᔾᔨᖏᓐᓂᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖏᓐᓄᑦ ᐊᑐᖅᑕᐅᔪᓄᑦ. ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ $PM_{2.5}$ ᓄᑦ ᐊᑭᐊᓃᑦᑐᑦ ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎᐅᑉ ᐊᑖᓃᓚᐅᖅᑐᑦ ᓄᓇᒥᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᒪᓕᒃᑕᐅᔪᖅᓴᖏᓐᓄᑦ 50-ᒥᑦ 75-ᒧᑦ ᒦᑕᓄᑦ (m) ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎᒥᑦ. ᐊᖏᓛᒃᑯᑦ ᐊᕐᕌᒍᑕᒫᑦ TSP ᑲᑎᓯᒪᔪᑦ ᓇᓚᐅᑦᑖᒻᑕᐅᔪᑦ ᐅᖓᑕᐅᑦᑎᓂᐊᕐᓂᖏᓐᓄᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓂᐃᓐᓂᖓᓄᑦ ᐊᖅᑐᖅᑕᐅᔪᒥᑦ (60 micrograms cubic ᒦᑕᑕᒫᑦ [g/m ᓯᕗᓪᓕᖅᐸᐅᔪᑦ 100-ᒥᑦ 300-ᒧᑦ ᒦᑕᓄᑦ ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎᒥᑦ. ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᐳᔪᖃᑖᓄᑦ ᓈᓴᐅᑏᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᐊᑖᓃᓐᓂᐊᕐᓂᖏᓐᓄᑦ BC ᐳᔪᖃᑖᖕᒧᑦ ᐊᑐᖅᓂᑕᐅᔪᓂᑦ 300 m ᒦᑕᓂᒃ ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎᒥᑦ. ᐊᕐᕌᒍᑕᒫᑦ ᐳᔪᖃᑖᒃ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᖅ ᐊᑦᑎᖕᓂᖅᓴᐅᓂᖓᓄᑦ ᐋᓂᐅᕆᔪᒥᑦ ᐳᔪᖃᑖᖕᒧᑦ ᐊᑐᖅᑕᐅᔪᒥᑦ 25 m ᒦᑕᐅᑉ ᐃᓗᐊᓂᑦ ᐅᓯᒃᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑕᐅᑉ ᐃᓗᐊᓂᑦ. ᑕᒪᒃᑯᐊ ᐊᑐᖅᑕᐅᔪᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ ᐊᐅᓚᑕᐅᓪᓚᕆᖕᓂᖕᒋᓐᓄᑦ ᐊᑐᖅᑕᐅᔪᓂᑦ ᑲᓇᑕᒥᑦ.

ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐳᔪᖃᑖᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑎᖕᓄᑦ ᐊᑭᐊᓂᑦ ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎ ᑮᓕᖃᖅᑐᑦ ᑎᑭᐅᑎᓂᕐᒧᑦ ᐊᖓᓯᖕᓂᕐᒧᑦ ᐊᒻᒪᓗ ᑕᐃᒪᐅᖃᑦᑕᓗᐊᖅᑐᑦ ᐸᓂᖅᑎᓪᓗᒍ ᐊᓄᕆᑐᔪᒥᑦ ᐊᐅᔭᒃᑯᑦ. ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐅᑎᕈᖕᓇᖅᑐᑦ ᐳᔪᖃᑖᑦ ᐊᒃᑐᖅᓯᓂᖃᕈᖕᓃᕐᓗᑎᒃ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᕆᔭᖏᓐᓄᑦ Whale Tail ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᐊᑐᖅᑕᐅᔪᖕᓃᖅᐸᑦ ᐊᒻᒪᓗ ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎ ᐊᑐᖅᑕᐅᔪᖕᓃᖅᐸᑦ.

ᐊᑐᖅᓱᒋᑦ ᕿᓂᖅᓴᐃᓂᕐᒧᑦ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒧᑦ ᖃᓄᐃᖓᓂᐅᔪᑦ, ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐅᐃᒍᒋᐊᖅᑕᐅᓂᖓᓄᑦ ᐊᐅᓛᖅᑎᑦᑎᓃᑦ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᓯᖃᓪᓕᑎᕆᕙᖕᒥᑦ ᐊᒻᒪᓗ ᓄᓇᓕᐊᓛᒥᑦ ᐊᓂᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖓᓄᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ ᐊᑦᑎᒃᑑᓂᖓᓄᑦ. ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐃᓱᒪᒋᔭᐅᔪᑦ ᐅᑎᖅᑎᑦᑐᖕᓇᕐᓂᐊᕐᓂᖕᒋᓐᓄᑦ ᐱᐅᖕᒋᑦᑐᑦ ᐊᓂᐊᔪᑦ ᐊᒃᑐᖅᓯᓂᖃᕈᖕᓃᕐᓂᐊᕐᒪᑕᑦ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖓᓄᑦ Whale Tail ᐃᓗᑦᑐᖅᓯᒪᔪᖅ ᐊᒻᒪᓗ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐅᔭᕋᖕᓂᐊᕐᕕᒃ ᐊᑐᖅᑕᐅᔪᖕᓃᖅᐸᑕ.

ᐅᑭᐅᓄᒃᑖᖅ ᐊᑉᕐᑯᑎᐅᔪᖅ (AWAR) ᐊᑯᓐᓂᖓᓃᑦᑐᖅ ᖃᒪᓂᑦᑐᐊᑉ ᐊᒻᒪᓗ ᐊᐳᖅᑎᓈᖅᑑᑉ ᓂᕆᐅᒋᔭᐅᔪᖅ ᐊᑐᖅᑕᐅᖕᒋᓇᕐᓂᐊᕐᓂᖓᓄᑦ ᐅᑭᐅᓄᑦ ᐱᖓᓱᓄᑦ ᑎᑭᓪᓗᒍ Whale Tail ᐃᓗᑦᑐᖅᓯᒪᔪᕐᒥᑦ ᐊᐅᓚᕐᓃᑦ ᓄᖅᑲᖅᑳᖅᑎᓪᓗᒍ. ᐅᖓᓯᖕᓂᖓ ᐊᑯᓐᓂᖕᒋᓐᓂᑦ AWAR ᐊᒻᒪᓗ Whale Tail-ᒥᑦ ᐊᐅᓚᕐᓃᑦ ᐊᒻᒪᓗ ᓂᕆᐅᒋᔭᐅᔪᖅ ᐊᑐᖅᑕᐅᖃᑦᑕᕐᓂᐊᕐᓂᖓ AWAR ᑮᓕᖃᖅᑎᑦᑎᔪᖅ ᑲᑎᒪᔪᓂᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓂᒃ ᐱᐅᖕᒋᑦᑐᓂᒃ ᐊᓂᐊᔪᓂᑦ ᐊᑐᖅᑕᐅᖕᒋᓇᕐᓂᖓᓄᑦ AWAR ᐊᒻᒪᓗ Whale Tail-ᒥᑦ ᐊᐅᓚᕐᓂᐅᔪᓄᑦ. ᒫᓇᓵᖑᓛᖑᔪᖅ (2015) ᖃᓄᐃᖓᓂᐅᔪᑦ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐳᔪᖃᑖᒥᒃ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒧᑦ ᑐᕋᖓᔪᖅ ᓇᓗᓇᐃᖅᓯᓚᐅᖅᑐᖅ ᖃᓂᑦᑑᒐᓗᐊᕐᒥᑦ ᐱᓕᕆᐊᑉ ᐊᐅᓚᕐᓂᕆᔭᖓᑕ, ᐆᒃᑐᕋᖅᑕᐅᔪᓗᒃᑖᑦ ᑖᑉᑯᓇᓂ ᐆᒃᑐᕋᖅᑕᐅᔪᓂᑦ ᐊᑕᐅᓯᖅ ᐃᓚᐅᖕᒋᕐᓱᒍ 48-ᖑᔪᓂᑦ ᑲᑎᑕᐅᔪᓂᑦ, ᐱᐅᓂᖅᓴᐅᓚᐅᖅᑐᑦ ᐃᐋᐳᑕᐅᑉ ᒪᓕᒃᑕᐅᔪᖅᓴᖏᓐᓄᑦ ᐳᔪᖃᑖᒧᑦ ᐊᑐᖅᑕᐅᒥᐊᖅᑐᒥᑦ ᐊᒻᒪᓗ ᐊᖏᕋᕆᔭᐅᔪᑦ ᐃᓂᖏᓐᓂᑦ.

ᖃᓄᐃᖓᓂᐅᔪᑦ ᖃᐅᔨᓴᐃᓂᕐᒥᑦ ᓇᓗᓇᐃᖅᓯᔪᑦ ᒥᑭᔪᑯᓗᖕᓂᑦ ᐊᒻᒪᓗ ᐳᔪᖃᑖᒥᒃ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᖅ Whale Tail ᐃᓗᑦᑐᖅᓯᒪᔪᕐᒥᑦ ᐊᒻᒪᓗ ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎᒥᑦ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐱᓕᕆᐊᖑᓯᒪᔪᖅ. ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒧᑦ ᑐᕌᖓᔪᖅ ᐊᑐᕐᓂᐊᖅᑐᖅ ᑕᐃᒪᐅᔪᕐᒥᒃ ᐊᓂᖅᓵᖅᑐᖅᑕᑉᑕ ᖃᓄᐃᓐᓂᖓᓄᑦ ᐊᒻᒪᓗ ᐳᔪᖃᑖᒧᑦ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒥᒃ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ, ᐊᒻᒪᓗ ᐳᔪᖃᑖᖕᒥᑦ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᕐᒧᑦ ᑐᕌᖓᔪᖅ ᐊᐳᖅᑎᓈᖅᑐᒥᑦ ᐊᑉᕐᑯᑎᒥᑦ ᖃᒪᓂᑦᑐᐊᕐᒧᙱᑕᐅᔪᒧᑦ.

ᑕᒪᕐᒥᒃ ᐃᓄᐃᑦ ᖃᐅᔨᒪᔭᑐᖃᖏᑦ ᐊᒻᒪᓗ ᐃᓕᓐᓂᐊᖅᓯᒪᓂᖃᕐᓂᒃᑯᑦ ᖃᐅᔨᒋᐊᖃᑦᑕᕐᓂᖅ ᓇᓗᓇᐃᖅᑐᖅ ᐊᑉᕐᑯᑎᒥᒃ ᐃᒻᒥᖅᑐᐃᓂᖅ ᐊᒻᒪᓗ ᐊᑐᖅᑕᐅᓂᖓ ᐳᔪᖃᑖᖃᑐᐊᖅᑕᐃᓕᑎᑦᑎᔾᔪᑏᑦ ᒥᒃᓵᒋᐊᖅᑎᑦᑎᔪᖕᓇᖅᑐᑦ ᐳᔪᖃᑖᒥᒃ.

ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪᓗ ᓴᔪᕋᓛᖕᓂᐅᔪᖅ

ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎ ᓴᓇᔭᐅᓂᖓᓄᑦ ᓂᐱᖃᕐᓂᐅᑉ ᓇᓃᓐᓂᕆᔭᖓᓂᑦ ᑕᒪᐃᓐᓄᓗᒃᑖᖅ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖕᒋᓐᓄᑦ ᑕᐅᒪᐅᔪᒥᒃ ᓂᐱᖃᕐᓂᐅᔪᒥᒃ ᑮᓕᖓᓄᑦ ᖃᓂᓐᓂᖅᓴᒥᑦ ᐊᒻᒪᓗ ᐅᖓᓯᖕᓂᖅᓴᒥᑦ ᖃᐅᔨᓴᐃᓂᐅᔪᓂᑦ (LSA ᐊᒻᒪᓗ RSA). ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᓈᓴᐅᑏᑦ ᓇᓗᓇᐃᖅᓯᖕᒥᔪᑦ ᐊᑦᑎᒃᑑᖓᔪᒥᒃ ᓂᐱᑕᖃᕝᔾᔭᖕᒋᓐᓂᖓᓄᑦ (LFN) ᖃᓄᐃᖓᓕᖅᑎᑦᑎᔪᒥᒃ LSA-ᒥᑦ ᑮᓕᐅᔪᒧᑦ. ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎᒥᑦ ᐊᐅᓛᕐᓂᐅᔪᒥᑦ ᓂᐱᖃᕐᓂᐅᑉ ᓇᓃᓐᓂᕆᔭᖕᒋᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᖕᒥᔪᑦ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖓᓄᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓃᓐᓂᐅᔪᓂᒃ ᐊᐅᔭᒧᑦ ᐊᒻᒪᓗ ᐅᑭᐅᖑᑎᓪᓗᒍ ᑮᓕᒋᔭᖓᓂᑦ RSA. ᐊᔾᔨᕐᓚᖓ, ᓇᓃᓐᓂᓗᒃᑖᖑᔪᓂᑦ, ᐅᓯᑲᑦᑕᖕᓂᕐᒧᑦ ᐊᑉᕐᑯᑎ ᐊᑐᖅᑕᐅᑎᓪᓗᒍ ᐱᓕᕆᐊᒥᑦ ᓂᐱᖃᕐᓂᐅᑉ ᓇᓃᓐᓂᕆᔭᖕᒋᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖓᓄᑦ 35 (dBA)-ᒥᑦ ᑮᓕᒋᔭᖓᓄᑦ LSA.

ᐃᓗᑦᑐᖅᓯᒪᔪᒥᑦ ᐊᐅᓛᕐᓂᕐᒧᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓅᓐᓂᐅᔪᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖓᓄᑦ 30 dBA-ᒥᑦ ᑮᓕᕿᔭᐅᔪᒥᑦ RSA ᑕᒪᐃᓐᓄᑦ ᐊᐅᔭᒃᑯᑦ ᐊᒻᒪ ᐅᑭᐅᒃᑯᑦ. ᑕᐃᒪᓐᓇᑦᑕᐅᖅ, ᐃᓗᑦᑐᖅᓯᒪᔪᒥᑦ ᐊᐅᓛᖅᑎᑦᑎᓂᕐᒧᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓅᓐᓂᐅᔪᖅ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᖅ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖓᓄᑦ 30 dBA ᑕᐃᒪᐅᔪᒥᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓅᓐᓂᐅᔪᒥᑦ ᑕᒪᐃᓄᓗᒃᑖᖅᖃᔭᖅ ᑮᓕᕿᔭᐅᔪᖅ LSA-ᒥᑦ ᐊᒻᒪ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᖅ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖓᓄᑦ 35 dBA-ᒥᑦ ᐃᓂᐅᔪᓗᒃᑖᓂᑦ LSA ᑮᓕᕿᔭᖓᓄᑦ. ᐊᐅᔭᒃᑯᑦ ᐅᑭᐅᒃᑯᓪᓗ ᐃᓗᑦᑐᖅᓯᒪᔪᒥᒃ ᐊᐅᓛᖅᑎᑦᑎᓂᕐᒥᑦ ᑲᑎᑉᐸᓪᓕᐊᔪᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓅᓐᓂᐅᔪᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᒥᑭᓂᖅᓴᐅᓂᐊᕐᓂᖏᓐᓄᑦ ᐊᑐᖅᑕᐅᔭᕆᐊᖃᖅᑐᒥᑦ AER ᒪᓕᒃᑕᐅᔪᒃᓴᒥᑦ 038 PSL-ᒧᑦ ᑮᓕᐅᔪᒥᑦ ᑕᒪᓗᒃᑖᒧᑦ LSA ᑮᓕᖃᖅᑎᑕᖓᓄᑦ. LFN-ᒥᒃ ᐱᔪᒥᒃ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᖅᑕᖃᕐᔪᖏᑦᑐᖅ LSA ᑮᓕᖃᖅᑎᑕᖓᓄᑦ. LSA ᑮᓕᖃᖅᑎᑕᖓᓂᑦ ᓯᓚᒨᐊᖅᑐᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᓇᓅᓐᓂᐅᔪᑦ ᐱᓕᕆᐊᕐᒥᑦ ᖄᖅᑎᕆᓂᕐᒧᑦ ᓇᓚᐅᑦᑖᖅᑕᐅᔪᑦ ᐊᑦᑎᖕᓂᖅᓴᑲᓪᓚᐅᓂᐊᕐᓂᖓᓄᑦ NCP-119-ᒥᑦ ᐊᑐᖅᑕᐅᔭᕆᐊᓕᖕᒥᑦ.

ᓇᓚᐅᑦᑖᖅᑕᐅᓯᒪᔪᖅ ᐅᖓᓯᖕᓂᐅᔪᑦ ᐃᓗᑦᑐᖅᓯᒪᔪᕐᒥᑦ ᖂᖅᑎᓇᓂᕐᓂᑦ ᐱᔭᕆᐊᖃᖅᑐᖅ ᒪᓕᒋᐊᖃᕐᓂᕐᒧᑦ ᐃᖃᓗᓕᕆᔾᔪᑦ ᓴᐳᒃᑎᑦᑎᓂᕐᒧᑦ ᐊᒻᒪ ᓂᐱᖃᕐᓂᕐᒧᑦ ᑮᓕᓕᐅᖅᓯᒪᔭᕆᐊᓄᑦ ᒥᐊᓂᕆᓂᕐᒧᑦ ᒪᓐᓂᓕᐅᖅᑐᖅ ᐃᖃᓗᐃᑦ ᐊᒻᒪ ᐃᓂᖏᑦ, 700 ᒦᑕᐅᔪᑦ ᐊᒻᒪ 148 ᒦᑕᐅᑉᓗᑎᒃ ᐃᖃᓗᐃᑦ ᒪᓐᓂᓕᐅᕐᕖᖏᓐᓂᑦ ᐃᓂᖏᓐᓄᓪᓗ. ᐃᓗᑦᑐᖅᓯᒪᔪᕐᒥᑦ ᐊᐅᓛᕐᓂᐅᑎᓪᓗᒍ, ᖂᖅᑎᓇᓂᖅ ᐊᐅᓚᑕᐅᑦᑎᐊᕐᓂᐊᖅᑐᖅ ᐊᒻᒪ ᖃᐅᔨᓯᐊᖅᑕᐅᖃᑦᑕᕐᓗᑎᒃ ᐃᖃᓗᓕᕆᔾᔪᑦ ᑮᓕᓕᐅᖅᓯᒪᔭᕆᑦ ᐋᕿᒃᓯᒪᔭᕆᓪᓗ ᓴᖅᑭᑕᐅᓗᑎᒃ ᓂᐱᖃᕐᓂᖅ ᐊᒻᒪ ᓴᐳᒃᑎᑦᑎᓂᖅ ᖂᖅᑎᓇᓂᕐᒥᑦ ᐱᔪᓂᒃ ᐊᒃᑐᖅᓯᓂᖃᕋᔭᖏᓪᒪᑕ ᒪᓐᓂᓕᐅᖅᑐᓂᒃ ᐃᓂᕆᔭᖏᓐᓂᓪᓗᓐᓂᑦ.

ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᑦ ᐱᔪᑦ ᐊᑉᑯᑕᐅᓗᐊᖅᑐᓂᑦ ᖃᐅᔨᓴᐃᓂᕐᒦᑦᑐᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓂᐅᔪᖕᓇᖅᑐᓂᑦ, ᐊᒻᒪ ᕿᒪᒃᑎᑦᑐᓄᑦ ᖃᓄᐃᖓᓕᖅᑎᑦᑎᓄᑦ ᐃᓂᓕᐅᖅᓯᒪᔪᑦ, ᐊᓯᖏᑦ ᐃᒃᐱᒋᓂᖃᕐᕕᐅᔪᑦ ᐃᓚᕿᔭᐅᔪᑦ, ᐱᓗᐊᖅᑐᒥᑦ ᓂᕐᔪᑎᓂᑦ, ᑎᖏᐊᓂᑦ, ᐊᒻᒪ ᐃᖃᓗᖕᓂᑦ.

ᖃᐅᔨᓯᐊᖃᑦᑕᕐᓂᖅ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐱᓕᕆᐊᕐᒧᑦ ᐱᓕᕆᐊᖑᓂᐊᖅᑐᖅ ᐊᔾᔨᒥᓗᒍ ᖃᐅᔨᓯᐊᖃᑦᑕᕐᓂᖅ ᒫᓐᓇᐅᔪᖅ ᐱᓕᕆᐊᖑᔪᑦ ᐃᓚᒋᔭᐅᑉᓗᓂ ᐊᐳᖅᑎᓐᓈᖅᑐᒥᑦ ᓂᐱᖃᕐᓂᕐᒧᑦ ᐊᐅᓚᑦᑎᓂᕐᒧᑦ ᐸᕐᓇᐅᑎᓂᑦ. ᐊᕐᕌᒍᑕᒫᖅ ᖃᐅᔨᓯᐊᖃᑦᑕᕐᓂᕐᒥᒃ ᐱᓕᕆᐊᖃᕐᓂᐊᖅᑐᑦ ᓯᑕᒪᓄᑦ ᐃᓂᐅᔪᓄᑦ ᐱᓕᕆᐊᕐᒥᑦ ᐃᓂᐅᔪᑦ ᓂᕈᐊᖅᑕᐅᓗᑎᒃ ᐊᒻᒪ ᐋᕿᒋᐊᖅᑕᐅᓗᑎᒃ ᐱᓕᕆᐊᖅ ᐱᕙᓪᓕᐊᓂᖓᓂ. ᖃᐅᔨᓯᐊᖅᑕᐅᖃᑦᑕᖅᑐᑦ ᓂᐱᖃᕐᓂᐅᑉ ᓇᓅᓐᓂᕆᔭᖏᑦ ᐅᖓᑕᐅᑦᑎᒃᐸᑕ ᑮᓕᐅᔪᓄᑦ, ᐊᒃᓅᒃᑯᑦ ᖃᓄᐃᓕᐅᕆᐊᕐᓂᐊᖅᑐᑦ ᐃᓕᑕᖅᓯᓂᕐᒧᑦ ᐱᔾᔪᑕᐅᔪᒥᒃ ᐅᖓᑕᐅᑎᓂᕐᒧᑦ ᐊᒻᒪ, ᓈᒻᒪᒃᐸᑦ, ᐊᖏᓗᐊᖏᑦᑎᐊᖅᑎᓪᓗᒋᑦ ᓂᐱᖃᖅᑎᑦᑎᔪᖅ.

SOMMAIRE DE GESTION – VOLUME 4 – L'ENVIRONNEMENT ATMOSPHÉRIQUE

Le Volume 4 de l'Énoncé des incidences environnementales du Projet de gisement Whale Tail et de route de transport (le Projet) traite des directives et lignes directrices émises par la Commission du Nunavut chargée de l'examen des répercussions, plus particulièrement celles relatives aux effets sur l'environnement atmosphérique, dont le climat et la météorologie, la qualité de l'air, ainsi que le bruit et les vibrations. L'évaluation des effets s'attarde à évaluer toutes les phases du Projet, incluant la construction, les opérations et la fermeture.

Le climat

La section sur le climat et la météorologie inclut un examen des documents pertinents, ainsi que des observations sur l'Inuit Qaujimajatuqangit (IQ) de la part d'Inuits de Baker Lake. Les changements climatiques sont une source d'inquiétude pour les aînés et les utilisateurs des terres puisque l'imprévisibilité des conditions climatiques a mené à un manque de confiance envers l'usage des connaissances traditionnelles pour prévoir la température. Les Inuits sont également concernés par les effets potentiels des changements climatiques sur la végétation, la faune, le poisson et les autres ressources traditionnelles.

Les émissions de gaz à effet de serre (GES) du Nunavut sont faibles en raison de sa population restreinte et de la faible intensité de ses activités urbaines/industrielles. Les émissions moyennes totales du Nunavut de 2007 à 2011 étaient de 434 kilotonnes d'équivalent de dioxyde de carbone par an (kt CO_{2e}/an). Le développement du gisement Whale Tail et des émissions engendrées par la circulation le long de la route de transport vers la mine Meadowbank devrait mener à une augmentation de 56 % des émissions de GES pour le Nunavut. Cependant, lorsque comparé aux émissions nationales du Canada (714 000 kt CO_2e/an), le Project contribue à une augmentation de moins de 0,05 % des émissions canadiennes de GES.

La courte durée du Projet proposé signifie que les effets du Projet associés aux changements climatiques sont susceptibles d'être négligeables.

La qualité de l'air et la poussière

Les Inuits dépendent de leur environnement local pour leur mieux-être social, culturel et économique. Ils sont conscients des changements subits par leur environnement, dont la qualité de l'air. Les Inuits ont documenté de récents changements à la qualité de l'air et se questionnent sur les effets potentiels de ces changements sur leurs activités et leurs ressources en lien avec l'utilisation traditionnelle de la terre. L'Inuit Qaujimajatuqangit met en relief des questionnements au sujet des effets des dépôts de poussière sur la végétation et la sensibilité du caribou du bœuf musqué et d'autres ressources traditionnelles à ces effets potentiels. Les effets potentiels du Projet sur la qualité de l'air les dépôts atmosphériques de la poussière ont été prévus et comparés aux directives nationales et territoriales sur la qualité de l'air étant donné u'il n'existe pas de normes pouvant être tirées explicitement des IQ.

Les Inuits locaux ont demandé que les émissions fugitives de poussière de route soient atténuées par l'arrosage des routes et l'application de contrôles chimiques de la poussière, et que l'accumulation de poussière soit surveillée. Agnico Eagle procède à la surveillance locale de la météorologie, de la qualité de l'air et des retombées de poussières à la mine Meadowbank et les possibilités d'atténuation et de surveillance du Projet proposé sont similaires à celles de la mine actuelle de Meadowbank.

Les concentrations au niveau du sol prédites par modélisation de la dispersion du monoxyde de carbone (CO), NO_2 et du dioxyde de soufre (SO_2) étaient très faibles comparées aux données de base et leurs normes pertinentes en matière de qualité de l'air ambiant. Les prévisions de $MP_{2,5}$ adjacentes à la route de transport se situaient en deçà des directives de qualité de l'air ambiant du Nunavut entre 50 et 75 mètres (m) à partir de la route de transport. Les concentrations de MPT annuelles maximales devraient dépasser la norme de qualité de l'air ambiant (60 microgrammes par mètre cube [$\mu g/m^3$]) à l'intérieur des premiers 100 à 300 m de la route de transport. Les taux de dépôt de poussière prévus devraient se situer en deçà de la norme de retombées de poussières de la C.-B. à l'intérieur des 300 m de la route de transport. Le dépôt annuel de poussière devrait se situer en deçà de la norme de retombées de poussières de l'Ontario à l'intérieur de 25 m à partir de la route de transport. Ces normes sont considérées comme les normes canadiennes les plus sévères en matière de dépôt de poussière.

Les effets des émissions fugitives de poussière sur la qualité de l'air à proximité de la route de transport sont limités dans l'espace et se produisent principalement en été, lors de journées venteuses et sèches. Ces effets sont réversibles et cette poussière fugitive cessera d'affecter la qualité de l'air une fois que la fosse Whale Tail sera déclassée et que la route de transport ne sera plus active.

Les effets des activités minières du gisement Whale Tail sur la qualité de l'air de la région sont limités dans l'espace et se produisent principalement en été, lors de journées venteuses et sèches. Ces effets sont réversibles et ces émissions cesseront d'affecter la qualité de l'air une fois que la fosse Whale Tail sera déclassée et que la route de transport ne sera plus active. En se basant sur une extrapolation des résultats de surveillance, les effets d'un prolongement des opérations de l'usine et du campement de Meadowbank sur la qualité de l'air de la région sont considérés comme faibles. Tout effet potentiel est considéré comme réversible et ces émissions cesseront d'affecter la qualité de l'air une fois que la fosse Whale Tail et l'usine de Meadowbank seront déclassées.

La route d'accès praticable par tous les temps (AWAR) entre la collectivité de Baker Lake et l'usine de Meadowbank devrait demeurer active pour une période allant jusqu'à 3 ans après le début des opérations de la fosse Whale Tail. La distance importante entre l'AWAR et les opérations de Whale Tail, ainsi que l'utilisation limitée envisagée de l'AWAR limitent le potentiel d'effets combinés des émissions résultant de l'usage continu de l'AWAR et des opérations de la fosse Whale Tail. Les résultats les plus récents (2015) du programme de surveillance des retombées de poussières de Meadowbank indiquent que même à proximité restreinte des activités du Projet, tous les échantillons sauf 1 sur les 48 qui ont été recueillis, ont pu être comparés favorablement aux directives de l'Alberta sur les retombées de poussières dans les zones récréatives et résidentielles.

Les résultats de cette évaluation indiquent que la surveillance des matières particulaires et des retombées de poussières autour de la fosse Whale Tail et le long de la route de transport jusqu'à la mine Meadowbank est garantie. Le programme de surveillance sera basé sur la surveillance actuelle de la qualité de l'air et des retombées de poussières autour de la mine de Meadowbank, ainsi que sur le programme de surveillance des retombées de poussières le long de l'AWAR de Meadowbank jusqu'à Baker Lake.

Autant la surveillance scientifique que celle des IQ suggèrent que l'arrosage des routes et l'application de contrôles chimiques de la poussière peuvent réduire les émissions de poussière fugitives.

Le bruit et les vibrations

Les niveaux de bruit de la construction de la route de transport pour toutes les périodes devraient être plus faibles que le niveau de bruit ambiant actuel à la limite des zones d'étude locale et régionale (ZEL et ZER). Les valeurs prévues indiquent également qu'il n'y aura pas d'effets causés par le bruit à basse fréquence (BBF) le long de la frontière de la ZEL. Les niveaux de bruit des activités de la route de transport devraient également être plus faibles que le niveau de bruit ambiant actuel en été et en hiver à la frontière de la ZER. De même, pour toutes les périodes, les niveaux de bruit du Projet associés aux activités de la route de transport devraient être en deçà de 35 décibels de gamme A (dBA) à la limite de la ZEL.

Les niveaux de bruit des activités de la fosse devraient être en deçà de 30 dBA à la limite de la ZER, autant en été qu'en hiver. De même, pour toutes les périodes, les niveaux de bruit des activités de la fosse devraient être plus faibles que le niveau de bruit ambiant actuel de 30 dBA pour la plupart des limites de la ZER et de moins de 35 dBA le long de tous les secteurs de la limite de la ZEL. Les niveaux de bruit cumulatifs des activités de la fosse en été comme en hiver devraient se situer en deçà de la directive AER applicable (limite de 038 PSL) le long de la totalité de la frontière de la ZEL. Il n'y aura pas d'effet BBF le long de la frontière de la ZEL. À la limite de la ZEL, les niveaux de bruit aérien de l'abattage par explosion du Projet devraient se situer bien en deçà de la norme NCP-119.

Les distances de retrait prévues pour les activités d'abattage par explosion de la fosse nécessitent de se conformer aux limites de vitesse de crête des particules (vibration) et de pic de pression (bruit) du MPO en matière de protection des poissons en frai et de l'habitat des poissons. Ces distances de retrait sont respectivement de 700 m et de 148 m pour les aires de frai des poissons et l'habitat des poissons. Au cours des opérations de la fosse, l'abattage par explosion sera prudemment géré et surveillé dans le contexte des limites du MPO et des distances de retrait appropriées seront établies afin que le bruit et la vibration provenant de l'abattage par explosion de la fosse n'affectent pas la reproduction des poissons ou leur habitat général.

Tout effet potentiel associé aux trajectoires primaires est saisi dans l'évaluation des effets potentiels, ainsi que la classification des effets résiduels, sur d'autres composantes valorisées, particulièrement au niveau de la faune, des oiseaux et des poissons.

Un suivi de la surveillance du bruit du Projet sera effectué d'une manière demeurant similaire à la surveillance présentement en cours dans le cadre des plans de gestion du bruit de la mine Meadowbank. Il sera procédé à une surveillance annuelle sur quatre emplacements à proximité du Projet. Ces emplacements seront sélectionnés et modifiés au fur et à mesure de l'évolution du Projet. Si les niveaux de bruit enregistrés excèdent les limites appropriées, Agnico Eagle prendra les mesures nécessaires pour identifier la cause spécifique du dépassement des limites et, dans la mesure du possible, atténuer la source du bruit.

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APPENDICES

LIST OF ACRONYMS

ACIA	Arctic Climate Impact Assessment
AER	Alberta Energy Regulator
AWAR	all-weather access road
CAC	criteria air contaminants
CO	carbon monoxide
DFO	Fisheries and Oceans Canada
FEIS	Final environmental impact statement
FTPCCCEA	Federal/Provincial Territorial Committee on Climate Change & Environmental Assessment
GHG	greenhouse gas
GHGRP	Greenhouse Gas Emissions Reporting Program
Golder	Golder Associates Ltd.
H^+	hydrogen ion
IPCC	Intergovernmental Panel on Climate Change
IQ	Inuit Qaujimajatuqangit
ISEE	International Society of Explosives Engineers
ISO	International Organization for Standardization
LFN	Low Frequency Noise
LSA	Local Study Area
NAD	North American Datum
NH_3	ammonia
NIA	noise and vibration impact assessment
NIRB	Nunavut Impact Review Board
NO_2	nitrogen dioxide
NO	nitrogen monoxide
NPRI	National Pollutant Release Inventory
OMOE	Ontario Ministry of Environment
PM10	particulate matter smaller than 10.0 micrometres in aerodynamic diameter
PM2.5	particulate matter smaller than 2.5 micrometres in aerodynamic diameter
PPL	Peak Pressure Level
PPV	Peak Particle Velocity
PSL	Permissible Sound Level
Rmax	maximum predicted Project noise level
RSA	Regional Study Area
SO_2	sulfur dioxide
the Project	Whale Tail Pit and Haul Road
TSP	total suspended particulate matter

LIST OF UNITS

%	percent
+/-	plus or minus
<	less than
>	greater than
°C	degrees Celsius
dB	decibel
dBA	A-weighted decibel
dBC	C-weighted decibel
dBZ	unweighted or linear decibels
$g/m^2/yr$	grams per square metres per year
eq $H^+/m^2/yr$	equivalent hydrogen per square meters per year
hr	hour
kg-N/ha/yr	kilograms of nitrogen per hectare per year
km	kilometre
kt CO_2e/yr	kilotonnes of carbon dioxide equivalents per year
$mg/cm^2/30days$	milligram per square centimetre per 30 days
$mg/dm^2/day$	milligrams per squared decimetre per day
m	metre
mm	millimetre
mm/s	millimetres per second
ppb	parts per billion
ppbv	parts per billion, volumetric
ppmv	parts per million, volumetric
t CO_{2e}/yr	tonnes of carbon dioxide equivalents per year
t/d	tonnes per day
$\mu g/m^3$	micrograms per cubic metre

4.0 ATMOSPHERIC ENVIRONMENT

4.1 Introduction

The purpose of this section is to address the Guidelines issued by the Nunavut Impact Review Board (NIRB) for the Meadowbank Mine (Cumberland 2005a), and specifically those relating to the impact of the Whale Tail Pit and Haul Road Project (the Project) on weather and climate, air quality, and noise and vibration. Volume 2, Appendix 2-B list the specific requirements set out in the guidelines, and relating to the baseline and impact assessment of these components.

Volume 4 includes a discussion on valued components (VCs), incorporation of Inuit Qaujimajatuqangit (IQ), description of the study areas, and an assessment of direct effects to changes to weather and climate, air quality, and noise and vibration in the study area. The effects assessment evaluates all Project phases, including construction, operations, and closure.

4.1.1 Volume Structure

- **Section 4.1:** Introduction
- **Section 4.2:** Climate and Meteorology
- **Section 4.3:** Air Quality
- **Section 4.4:** Noise and Vibration

4.1.2 Valued Components

Table 4.1-1: Valued Components of the Atmospheric Environment

Valued Component	Rational
Weather and Climate	■ Greenhouse gas emissions from the Project can contribute to climate change. ■ Climate change will affect weather in the Kivalliq region. ■ Community elders are concerned about climate change and recent unpredictability in weather (Volume 7, Appendix 7-A).
Air Quality	■ Combustion emissions from mobile and stationary equipment have the potential to affect air quality. ■ Fugitive dust emissions from mining activities at the Whale Tail Pit have the potential to affect air quality ■ Fugitive road dust emitted from the haul road has the potential to affect air quality. ■ Community elders are concerned about the effects aerial deposition of fugitive dust may have on other VCs; for example, soil quality, water quality, flora and fauna (Volume 7, Appendix 7-A).
Noise and Vibration	■ Noise and vibration were included as a VC in the EIS prepared for the Meadowbank Gold Project (Cumberland 2005a; Cumberland 2005b). ■ Community elders are concerned about Project noise effects on birds (Volume 7, Appendix 7-A). ■ Hunters and trappers are concerned about Project noise effects on wildlife, especially caribou (Cumberland 2005c). ■ Increased ambient noise levels resulting from Project noise emissions can result in effects to humans and wildlife. ■ Ground vibration and airborne noise resulting from Project blasting can result in effects to humans and wildlife.

VC = valued component; EIS = Environmental Impact Statement.

4.1.3 Spatial and Temporal Boundaries

4.1.3.1 Weather and Climate

The spatial boundary associated with the weather and climate VC is considered to be the Kivalliq region of Nunavut. The temporal boundary for existing weather and climate is the Environment Canada 30-year climate normal data from 1981 to 2010 for the Baker Lake meteorological station. Temporal boundaries for the assessment of potential effects related to climate change are considered up to year 2100.

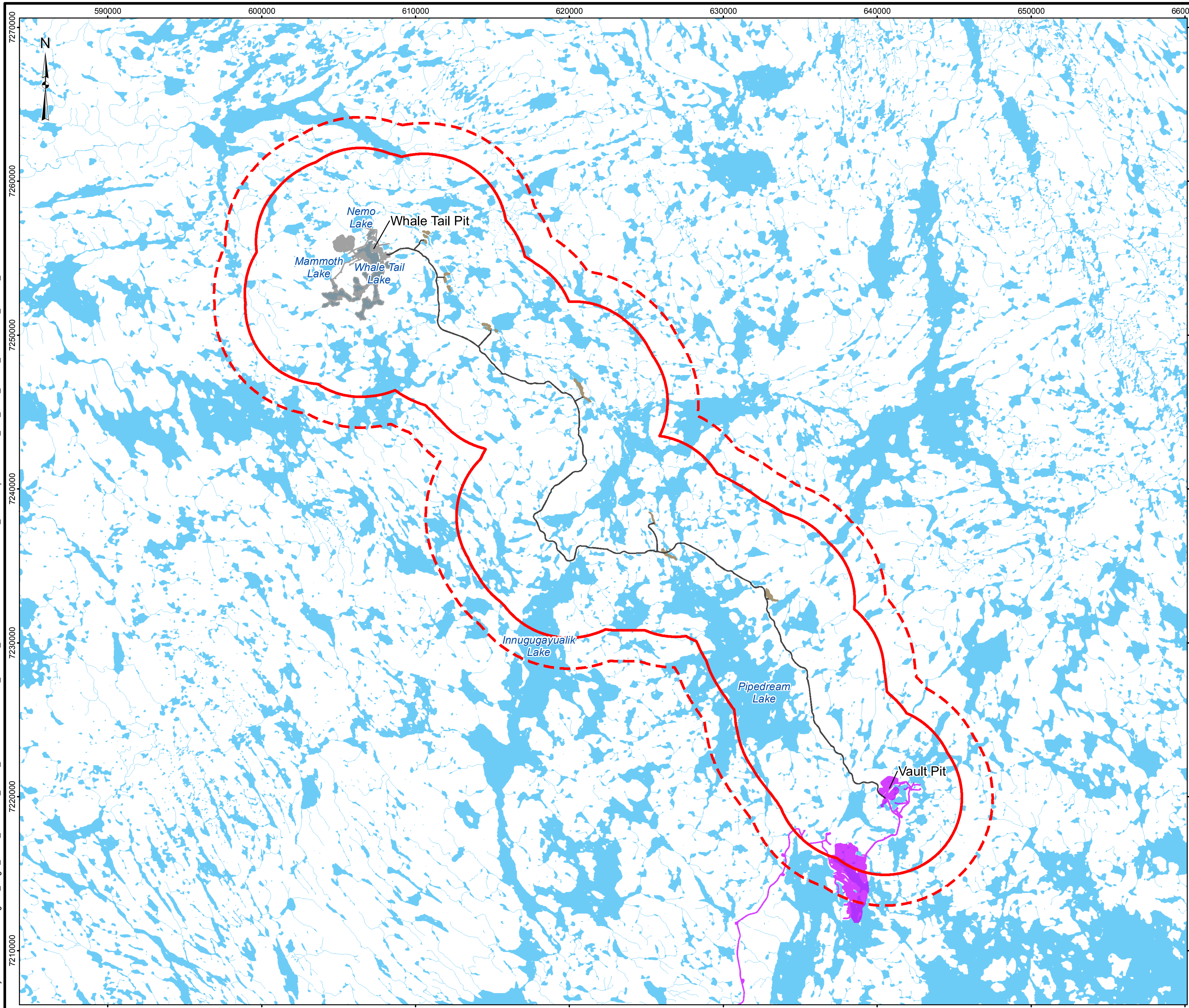
4.1.3.2 Air Quality

The spatial boundary for the assessment of potential effects of the Project on regional air quality is a 60 kilometre (km) by 60 km domain centered on the Whale Tail Pit. For the purpose of assessing the potential effects of the haul road on air quality, a representative 1-km length of the haul road was modelled, and air quality predictions were calculated as a function of distance from the haul road. The meteorological data used to perform the air quality modelling was the 2005 to 2009 data from the Environment Canada meteorology station located at Baker Lake. For the purpose of conservatively assessing Project-related emissions on air quality, the peak emissions year for the Project (2020) was used in the assessment.

4.1.3.3 Noise and Vibration

For the purposes of the assessment of potential effects of the proposed Project on noise and vibration the temporal boundary for construction, operations, and closure of the Project is about seven years. This includes one year construction, three to four years operations, and two years closure (Volume 3, Section 3.3.2).

The Local Study Area (LSA) and Regional Study Area (RSA) for the Project noise and vibration impact assessment (NIA) were selected for consistency with the noise and vibration study areas used in the Meadowbank Final Environmental Impact Statement (FEIS) (Cumberland 2005a; Cumberland 2005b). The LSA was established as a buffer surrounding the Project footprint at a distance of 5 km and the RSA was established as a buffer surrounding the Project footprint at a distance of 7 km (Figure 4.1-1). 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. Noise and vibration levels were predicted for a grid of receptors covering the LSA and RSA and for a discrete receptor corresponding to the most impacted location on the LSA boundary.



LEGEND

- NOISE AND VIBRATION LOCAL STUDY AREA
- NOISE AND VIBRATION REGIONAL STUDY AREA

WHALE TAIL

- BORROW SOURCE
- INFRASTRUCTURE
- PROPOSED HAUL ROAD

MEADOWBANK

- INFRASTRUCTURE/ALL WEATHER ROAD
- WATERCOURSE
- WATERBODY

REFERENCE

1. WHALE TAIL INFRASTRUCTURE OBTAINED FROM AGNICO EAGLE MINES LIMITED ON DECEMBER 21, 2015.
2. MEADOWBANK INFRASTRUCTURE OBTAINED FROM AGNICO EAGLE MINES LIMITED ON NOVEMBER 12, 2015.
3. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
4. INSET MAP DATA OBTAINED FROM ESRI

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

5 0 5

KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

NOISE AND VIBRATION STUDY AREAS FOR PIT OPERATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	VY	01 Mar. 2016	SCALE AS SHOWN	REV. 0
GIS	CDB	01 Mar. 2016		
CHECK	JR	06 May 2016	FIGURE 4.1-1	
REVIEW	LY	06 May 2016		

Y:\burnaby\CAD-GIS\Client\Agnico_Eagle_Mines_Ltd\Whale_Tail\99_PROJECTS\1541520_FEIS\02_PRODUCTION\FEIS\MXD\4200_Noise\Report\1541520_FIG_4.1-1_NOISE_VIBRATION_STUDY_AREAS.mxd

4.2 Climate and Meteorology

4.2.1 Incorporation of Inuit Qaujimajatuqangit

Within the context of climate change (and meteorology), indigenous observations and perspectives offer insights into the nature and extent of environmental change, and in terms of the significance of changes for those peoples whose cultures are built on an intimate connection with the Arctic landscape (ACIA 2005).

To incorporate IQ into the climate and meteorology section of the FEIS Amendment, the following documents were reviewed:

- Arctic Climate Impact Assessment, Chapter 3: The Changing Arctic: Indigenous Perspectives (ACIA 2005).
- Unikkaaqatigiit: Putting the Human Face on Climate Change, Perspectives from Nunavut Communities (Communities of Arctic Bay, Kugaaruk and Repulse Bay 2005).
- Public Information Meeting Summary Report September 4, 2014 for the NIRB's monitoring of Agnico Eagle Mines Ltd.'s Meadowbank Gold Project (NIRB 2014).
- Public Information Meetings Summary Report, September 9 – September 11, 2015. Created for the NIRB's Monitoring of Agnico Eagle Mines Ltd.'s Meadowbank Gold Mine Site (NIRB 2015).
- Back River Project Final Environmental Impact Statement: Volume 4: Atmospheric Environment and references therein (Sabina 2015).
- Whale Tail Inuit Qaujimajatuqangit Baseline Report and references therein (Volume 7, Appendix 7-A).

4.2.1.1 Existing Environment and Baseline Information

Inuit from Baker Lake have observed changes in weather and climate over the years (Volume 7, Appendix 7-A). Several of these observations were stated by Elders during the Traditional Knowledge (TK) workshop in 2014 and during a follow-up consultation meeting in 2016, including:

> *" Water levels everywhere have dropped"*
>
> *"Speaking of water, there used to be more moisture on the ground. The land is now very dry."*
>
> *" The lake level is lower, and there is less water in the rivers." The summers are longer, the weather has changed. In the 1960s and earlier, the summers were much shorter."*
>
> *"We used to be able to make good snow shelters, but now there is often not enough snow or the right kind of snow to make a shelter".*
>
> *" …noticed that the ice isn't safe anymore. There are many spots with thin ice and open water, even in the winter. It is dangerous to travel now, because we can't rely on safe ice. We used to be able to travel at night in the springtime when the snow was hard. Now, we can't do this reliably, because it often doesn't refreeze at night."*
>
> *"When there is snow, it is not the same consistency as in the past. It is harder than usual, with more layers, and is not good for making snow blocks. It is not as easy to make an igloo as it was in the past".*
>
> *"Nothing is as expected"*

"There is less snow on the south sides of the hills now, and a change in the direction of the winds that bring the snow. We sued to be able to tell the way to go by the drifts of the snow, but no longer can do that".

"The shrubs growing on the land now seem to be growing more and getting larger than in the past"

"The berries are not growing right today. They are not developing right and don't get ripe when we expect them to ripen. Sometimes there are very few berries."

"There are now abrupt changes in the weather, extremes, spring going from thaws to cold, summers with cold phases, then hot, droughts, more storms, but sometimes shorter storms, the storms following one after the other".

Climate change is a concern for Elders and land users because the unpredictability of weather conditions has resulted in a lack of confidence in using traditional knowledge to predict weather, which has implications for the safety of land users during harvesting and other activities. Inuit are also concerned about the potential impacts of climate change to vegetation communities and wildlife habitat, and to fish, wildlife and other traditional resources that they depend on. The current impact of climate change on vegetation (wildlife habitat) is summarized as part of the existing environment in Volume 5, Section 5.4.2.

4.2.1.2 Valued Component Selection

Several concerns about the effects of climate change on traditional land use activities and resources have been raised by Baker Lake Elder and land users during the TK workshop in 2014 and during follow-up consultation meetings in 2015 and 2016. Concerns related to climate change affecting traditional land use activities and resource use (Volume 7, Appendix 7-A) include:

- Warmer temperatures during the late summer resulting in a delayed and shorter caching period.
- The sporadic freeze-thaw cycle causing spots of thin ice and open water on the land, and resulting in a decreased ability to access resources, dangerous travel conditions, and loss of traditional travel routes.
- Lower water levels in rivers and lakes have made them more difficult to navigate over the past five years.
- Less rain and vegetation growth has resulted in a reduction in feeding areas for wildlife and traditional plant harvesting areas.
- A decline in the health of caribou due to less food availability, and in the quality of caribou meat and skin.
- Changes in caribou habitat and range, shifts in their migration patterns, and increased occurrence of starving and drowning.
- Lower water levels resulting in decreased fish populations and fish health, and changes to spawning runs.
- An overall reduction in species available for hunting, fishing, and gathering activities.

The effects of the Project on weather and climate cannot be measured (FTPCCCEA 2003), therefore climate was not selected as a VC; however, given that climate change has been described as one of the most significant environmental issues facing Inuit communities, and due to their close ties with the land and resources, IQ perspectives related to climate change and concerns raised have been incorporated into this assessment where appropriate.

4.2.1.3 Impact Assessment

The impacts of climate change have the potential to affect a wide range of environmental, social and economic systems of value to Inuit, as indicated by the observations and changes experienced by Baker Lake traditional land users.

Climate change is a global issue caused by emissions of greenhouse gases (GHG). The contribution of the Project, and total GHG emissions from Nunavut (less than 0.5 million metric tonnes per year), are negligible compared to the magnitude of global GHG emissions (approximately 45,000 million metric tonnes per year). It is not possible to measure the effects of the Project on climate (FTPCCCEA 2003), as compared to observing the effects of global climate change on the Kivalliq region. Consequently, this assessment quantifies Project-related greenhouse gas emissions and puts them into regional context by comparing them to GHG emissions from all of Nunavut.

4.2.1.4 Mitigation and Monitoring

Traditional harvesters have stated that they have had to adapt their land use patterns based on climate change. Warmer temperatures during the late summer have resulted in land users delaying the caching period by a month due to meat rotting, and a shorter caching period for hunters. Shifts in caribou migration patterns and caribou availability have caused harvesters to shift their harvesting patterns (Volume 7, Appendix 7-A). Monitoring of weather is conducted regionally by Environment Canada and is predicted to continue indefinitely as a means of monitoring long-term trends in regional climate.

4.2.2 Existing Environment and Baseline Information

The Project is located in Canada's Northern Arctic ecozone. This region includes most of Canada's Arctic Archipelago and northern regions of continental Nunavut and the Northwest Territories. This ecoregion is classified as a polar desert and is characterized by long cold winters and short cool summers. Extreme winter cold, low precipitation and persistent drying winds make this one of the harshest climates in Canada (McGill University 2016; University of Guelph 2016).

Environment Canada operates a meteorological monitoring station at Baker Lake, approximately 125 km from the Project. Long-term (1981 to 2010) meteorological records from the Baker Lake A meteorology station record average daily air temperatures in June to September of approximately 7 degrees Celsius (°C), with October to May average daily air temperatures of -20.6°C. Total annual precipitation at Baker Lake is low, averaging just 273 millimetres (mm) per year, most of which falls as rain in May through October. Winds are predominantly from the northwest and exceed 20 kilometres per hour more than 25 percent (%) of the time.

Meteorological data from 2004 to 2009 for the Baker Lake meteorological station were used as input to the air quality dispersion model used to assess potential Project-related effects to air quality. A detailed description of the existing regional weather and climate near the Project are included in Volume 4, Appendix 4-A.

Inuit and the scientific community have identified the Arctic as a region already experiencing climate change. However, these changes are caused by historic and contemporary greenhouse gas emissions that predominantly occur outside of Nunavut. It is now generally accepted that the existing weather and climate in the Kivalliq region from 1981 to 2010 is different than past weather and climate, and the historical periods included in Inuit oral traditions.

The IQ is supported by independent observations by the scientific community, for example the following (Hinzman et al. 2005):

New extreme and seasonal surface climatic conditions are being experienced, a range of biophysical states and processes influenced by the threshold and phase change of freezing point are being altered, hydrological and biogeochemical cycles are shifting, and more regularly human sub-systems are being affected.

4.2.3 Climate and Project Interactions

Pathway analysis is provided in Volume 3, Section 3.4. Primary pathways that require further effects analysis to determine the environmental significance from the Project are provided below. Pathways determined to have no linkage or those that are considered secondary are not predicted to result in environmentally significant effects are provided in Volume 3, Appendix 3-C, Table 3-C-1.

Changes to weather and climate have the potential to affect environmental, social and economic systems of value to the Inuit and other regional stakeholders. Project-related emissions of GHGs have the potential to contribute to climate change. However, the Federal/Provincial Territorial Committee on Climate Change & Environmental Assessment (FTPCCCEA) stated that "…the contribution of an individual project to climate change cannot be measured" (FTPCCCEA 2003). Consequently there is no assessment endpoint for climate. Greenhouse gas emissions from the Project are calculated as a measurement endpoint and compared to emissions from Nunavut to put the Project-related emissions into better context (see Section 4.2.3.1).

4.2.3.1 Effects of the Project on Climate

Greenhouse gas emissions from the Project can contribute to climate change, even though the contribution of any one Project to global climate change cannot be measured (FTPCCCEA 2003). Facilities in Canada that emit greater than 50,000 tonnes of carbon dioxide equivalents per year (t CO_{2e}/yr) are required to quantify and report their emissions to Canada's Greenhouse Gas Emissions Reporting Program (GHGRP).

As part of this assessment, Project-related emissions of GHGs were calculated using methods consistent with the GHGRP. These emissions estimates were then compared to the GHGRP reporting threshold (50,000 tonnes), to total emissions from Nunavut, and to Canada's national GHG emissions estimates. The total emissions for Nunavut and Canada are calculated from the 5-year average of emissions from 2007 to 2011 (Environment Canada 2013).

Table 4.2-1 summarizes predictions of greenhouse gas emissions for the Project for the peak year of production (i.e., 2020). Table 4.2-2 summarizes predictions from the Project plus those from the existing Meadowbank Mill and camp. As indicated, emissions are expected to exceed 50,000 tonnes per year. Therefore the Project will continue to report their annual emissions to Environment Canada's GHGRP. Greenhouse gas emissions from Nunavut are low due to its low population and low intensity of urban/industrial activities. Total average emissions from Nunavut from 2007 to 2011 were 434 kilotonnes CO_2e/yr (kt CO_{2e}/yr; Table 4.2-1). Development of the Whale Tail Pit and emissions from traffic along the haul road to Meadowbank Mine are predicted to result in a 56% increase in GHG emissions for Nunavut. Throughput for the Meadowbank Mill is predicted to be 15% to 20% lower than current throughput when processing ore from the Whale Tail Pit. Therefore the current GHG emissions rate of 180 kt CO_{2e}/yr is considered a conservative estimate for the future Meadowbank Mill (Table 4.2-1).

When compared to Canada's national emissions (714,000 kt CO_2e/yr), the Project contributes to a less than 0.05% increase in national GHG emissions.

Table 4.2-1: Greenhouse Gas Emissions Summary for the Project

Emissions Source	Greenhouse Gas Emissions (kt CO_{2e})	Project Emission as a Proportion of Nunavut and Canadian Emissions (%)
Off-road exhaust	52.8	—
On-road exhaust	4.4	—
Power plant	4.1	—
Camp heater	2.9	—
Project Total[a]	**64.2**	**—**
Nunavut Total[b]	**434**	**14.8**
Canadian Total[b]	**714,000**	**<0.01**

[a] Project total includes emissions from the Whale Tail Pit and the Haul Road.

[b] 2007 to 2011 average (Environment Canada 2013).

ktCO_{2e} = kilotonnes of carbon dioxide equivalents; % = percent; < = less than.

Table 4.2-2: Greenhouse Gas Emissions Summary for the Project and the Meadowbank Mill

Emissions Source	Greenhouse Gas Emissions (kt CO_{2e})	Project plus Meadowbank Emission as a Proportion of Nunavut and Canadian Emissions (%)
Whale Tail[a]	64.2	—
Meadowbank mill	180	—
Project plus Meadowbank Total	**244**	**—**
Nunavut Total[b]	**434**	**56**
Canadian Total[b]	**714,000**	**<0.04**

[a] Project total includes emissions from the Project.

[b] 2007 to 2011 average (Environment Canada 2013).

Kt CO_{2e} = kilotonnes of carbon dioxide equivalents; % = percent; < = less than.

4.2.3.2 Effects of Climate Change on the Project

The climate in the Arctic is changing faster than at mid-latitudes (ACIA 2005; IPCC 2014). The most recent set of climate model projections (CMIP5) predict an Arctic-wide year 2100 multi-model mean temperature increase of +13°C in late fall and +5°C in late spring under the Intergovernmental Panel on Climate Change (IPCC)'s "business as usual scenario" (RCP8.5). IPCC climate change mitigation scenario RCP4.5 results in a year 2100 multi-model Arctic wide prediction of +7°C in late fall and +3°C in late spring (Overland et al. 2013). The effects of changes of this magnitude to terrestrial, aquatic and marine ecosystems, social and economic systems of the Arctic are an active area of research (e.g., NASA ABoVE[1]). However, the short duration of the proposed Project mean that climate change related effects to the Project are likely negligible.

[1] http://above.nasa.gov/

4.2.4 Monitoring and Follow-up

Environment Canada currently conducts long-term monitoring of weather and climate in the Kivalliq region of Nunavut. There are currently no plans to conduct supplementary meteorological monitoring at the Project.

4.3 Air Quality

4.3.1 Incorporation of Inuit Qaujimajatuqangit

To incorporate IQ into the air quality section of the FEIS Amendment, the following documents were reviewed:

- Unikkaaqatigiit: Putting the Human Face on Climate Change, Perspectives from Nunavut Communities (Communities of Arctic Bay, Kugaaruk and Repulse Bay 2005).
- Public Information Meeting Summary Report September 4, 2014 for the NIRB's monitoring of Agnico Eagle Mines Ltd.'s Meadowbank Gold Project (NIRB 2014).
- Public Information Meetings Summary Report, September 9 – September 11, 2015. Created for the NIRB's Monitoring of Agnico Eagle Mines Ltd.'s Meadowbank Gold Mine Site (NIRB 2015).
- Back River Project Final Environmental Impact Statement: Volume 4: Atmospheric Environment and references therein (Sabina 2015).
- Whale Tail Inuit Qaujimajatuqangit Baseline Report and references therein (Volume 7, Appendix 7-A).

4.3.1.1 Existing Environment and Baseline Information

Since the Inuit depend upon their local environment for their social, cultural, and economic well-being, they are aware of changes to their environment, including air quality. Inuit have documented recent changes to air quality, and are concerned about the potential effects of these changes on their traditional land use activities and resources (Agnico Eagle 2014a; Volume 7, Appendix 7-A and references therein), and this IQ is incorporated into Section 4.3.2.

4.3.1.2 Valued Component Selection

Local Inuit who use the Project study area have identified air quality and the effects of atmospheric deposition as a topic of concern during the 2014 TK workshop and follow-up consultation meetings in 2015 and 2016. Specific concerns related to dust include potential effects on:

- wildlife habitat and wildlife foraging behaviour;
- fish and fish habitat;
- water quality;
- caribou habitat, vegetation, and on plants that caribou rely on for foraging;
- meat caches located near the road; and
- the cumulative effects of dust.

Due to these concerns, air quality was assessed as a VC. Specifically, the air quality portion of the assessment examines the effects of the Project on air quality, and the atmospheric deposition of acidic gases and windblown fugitive dust.

4.3.1.3 Impact Assessment

Inuit Qaujimajatuqangit highlighted concerns about the sensitivity of caribou and muskox to losses of vegetation habitat (habitat quantity) and changes in vegetation habitat quality (habitat quality) because of dust deposition. Concerns were also raised related to the effects of dust on other traditional resources and activities that Inuit depend on. Potential effects of the Project on air quality and atmospheric deposition were predicted and compared to national and territorial air quality guidelines as there are no standards that can be drawn explicitly from IQ. The results of the air quality modelling were used to assess the impacts to vegetation in wildlife in Volume 5, to water quality and fish and fish habitat in Volume 6.

4.3.1.4 Mitigation and Monitoring

Local Inuit requested that emissions of fugitive road dust be mitigated through the use of road watering and the application of chemical dust suppressants, and that the accumulation of dust be monitored over time (NIRB 2015a; Agnico Eagle 2016b, 2016c, 2016d). In response to local Inuit concerns, and as a NIRB requirement (Project Certificate No. 004; Condition 71), Agnico Eagle conducts local meteorology, air quality, and dustfall monitoring at their existing Meadowbank Mine (e.g., Agnico Eagle 2013a; Agnico Eagle 2015).

Mitigation and monitoring opportunities at the proposed Project are similar to those at the existing Meadowbank Mine. Public consultation with local Inuit indicates that they expect mitigation and monitoring strategies employed at the proposed Project to be similar to those employed at the Meadowbank Mill.

4.3.2 Existing Environment and Baseline Information

Since the Arctic is far from large mid-latitude sources of urban/industrial air pollution, it is often viewed as a pristine environment with excellent air quality. In fact, the Western Arctic is subject to seasonal reductions in air quality due to Arctic Haze (Shaw 1995; Quinn et al. 2007), long-range transport of Asian air pollution and mineral dust (McNaughton et al. 2011), and long-range transport of smoke from boreal forest fires (Forster et al. 2001; Warneke et al. 2009).

Other jurisdictions in Canada have published background concentrations of criteria air contaminants (CACs) that are used to assess Project-related changes to air quality. There are no published background air quality values available for Nunavut. To quantify existing air quality in the Kivalliq Region, this assessment undertook a comprehensive analysis of available air quality measurements in Arctic Canada, including results of the 2008 NASA ARCTAS[2] airborne field campaign. The methods and results of this analysis are summarized in Volume 4, Appendix 4-A.

Table 4.3-1 summarizes background concentrations of CACs used in this assessment. These background concentrations are added to air quality model predictions of maximum concentrations of CACs that result from emissions generated during the operations of the Project. The maximum plus background concentrations are then compared to the relevant Nunavut or Canadian ambient air quality guidelines or standards.

[2] https://espo.nasa.gov/arctas

Table 4.3-1: Summary Statistics for Criteria Air Contaminants

Compound (units)	Averaging Period	Percentile	Background Concentrations used in the FEIS Amendment	Air Quality Standard
CO (ppmv)	1-hr	90th	**0.3**	13
	8-hr	90th	**0.3**	5
NO_2 (ppbv)	1-hr	90th	**5.0**	159
	24-hr	90th	**4.5**	106
	Annual	50th	**1.9**	24
O_3 (ppbv)	1-hr	90th	**17.3 – 30.6[a]**	82
	8-hr	90th		63
SO_2 (ppbv)	1-hr	90th	**1.0**	172
	24-hr	90th	**1.0**	48
	Annual	50th	**0.1**	8
$PM_{2.5}$ (µg/m^3)	24-hr	90th	**6.6**	28
	Annual	50th	**3.6[b]**	8.8

[a] Indicated values are the range in monthly average concentrations used as input for the conversion of NO_2 to NO in the air quality model.

[b] Geometric average (median or 50th percentile) of 5-years of 24-hr average concentrations after removing zeros and hourly concentrations above the 97.6th percentile.

CO = carbon monoxide; NO_2 = nitrogen dioxide; NO = nitrogen monoxide; SO_2 = sulfur dioxide; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometres in aerodynamic diameter; O_3 = ozone; ppbv = parts per billion, volumetric; ppmv = parts per million, volumetric; µg/m^3 = micrograms per cubic metre; FEIS = Final Environmental Impact Statement.

In general, air quality in the Kivalliq region is good. However, IQ has documented recent changes to air quality (Communities of Arctic Bay, Kugaaruk and Repulse Bay 2005; Agnico Eagle 2014a; Sabina 2015; Volume 7, Appendix 7-A and references therein).

The Arctic is subject to seasonal reductions in air quality as a result of episodic events (e.g., boreal forest fires), seasonal changes in solar insolation (polar winter versus polar summer), and weather patterns that favour transport of mid-latitude pollution into the Arctic (e.g., spring time "Arctic haze" events). An example of seasonal changes in air quality is presented in Figure 4.3-1, which pools 10-years of 24-hour average observational data collected at the Sir John Franklin and Norman Wells National Air Pollution Surveillance stations from 2005 to 2009 (see Volume 4, Appendix 4-A for more details).

Elevated ambient concentrations of nitrogen dioxide (NO_2) in winter (Figure 4.3-1; top panel) are primarily due to wintertime buildup of NO_2 in the absence of sunlight responsible for NO_2's photo-chemical destruction. In general, elevated spring and summer concentrations of particulate matter smaller than 2.5 micrometres in aerodynamic diameter ($PM_{2.5}$; Figure 4.3-1; bottom panel) are due to meteorology that favours transport of mid-latitude air pollution to the Arctic in spring, and transport of smoke from boreal forest fires to the Arctic in summer. For the 10-years of daily average NO_2 presented in Figure 4.3-1, background concentrations of NO_2 reach values 5% to 10% of the 24-hour Nunavut air quality standard (106 parts per billion, volumetric [ppbv]). Average $PM_{2.5}$ concentrations can reach 25% of the 24-hour air quality standard (28 micrograms per cubic metre [µg/m^3]).

During episodic events, $PM_{2.5}$ concentrations can meet or even exceed the Nunavut air quality standards. These events, while infrequent, could result in air quality monitoring observations at the proposed Whale Tail Pit and the Meadowbank Mine that exceed the Nunavut air quality standard. The primary cause of such observed air quality exceedances may not be mining operations related to the Project, but natural or man-made events beyond Agnico Eagle's control.

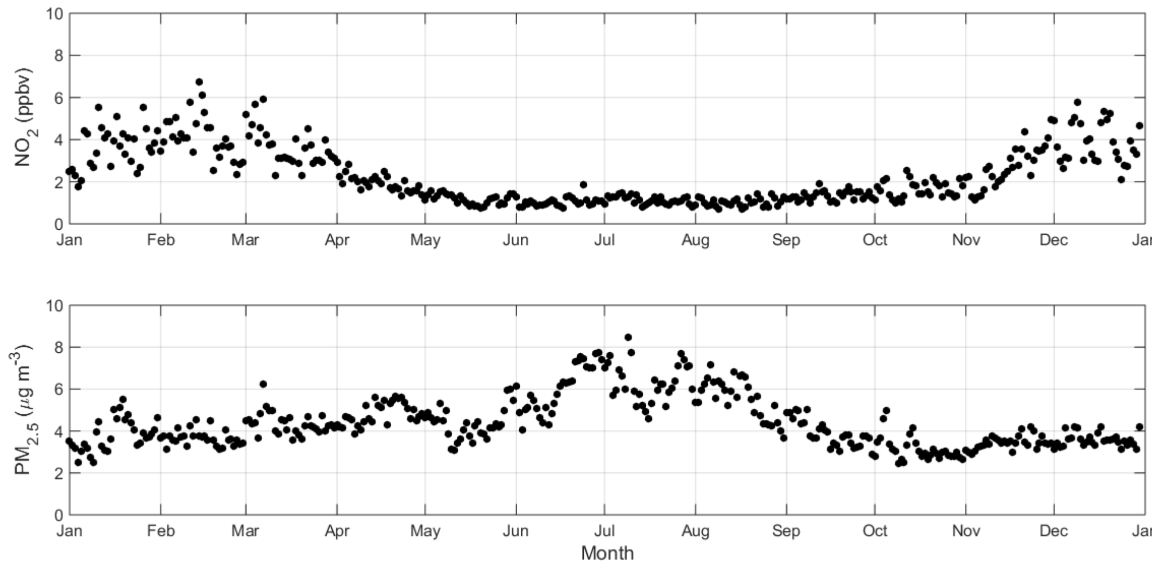


Figure 4.3-1: Ten-year (2005 to 2009) Average 24-hour NO_2 (top) and $PM_{2.5}$ (bottom) Concentrations Observed at Sir John Franklin (NWT) and Normal Wells (NWT) National Air Pollution Surveillance Stations

4.3.3 Potential Project-related Effects Assessment

Inuit Qaujimajatuqangit and professional scientific opinion were used to identify potential Project related effects to air quality. These pathways are summarized in Volume 3, Appendix 3-C, Table 3-C-1. Primary pathways include the following:

1) Traffic along the proposed haul road from the Whale Tail Pit to the existing Meadowbank Mine has the potential to generate combustion emissions and fugitive road dust that can affect air quality.

2) Mining operations at the Whale Tail Pit have the potential to produce combustion emissions and fugitive dust that can affect air quality.

3) Extension of Meadowbank Mill and Camp Operations have the potential to produce combustion emissions and fugitive dust that can affect air quality.

Traffic on the haul road during construction and decommissioning of the Whale Tail Pit, in addition to construction and decommissioning of the Whale Tail Pit, also have the potential to affect air quality. However, the emissions intensity from construction and decommissioning activities is much lower than the intensity of air emissions, including fugitive dust, during the Project's operations phase. This assessment considers emissions during the Project's operations phase (specifically year 2020, the peak year of mining activity) to be a conservative estimate of the maximum potential Project related to effects to air quality. Therefore emissions from construction and decommissioning are considered secondary pathways and are not explicitly assessed.

Project related air emissions have the potential to deposit to local terrestrial, aquatic, and marine ecosystems. Atmospheric deposition of acidic gases and fugitive dust therefore have the potential to affect soil and water quality, local flora and fauna, and the Inuit communities that depend on these resources for their cultural, social, and economic well-being. This air quality assessment includes quantification of these air emissions and predictions of the spatial patterns of their regional atmospheric deposition. These results are discussed in the following sections and were used in the effects assessment for other valued ecosystem components (e.g., water quality, soils, human health).

4.3.3.1 Effects of Haul Road on Air Quality

To evaluate potential effects of the haul road on air quality, this assessment undertook the following:

1) Quantification of baseline concentrations of CACs in the Kivalliq Region of Nunavut (see Volume 4, Appendix 4-A).

2) Calculation of CAC emissions from the following haul road sources (see Volume 4, Appendix 4-B):

    a. exhaust from vehicles operating on the haul road; and

    b. un-paved road dust from the haul road.

3) Air quality dispersion modelling of a representative 1 km section of the haul road oriented northeast to southwest was used to predict the following (See Volume 4, Appendix 4-C):

    a. maximum plus background concentrations of CAC as a function of distance from the haul road; and

    b. maximum dust deposition as a function of distance from the haul road.

The model predicted ground level concentrations of carbon monoxide (CO), NO_2, and sulfur dioxide (SO_2) were very low compared to the baseline and to their relevant ambient air quality standards (see Volume 4, Appendix 4-C). Predictions of $PM_{2.5}$ adjacent to the haul road were below Nunavut ambient air quality guidelines within 50 to 75 metres (m) from the haul road. Thus, the focus of the assessment is the potential effects of total suspended particulate matter (i.e., fugitive dust) on air quality adjacent to the haul road.

Table 4.3-2 summarizes maximum predicted total suspended particulate (TSP) concentrations as a function of distance from the haul road. Figure 4.3-2 plots predicted TSP concentrations as a function of distance from the haul road. In the near field, maximum TSP concentrations adjacent to the road are predicted to exceed the 24-hour average ambient air quality standard (Figure 4.3-2; red line = 120 $\mu g/m^3$) at distances of up to 1,500 m from the haul road. Maximum annual TSP concentrations are predicted to exceed the ambient air quality standard (60 $\mu g/m^3$) only within the first 100 to 300 m from the haul road.

Table 4.3-2: Maximum Total Suspended Particulate Concentrations Function of Distance from the Haul Road

Distance (m)	24-hr (µg/m³)	Annual (µg/m³)
25	1740	172
50	1330	118
75	1170	91.4
100	1040	73.5
300	498	26.7
500	358	15.4
750	254	9.7
1,000	213	6.4
1,500	92.4	3.2
2,000	52.7	1.9

m = metre; µg/m³ = micrograms per cubic metre.

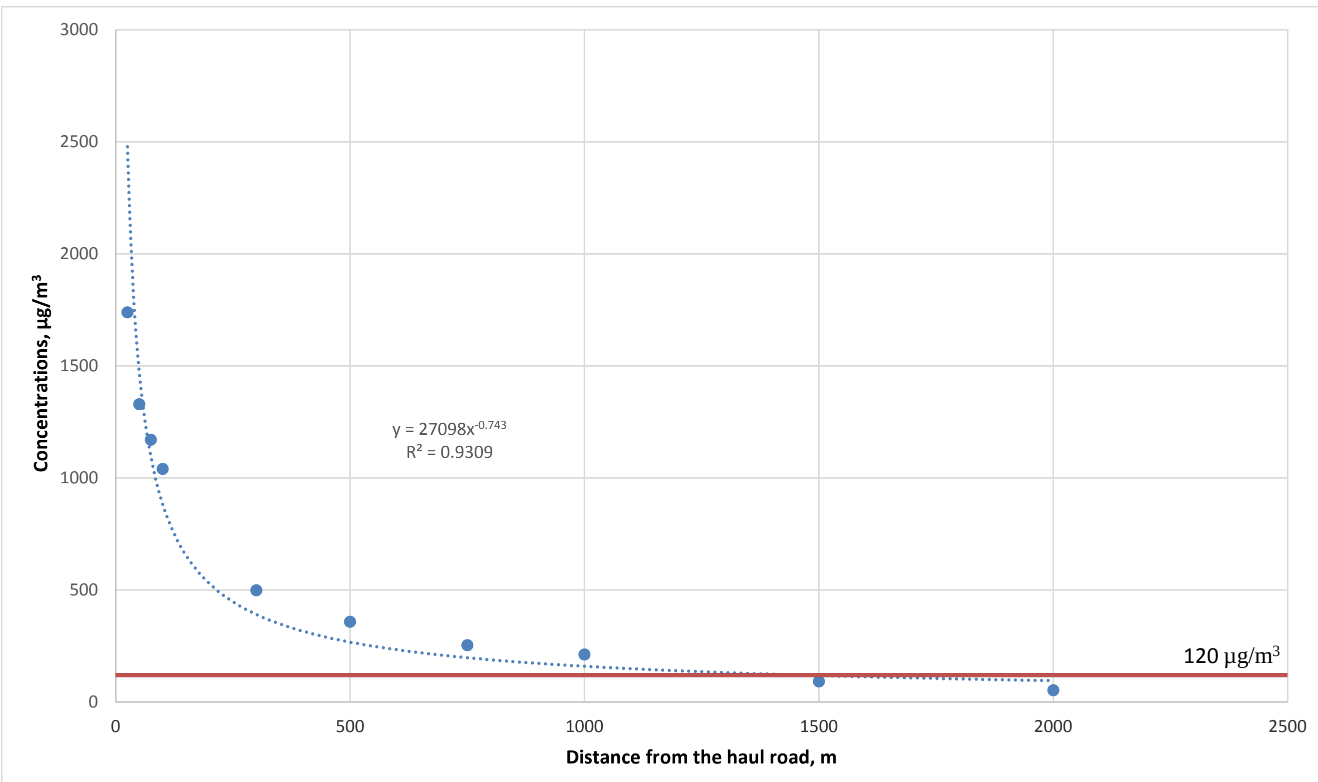


Figure 4.3-2: Total Suspended Particulate Concentrations as a Function of Distance from the Haul Road

Table 4.3-3 summarizes maximum predicted dust deposition as a function of distance from the haul road. Figure 4.3-3 plots predicted dust deposition as a function of distance from the haul road. Predicted dust deposition rates are compared to the British Columbia and Ontario standards as they are the most stringent among the Provinces of AB, BC, and ON (see Volume 4, Appendix 4-C). The British Columbia lower monthly dust fall standard for mining is 1.7 milligrams per squared decimetre per day ($mg/dm^2/day$). This value corresponds to deposition rates of 0.51 milligram per square centimetre per 30 days ($mg/cm^2/30days$). The Ontario annual dust fall standard is 4.6 $g/cm^2/30$-days which is equivalent to 0.46 $mg/cm^2/30days$. Maximum predicted monthly dustfall is predicted to be below the BC dustfall standard within 300 m of the haul road. Annual dust deposition is predicted to be below the Ontario dustfall standard within 25 m from the haul road.

Included in Figure 4.3-3 are the observed dust deposition rates at upwind and downwind dustfall monitoring stations along the Meadowbank Mine Vault haul road (Agnico Eagle 2015). Meadowbank road bed material is predicted to have a higher silt content (silt = 9.3%; Cumberland 2005) than esker material being considered as construction material for the Whale Tail Pit haul road (silt = 6.1%; Englobe 2015). Fugitive road dust emissions are very sensitive to road bed silt content. Therefore direct comparison between the predictions for the Whale Tail haul road and the observations from the Meadowbank haul road is not appropriate. However, Whale Tail haul road predictions appear comparable to the Meadowbank observations and lend confidence to the predictions presented in this assessment.

Table 4.3-3: Maximum Dust Deposition as a Function of Distance from the Haul Road

Distance (m)	Monthly ($mg/cm^2/30days$)	Annual ($mg/cm^2/30days$)
25	1.19	0.15
50	0.77	0.10
75	0.65	0.07
100	0.56	0.05
300	0.26	0.02
500	0.18	0.01
750	0.14	0.01
1000	0.11	0.00
1500	0.07	0.00
2000	0.05	0.00
Dust fall criteria	0.51	0.46

m = metre; $mg/cm^2/30days$ = milligram per square centimetre per 30 days.

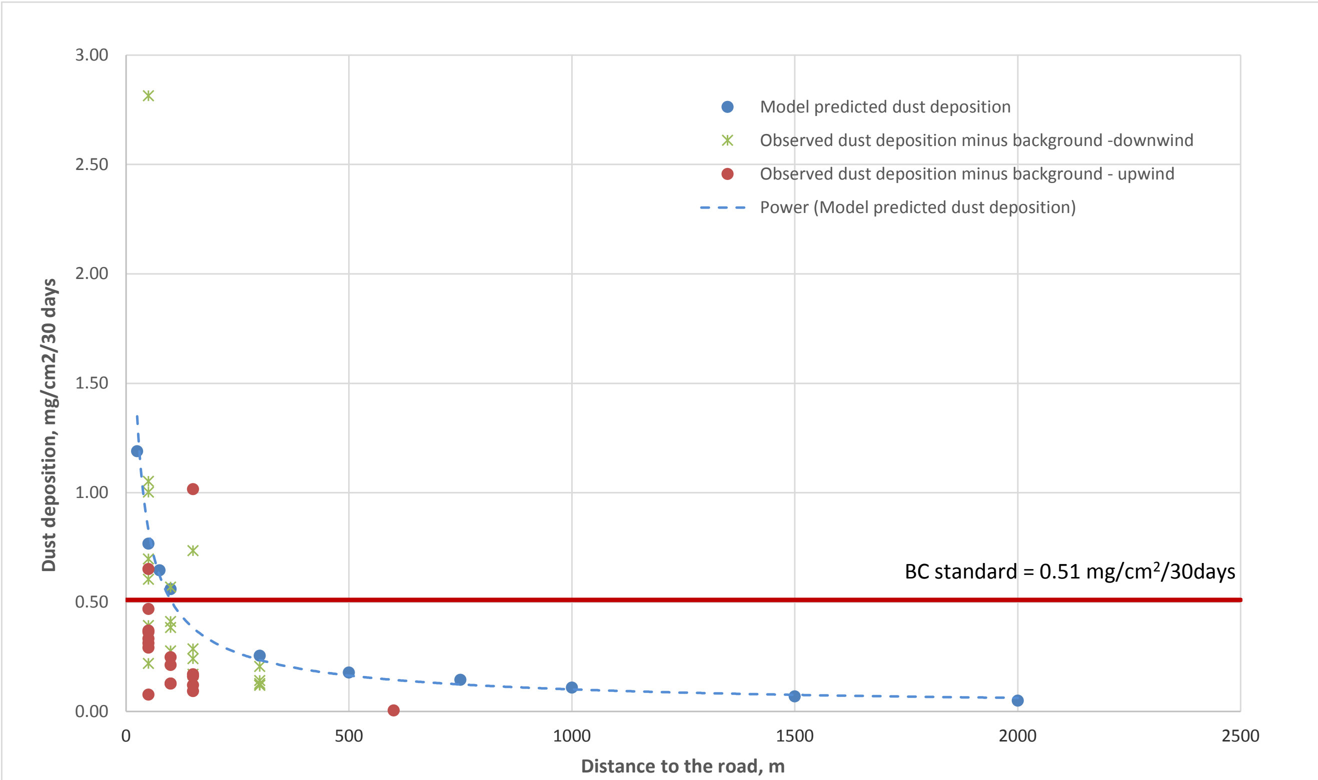


Figure 4.3-3: Predicted (this assessment) and Observed (Meadowbank Mine) Dust Deposition as a Function of Distance from Mine Haul Roads

The effects of fugitive dust emissions on air quality adjacent to the haul road are limited in spatial extent and occur primarily on dry windy days in the summer. These effects are reversible in that fugitive dust will no longer affect air quality once the Whale Tail Pit is decommissioned and the haul road becomes inactive. Atmospheric deposition of fugitive dust also has the potential to affect soil and water quality, and flora and fauna that the Inuit depend upon for their social, cultural, and economic well-being. Dust deposition results were used in the assessment of effects to soil, water quality, and human health and are discussed in Sections 5.3, 6.4, and Volume 3, Appendix 3-B, respectively. Results of this assessment indicate rates of atmospheric deposition are below relevant dustfall standards within 300 metres from the haul road. Analysis of the geochemistry of the locally-sourced haul road material does not indicate that the dust being deposited has the potential to affect soil and water quality (Golder 2014).

4.3.3.2 Effects of the Whale Tail Pit on Air Quality

To evaluate potential effects of the Whale Tail Pit on air quality, this assessment undertook the following:

1) Quantification of baseline concentrations of CAC in the Kivalliq Region of Nunavut (see Volume 4, Appendix 4-A).

2) Calculation of CAC emissions from the following sources (see Volume 4, Appendix 4-B):

    a. Whale Tail Pit activities, including:

i. in pit drilling and blasting;

ii. in pit material handling;

iii. un-paved road dust from the pit; and

iv. exhaust from off-road equipment operating in the pit;

b. wind erosion from ore pad and waste storage pile;

c. stationary combustion emissions from the camp heating and camp power; and

d. un-paved road dust and vehicle exhaust from the section of haul road within the Property boundary.

3) Air quality dispersion modelling to predict maximum plus background concentrations of CAC at the Property boundary (see Volume 4, Appendix 4-C).

Table 4.3-4 summarizes the background CAC concentrations, predicted maximum plus background concentrations near the Project, and ambient air quality criteria for Nunavut. Air quality modelling results predict the occurrence of maximum plus background concentrations of particulate matter smaller than 10.0 micrometres in aerodynamic diameter (PM_{10}) and TSP above the Nunavut air quality guidelines outside the Property boundary. For PM_{10}, the worst year of the 5-year simulation includes a single PM_{10} exceedance. For TSP, the worst year of the 5-year simulation includes three 24-hour TSP exceedances. Figure 4.3-4 illustrates the predicted spatial distribution of maximum plus background 24-hour average TSP concentrations. As indicated, the region where the maximum plus background TSP concentrations are predicted to exceed the air quality criteria over a 24-hour period is small.

Air quality modelling also included an evaluation of maximum plus background concentrations of CACs at important local cultural or human health receptors. Predicted concentrations of all CAC were below their relevant ambient air quality standards at all of these local receptors.

The effects of mining activities at the Whale Tail Pit on regional air quality are limited in spatial extent and occur primarily on dry windy days in summer. These effects are reversible in that emissions will no longer affect air quality once the Whale Tail Pit is decommissioned and the haul road become inactive.

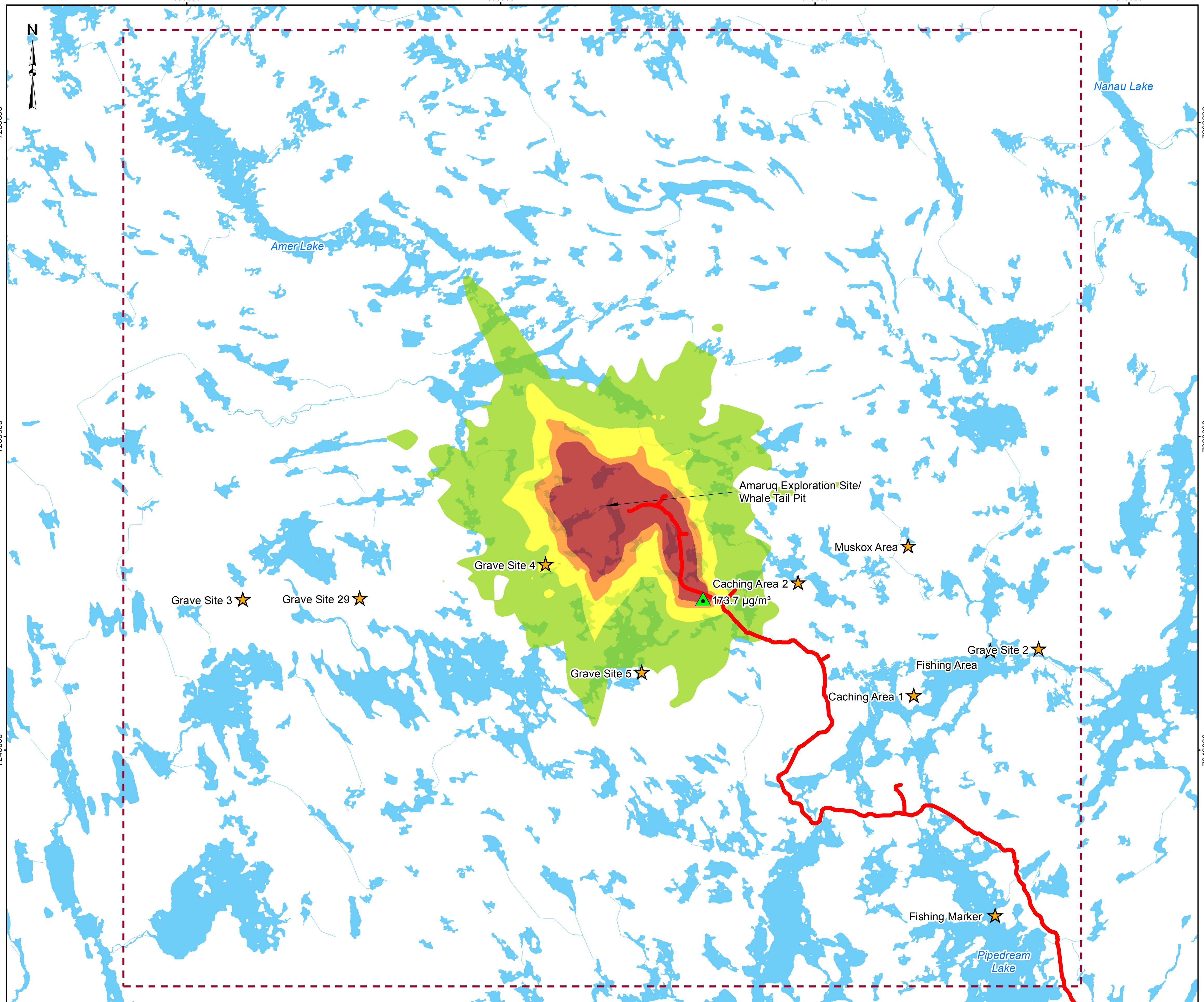
Table 4.3-4: Summary Statistics for Criteria Air Contaminants

Compound (units)	Averaging Period	Background Concentrations	Maximum plus Background Concentrations	Air Quality Standard
CO (ppmv)	1-hr	0.3	0.9	**13**
	8-hr	0.3	0.5	**5**
NO_2 (ppbv)	1-hr	5.0	0.1	**159**
	24-hr	4.5	30.3	**106**
	Annual	1.9	4.4	**24**
SO_2 (ppbv)	1-hr	1.0	6.7	**172**
	24-hr	1.0	2.2	**48**
	Annual	0.1	0.2	**8**
$PM_{2.5}$ (µg/m^3)	24-hr	6.6	20.1 (13.5[b])	**28[b]**
	Annual	3.6[a]	4.3	**8.8**
PM_{10} (µg /m^3)	24-hr	3.6[a]	52.4	**50**
TSP (µg /m^3)	24-hr	3.6[a]	174	**120**
	Annual	3.6[a]	16.9	**60**

[a] Geometric average (median or 50th percentile) of 5-years of 24-hr average concentrations after removing zeros and hourly concentrations above the 97.6th percentile.

[b] 3-year, 98th percentile.

CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometres in aerodynamic diameter; PM_{10} = particulate matter smaller than 10.0 micrometres in aerodynamic diameter; TSP = total suspended particulate matter; ppbv = parts per billion, volumetric; ppmv = parts per million, volumetric; µg/m^3 = micrograms per cubic metre; hr = hour.



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 30
- 30 - 60
- 60 - 90
- 90 - 120
- > 120

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5 0 5
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOW BANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR TSP CONCENTRATIONS

Golder Associates

PROJECT		1524321	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11	FIGURE 4.3-4	
REVIEW	CM	2016-05-11		

\\golder.gds\gal\Saskatoon\GGIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_EIS_FIG_4_4_Model_Predicted_24hr_TSP.mxd

4.3.3.3 Effect of Extension of Meadowbank Mill and Camp Operations on Air Quality

The Meadowbank Mill and camp will continue to operate during the mining of the Whale Tail Pit. Emission sources from Meadowbank and camp operations include the following:

- power plant;
- primary crusher and mills;
- stockpile wind erosion;
- tailing wind erosion;
- an incinerator, and
- waste rock disposal fugitive emissions from three distinct sources including:
  - equipment traffic in storage area;
  - waste aggregate unloading (handling); and
  - wind erosion of pile surfaces and surrounding area.

Potential effects of the continued operations of the Meadowbank Mill and camp on air quality are assessed by evaluating the 2014 monitoring results from the Meadowbank Mine. The rational for using this approach includes the following:

- In the Cumberland (2005d) air quality impact assessment, the power plant, mobile emission sources, and the fugitive dust sources were modelled. The air quality impact assessment for the Meadowbank Mine predicted effects to air quality would be negligible to the LSA, and were predicted to have no impact to the RSA.
- Since November, 2011, Agnico Eagle has conducted dustfall and air quality monitoring at Meadowbank Mine. The objective of this program is to monitor ambient air quality around the mine site perimeter to verify compliance with relevant environmental standards and, if necessary, mitigate any potential environmental effects. Results of the dustfall and air quality monitoring program are briefly summarized in the sections below.
- During 2014, the Meadowbank Mill processed an average of 11,313 tonnes of ore per day (t/d). The proposed ore production of the Whale Tale pit in the peak year is 328,500 tonnes, which is equivalent to approximately 9,000 t/d. Therefore, the proposed throughput at the Meadowbank Mill while processing ore from the Whale Tail Pit is approximately 15 to 20% lower than the current throughput.
- The Whale Tail Pit is located approximately 53 km from the Meadowbank Mill. Combustion emissions from the Project are low, and the potential effects of fugitive dust are local (i.e., <10 km) rather than regional (i.e., > 10 km) in extent. Therefore no measurable cumulative effects are predicted to occur as a result of the development of the Whale Tail Pit and continued operations of the Meadowbank Mill and camp.

In the following sections the 2014 air quality and dustfall monitoring program at Meadowbank Mine are reviewed and results compared to the relevant ambient air quality standards.

Air Quality Monitoring Locations

There are four air quality monitoring locations at Meadowbank, which were selected in consultation with Environment Canada. Table 4.3-5 summarizes the parameters measured at the stations and the station locations. Station DF-1 is located next to explosive storage area, and approximately 500 m north of the all-weather access road. Station DF-2 is located at the northern corner of south Camp Island. Station DF-3 is approximately 1.8 km east of the East Dike. Station DF-4 is approximately 1.5 km southwest of Vault Pit.

Table 4.3-5: UTM Coordinates and Dates of Measurement for the Meadowbank Air Quality and Dustfall Monitoring Locations

Monitoring Location	Measured Parameters	Easting, m	Northing, m
DF-1	TSP, PM_{10}, $PM_{2.5}$, NO_2, Dustfall	636850	7217663
DF-2	TSP, PM_{10}, $PM_{2.5}$, NO_2, Dustfall	637895	7213049
DF-3	Dustfall	639599	7213198
DF-4	Dustfall	639233	7217074

NO_2 = nitrogen dioxide; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometres in aerodynamic diameter; PM_{10} = particulate matter smaller than 10.0 micrometres in aerodynamic diameter; TSP = total suspended particulate matter.

Monitoring Methods

In 2014, size-resolved particulate measurements (TSP, PM_{10}, $PM_{2.5}$) at two locations (DF-1 and DF-2) were collected for 24-h periods every six days using Partisol Plus Model 2025 Sequential Air Samplers (TSP) and Partisol Plus Model 2025-D Dichotomous Sequential Air Samplers ($PM_{2.5}$ and PM_{10}). Partisol samplers draw in a stream of ambient air at a controlled flow rate, and particulates are collected on a pre-weighed filter supplied by an accredited laboratory (Maxxam Analytics). The exposed filter is then shipped back to the laboratory and re-weighed to measure the total accumulated particulate; TSP, PM_{10}, and $PM_{2.5}$ concentrations are then calculated based on filter mass, flow rate, and duration of the sample.

Dustfall was collected in open vessels containing a purified liquid matrix over periods of approximately one month at each of the four air quality monitoring stations. Particles are deposited into the liquid matrix, which was then analyzed for total and fixed (non-combustible) dustfall. Calculated dustfall rates were normalized to 30 days (mg/cm^2/30days) for comparison to relevant air quality standards.

Passive NO_2 sampling devices are deployed at the air quality monitoring stations over approximately one month periods. After exposure the passive samples are put into sealed containers and shipped to Maxxam Analytics who analyze the media to calculate ambient concentrations of NO_2 by volume (parts per billion [ppb]).

Monitoring Results

The suspended particulate matter sampling units were nearly fully operational in 2014. TSP concentrations are generally highest in April, and include one exceedance of the 24-h standard of 120 µg/m^3 at 219 µg/m^3. The annual geometric mean concentrations of TSP at DF-1 and DF-2 were 6.5 and 12.8 µg/m^3, respectively. These concentrations are well below the annual TSP standard of 60 µg/m^3.

The highest PM_{10} concentrations were observed at DF-2 between April and November. There is no 24-hr air quality standard for PM_{10} in Nunavut. Annual average 24-hr PM_{10} concentrations were 10 and 11 µg/m^3 at DF-1 and DF-2, respectively.

One 2014 sample exceeded the Government of Nunavut standard of 30 µg/m^3 for 24-h average $PM_{2.5}$, and the Canadian Ambient Air Quality Standard of 28 µg/m^3; the $PM_{2.5}$ concentration was 56 µg/m^3. Annual average concentrations of $PM_{2.5}$ were 1 and 5 µg/m^3 at DF-1 and DF-2, respectively. These values are consistent with estimated annual average background concentration of $PM_{2.5}$ (3.6 µg/m^3) and are below the Canadian Ambient Air Quality Standard annual average $PM_{2.5}$ concentration of 10 µg/m^3.

There are no dustfall standards or guidelines for Nunavut. Of the 44 dustfall samples collected in 2014, there are five measurements that exceed the BC lower dustfall criteria of 0.51 mg/cm^2/30days. To provide additional context, Alberta Environment and Parks specifies recreational/residential and industrial/commercial area dustfall guidelines of 0.53 mg/cm^2/30days and 1.58 mg/cm^2/30days for total dustfall. The Alberta recreational/residential area guideline was exceeded in 5 out of 44 samples but the industrial/commercial area guideline was not exceeded in 2014. Historically dustfall guidelines were created to prevent the accumulation of nuisance dust. The applicability of these guidelines to the Project are not well established, as there are no recreational or residential activities occurring near the Whale Tail Pit or the haul road to the Meadowbank Mill.

Concentrations of NO_2 vary between non-detect (<0.1 ppb) and 3.3 ppb. Annual arithmetic mean concentrations were calculated for each station from the monthly-average values. The annual mean concentrations of NO_2 were 0.5 ppb and 1.9 ppb for DF-1 and DF-2, respectively (January 2, 2014 – January 18, 2015). These values are consistent with the estimated annual average background NO_2 concentration of 1.9 ppbv (Table 4.3-1) and well below the Government of Nunavut Ambient Air Quality Standard annual average (32 ppbv).

Summary

The 2014 air quality and dustfall monitoring indicate one 24-hr exceedance each for Government of Nunavut's ambient air quality standards for TSP and $PM_{2.5}$ in 2014. There were no exceedances of NO_2 concentrations in 2014. There are no dustfall guidelines for Nunavut. However, 5 out of 44 dust fall samples at Meadowbank exceeded the Alberta recreational/residential area dustfall guideline; no dustfall samples at Meadowbank exceed the industrial/commercial dustfall guideline.

Based on: monitoring results; an estimated 15 to 20% reduction in Meadowbank Mill throughput using ore from the Whale Tail Pit; and, the short operations phase of the Project; the spatial and temporal effects of an extension to the operations of the Meadowbank Mill and camp on regional air quality are considered low. Any potential effects are considered reversible in that emissions will no longer affect air quality once the Whale Tail Pit and Meadowbank Mill are decommissioned.

4.3.3.4 Effect of Extension of All Weather Access Road on Air Quality

The All-Weather Access Road (AWAR) between the community of Baker Lake and the Meadowbank Mine is expected to remain active for a period of up to three years after the Whale Tail Pit operations commence. The potential combined effects of emissions resulting from the ongoing use of the AWAR and the Whale Tail Pit operations including the haul road have been considered qualitatively in this assessment because of the limited possibility for interaction between the multiple potential emissions sources, the significant distance between the AWAR and the Whale Tail operations and the expected limited use of the AWAR.

The quantitative assessment completed for the Whale Tail haul road can also be used as an appropriate analog for the AWAR. The findings of the modelling assessment (Section 4.3.3.1) indicate that predictions of $PM_{2.5}$ adjacent to the haul road were below Nunavut ambient air quality guidelines within 50 to 75 m from the haul road and further, that in the near field, maximum TSP concentrations adjacent to the road are predicted to exceed the

24-hour average ambient air quality standard at distances of up to 1,500 m from the haul road. Maximum annual TSP concentrations are predicted to exceed the ambient air quality standard (60 $\mu g/m^3$) only within the first 100 to 300 m from the haul road.

The effects of fugitive dust emissions on air quality adjacent to the haul road are limited in spatial extent and occur primarily on dry windy days in the summer. These effects are reversible in that fugitive dust will no longer affect air quality once the AWAR is decommissioned.

The most recent (2015) results of the Meadowbank dustfall monitoring program were reported in March of 2016. They indicate that even in close proximity to the project operations, all samples but one out of the 48 collected compared favourably with the Alberta guidance on dustfall for recreational and residential areas. The single excursion above the Alberta guideline was recorded immediately adjacent to the explosives emulsion plant where there is regular activity. None of the samples collected resulted in deposition rates above the Alberta guidance for industrial areas and all samples were collected within approximately 500 m of the Meadowbank facility operations. A supplemental dustfall monitoring program is planned for the AWAR and for the Whale Tail Pit haul road to confirm the assessment conclusions.

4.3.3.5 Potential for Acid Deposition

Atmospheric deposition of acid gases and particulate matter produced from the use of explosives and from fuel combustion can affect soil quality, water quality, and therefore flora and fauna upon which the Inuit depend for the social, cultural, and economic well-being.

Acid deposition modelling requires the use of specialized air quality models (e.g., CALPUFF). In Alberta, acid deposition modelling may be required if:

1) the proponents combined emissions of SO_2, NO_x and ammonia (NH_3) is greater than 0.175 t/d of hydrogen ion (H^+) equivalents in t/d, where:

   Total H^+ equivalent = $2*(SO_2)/(64)+1*(NO_x)/(46)+1*(NH_3)/(17)$; or

2) there is evidence that regional soil and surface water is more sensitive to acidification than estimated in the <Alberta> framework; or

3) there is existing deposition and/or acidification impact monitoring that indicates a potential concern is acid deposition increases.

Table 4.3-5 summarizes Project emissions of SO_2, NO_x (as NO_2) and NH_3, current emissions estimates for the Meadowbank Mill and camp, as well as emissions from other reported sources in Nunavut (Environment Canada 2016). Project emissions and emissions from the Meadowbank Mill and camp are conservative because annual totals are based on maximum daily output and because it is assumed that the Projects emit enough ammonia to completely neutralize all emissions of sulfur and nitrogen oxides. Including ammonia represents a very conservative assumption as the Project is not a source of these emissions (other than very small amounts that may be emitted from wastewater systems).

Results indicate that conservatively estimated Project emissions of hydrogen ion equivalents (0.140 t/d) do not meet acid deposition modelling requirement #1 (i.e., 0.175 t/d). Project emissions plus current emissions of hydrogen ion equivalents from the Meadowbank Mill and camp (0.24 t/d) exceed modelling requirement #1 (Table

4.3-6). However, acid deposition modelling was not undertaken because: there are few sources in Nunavut and they are distributed over a large area; emissions reported for Nunavut are likely underestimated; and, there is no evidence that current emissions from the Meadowbank Mine/Mill and camp result in acid deposition related impacts. Further justification is provided in the discussion that follows.

Table 4.3-6: Acidic Gas Emissions Summary

Parameter	SO_2	NO_2	NH_3
Whale Tail Pit and Haul Road Emission (t/d)	0.03	3.2	1.2[a]
Meadow Bank Mill Emissions (t/d)	0.05	5.4	2.0[a]
Total Project Emissions (t/d)	0.08	8.6	3.2[a]
Total Nunavut Emissions (t/d)	0.41[b]	9.9[c]	-[d]
Project H^+ equivalents (t/d)	0.14		
Project plus Meadowbank Mill H^+ equivalents (t/d)	0.38		
Acid Deposition Modelling Threshold	0.175		

[a] assuming complete conversion of SO_2 to sulfate (SO_4^{2-}) and NO_x to nitrate (NO_3^-), and their complete neutralization by ammonium (NH_4^+).

[b] 2010 to 2014 NPRI average (Environment Canada 2016).

[c] 2010 NPRI data only.

[d] no NH_3 air emissions reported to NPRI (2010 to 2014).

SO_2 = sulfur dioxide; NO_2 = nitrogen dioxide; NH_3 = ammonia; t/d = tonnes per day; % = percent; NPRI = National Pollutant Release Inventory.

National Pollutant Release Inventory (NPRI) SO_2 emissions for Nunavut are likely under-reported as there are no reported SO_2 emissions for 2013 or 2014 and only a single facility reported in 2011 and 2012. SO_2 emissions in Table 4.3-6 are based on 2010 data, for which 6 facilities reported emissions. NO_2 emissions for Nunavut are based on the 5-year 2010 to 2014 average (approximately 30 facilities). However, NPRI emissions exclude mobile and transportation emissions of NO_2, which may be a significant source of emissions for Nunavut. There are no 2010 to 2014 NPRI reported NH_3 emissions for Nunavut.

The Canada-wide requirement for the use of ultra-low sulfur diesel in on- and off-road equipment results in a low rates of SO_2 emissions from the Project plus the Meadowbank Mill (0.08 t/d). Maximum predicted SO_2 deposition near the Whale Tail Pit is 0.012 grams per square metre per year (g/m^2/yr). This is equivalent to 0.036 equivalent hydrogen per square meters per year (eq H^+/m^2/yr) and occurs within the Project boundary.

NO_2 emissions rates from the Project are predicted to be 3.2 t/d, which is below the current Meadowbank emissions rate (5.4 t/d). The maximum predicted NO_2 deposition rate is within the Whale Tail property boundary (0.39 g/m^2/yr) and is equivalent to 1.2 kilograms of nitrogen per hectare per year (kg-N/ha/yr). The region near the Whale Tail Pit with NO_2 deposition rates greater than 0.04 g/m^2/yr extends to ~8 km south-east of property boundary. There are no rates of nitrogen deposition greater than 0.04 g/m^2/yr outside the property boundary in other directions. A deposition rate of 0.04 g/m^2/yr is equivalent to an increase in nitrogen deposition rates in the region of 0.12 kg-N/ha/yr.

Background levels of Arctic nitrogen deposition are approximately less than 1 kg-N/ha/yr. Changes to Arctic heath composition appear at ~10 kg-N/ha/yr, and the critical load of nitrogen is predicted to be on the low end of 5 to 15 kg-N/ha/yr (Gordon et al. 2001). The nitrogen deposition results presented in this assessment indicate that even within the property boundary, no changes to tundra vegetation due to N deposition is expected. Results from the monitoring program in place at the Meadowbank Mine appear to confirm this, as there have been no effects to water quality detected due to acid deposition. As a result, the NO_x term in the Total H^+ equivalent emissions determination can likely be ignored (i.e., these rates of nitrogen [a nutrient] deposition are not predicted to have adverse effects on the Arctic terrestrial or aquatic ecosystems).

NH_3 emissions have not been directly estimated for this assessment. There is some potential for NH_3 emissions from the use of ammonium nitrate and fuel oil explosives, and from ammonia generated by camp waste water systems. For this assessment, NH_3 emissions are estimated by assuming that each equivalent of sulfate (2) and each equivalent of nitrate (1) is neutralized by one equivalent of ammonium (i.e., 2 + 1 = 3 equivalents). For this location, with a presumed absence of major NH_3 emissions (dominant sources = sewage, livestock, and agriculture), the complete neutralization of acidic sulfate and nitrate emissions by ammonium is a very conservative assumption.

4.3.4 Residual Impact Classification

Primary pathways have been identified for air quality. However, no residual impact classification are made because air quality does not have an assessment endpoint, only measurement endpoints (i.e., comparison to relevant ambient air quality guidelines or standards). Any potential effects associated with the primary pathways are captured in the assessment of potential effects to, and residual impact classifications for, other VCs (e.g., soil quality, water quality, and human health).

4.3.5 Cumulative Effects Assessment

No cumulative effects for air quality are anticipated for this Project because of the following:

- emissions of gases and $PM_{2.5}$ from the Project are relatively low;
- concentrations of gases and $PM_{2.5}$ are all well below their relevant air quality guidelines or standards outside the Project boundary;
- air quality and dustfall monitoring at the existing Meadowbank Mine indicate only occasional exceedances of the 24-hr air quality standard for total suspended particulate and dust fall, but with annual averages near regional background values; and
- other than the existing Meadowbank Mine, there are no existing or proposed additional sources of TSP emissions within the 60 km x 60 km study domain, a region that can reasonably be expected to bind the area over which TSP concentrations above background values can be measured/monitored.

4.3.6 Uncertainty

The following sources of uncertainty could affect the predictions of air emissions and/or the predicted concentrations and deposition rates of CACs within the study domain:

- Differences in actual versus predicted emissions from the uses of explosives or the consumption of fossil fuels at the Project.
- Differences in actual versus predicted natural mitigation of windblown fugitive dust from un-paved road surfaces, drilling and blasting activities, materials handling, or wind erosion of the ore pad or the waste rock storage facility.

- Differences in actual versus predicted road-bed silt content and/or the effectiveness of proposed dust mitigation measures at the Project.
- Extension of the life of the Whale Tail Pit, and/or development of new mines or mining areas in the region could affect the amount of fugitive dust generated at the site and along the haul road.
- Actual emissions are predicted to be below those presented in this assessment because they are conservatively estimated assuming equipment (e.g., power generators) are operated at 100% of their capacity at all times.

4.3.7 Monitoring and Follow-up

4.3.7.1 Dust Mitigation

Both IQ and scientific monitoring suggest that road watering and the application of chemical suppressants can reduce fugitive dust emissions. Road watering is a simple cost effective dust mitigation option provided that adequate water resources are available. Proposed dust mitigation efforts include the following:

1) daily road watering at the Whale Tail Pit and Meadowbank Mill during the frost free summer season;
2) continued use of current mitigation measures on the all-weather-access road;
3) enforcement of haul truck speed limits along the haul road; and
4) strategic road watering along the haul road at hot-spots, near sensitive habitat, and/or during dry windy conditions in summer.

The use chemical dust suppressants was considered (see Volume 4, Appendix 4-C) but is not recommended for the Project. Chemical suppressants include organic hydrocarbon-based products and mineral salts (e.g., EK-35 or calcium chloride). While the human health and ecological effects of these dust suppressants are predicted to be low, they are not native to the Kivalliq region and their long-term effects on Arctic ecosystems has not been evaluated. Chemical suppressants can run off mine and road surfaces during spring melt and during precipitation events with the potential to affect soil or water quality.

4.3.7.2 Particulate Matter and Dustfall Monitoring

Agnico Eagle currently monitors NO_2, particulate matter ($PM_{2.5}$, $PM_{10,}$ and TSP) and dustfall at the Meadowbank Mine and along the Meadowbank AWAR to Baker Lake (Agnico Eagle 2015).

The results of this assessment indicate particulate matter and dustfall monitoring at the Whale Tail Pit and along the haul road to the Meadowbank Mine is warranted. The monitoring program will be based on the existing air quality and dustfall monitoring conducted at the Meadowbank Mine, and dustfall monitoring along the Meadowbank AWAR to Baker Lake (Agnico Eagle 2013a; 2015).

4.4 Noise and Vibration

4.4.1 Incorporation of Inuit Qaujimajatuqangit

As part of the Project NIA, the following documents were reviewed for IQ-specific information and guidance:

- Inuit Qaujimajatuqangit Baseline Report (Volume 7, Appendix 7-A);
- Guidelines for the Integration of IQ into the Environmental Assessment (Golder 2016);
- Public Information Meeting 2014 Summary Report (NIRB 2014);
- Public Information Meeting 2015 Summary Report (NIRB 2015);
- Meadowbank Gold Project – Baseline Traditional Knowledge Report (Cumberland 2005c);
- Proposed All-weather Exploration Road from the Meadowbank Mine to the Amaruq Site – Baseline Traditional Knowledge Report Version 2 (Agnico Eagle 2014a); and
- Community Consultations/Public Information Meeting Summary Reports for 2014 and 2015 (NIRB 2014, 2015).

4.4.1.1 Existing Environment and Baseline Information

It is well-known that wildlife may *"temporarily avoid an area until they become familiar with or acclimatized to industrial noise"* (AER 2007). As such, changes in noise levels are particularly relevant to IQ because potential changes in wildlife distribution, especially to caribou, will have effects on traditional land use and harvesting patterns. In addition, concerns were expressed by Baker Lake community members that are either directly or indirectly related to Project noise effects on wildlife (Volume 7, Appendix 7-A).

4.4.1.2 Valued Component Selection

Noise and vibration was selected as a VC for the Project, partly in response to IQ-specific concerns (Volume 7, Appendix 7-A; Cumberland 2005c). Concerns about the direct and indirect effects of noise on wildlife have been raised by Baker Lake Elder community members during consultation for the Meadowbank Mine, and again during the TK workshop in 2014 and follow-up consultation meetings in 2015 and 2016 (Volume 7, Appendix 7-A).

Concerns that were raised by Baker Lake Elders and land users that are directly related to noise include:

- The destruction or disturbance of nesting and moulting waterfowl and geese habitat due to the effects of noise and repeated disturbance, and especially to nesting, moulting and staging habitats of the highly sensitive snow goose.
- The impact of noise on wildlife, notably caribou.

Concerns that were raised by Baker Lake community members that are indirectly related to noise include:

- Potential changes in caribou distribution.
- Potential effects of construction activities on caribou.
- Disturbance to dens of wolves, foxes, and wolverines near the Project footprint.

- Potential disturbance to wolves due to construction activities causing them to leave the area.

4.4.1.3 Impact Assessment

In the documents listed in Section 4.4.1, members of the community, including Elders, hunters, and trappers, expressed a general concern with the effects of industrial noise on wildlife. Particular concerns were expressed about the effects of industrial noise on caribou and birds. In addition, one community member interviewed as part of the TK baseline study for the Meadowbank Mine indicated that he could *"hear a noise all night long"* at a site of spiritual significance (Cumberland 2005c), which suggests a general community concern about the audibility of industrial noise at spiritual sites.

In the absence of IQ-specific guidance on assessment methodologies or acceptable limits, the Project NIA considered noise and vibration regulations based on western science (AER 2007; DFO 1998; OMOE 1978). However, outputs from the Project NIA (i.e., predicted noise and vibration levels) were provided to the IQ and wildlife disciplines for assessment of the effects of noise on wildlife, including caribou (Table 4.3 of Cumberland 2005a).

4.4.1.4 Mitigation and Monitoring

The mitigation and monitoring plan for the Project is largely consistent with the management plan originally developed for the Meadowbank Mine in 2005 (Cumberland 2005d) and subsequently updated in 2009 and 2013 (Agnico Eagle 2009, 2013b). Based on public concerns related to the effect of noise on wildlife, the plan outlines Agnico Eagle's strategies for reducing noise disturbance with particular regard to wildlife.

4.4.2 Existing Environment and Baseline Information

As discussed in Volume 4, Appendix 4-E, the Permissible Sound Level (PSL) values used to assess broadband noise from conventional Project sources (i.e., all Project noise sources except blasting) are cumulative limits that apply to Project noise in combination with existing ambient noise levels. To gather information about existing ambient noise levels in support of the Project NIA, a baseline field survey was completed in August 2015 (Volume 4, Appendix 4-D). The purpose of this baseline field survey was to measure existing ambient noise levels at four locations in the LSA and RSA.

The results of the baseline field survey are described in detail in Volume 4, Appendix 4-D. The key findings of the baseline survey (i.e., existing daytime and nighttime ambient noise levels measured at locations in the LSA/RSA) are re-produced in Table 4.4-1.

Existing ambient noise levels at R6 were dominated by noise from the Meadowbank Vault Pit: a facility whose noise effects have already been well-characterized as part of an earlier regulatory process (Cumberland 2005a; Cumberland 2005b) and will cease operations during the operations of Whale Tail Pit. The objective of the Project NIA was to assess potential noise and vibration effects from the Project and not to reassess potential effects from Meadowbank. As such, the existing ambient noise levels measured at R6 were excluded when estimating representative existing ambient noise levels for use in the Project NIA.

Table 4.4-1: Baseline Field Survey - Results Summary

Baseline Noise Monitoring Location	Universal Transverse Mercator Coordinates [NAD83, Zone 14]		Description	Measured Existing Ambient Nosie Level [dBA]		Measured Existing Ambient Nosie Level [dBC]	
	Easting [m]	Northing [m]		Daytime	Nighttime	Daytime	Nighttime
R6	640708	7221964	Unoccupied location north of existing Meadowbank Vault Pit; noise environment dominated by activities in Vault Pit	39	41	59	58
R7	620194	7239038	Unoccupied location adjacent to the proposed Project haul road; noise environment dominated by natural sources (e.g., wind, waves, birds)	29	29	42	43
R8	610725	7256677	Unoccupied location northeast of proposed Whale Tail Pit; noise environment dominated by wind and activities associated with existing Whale Tail Exploration Camp	30	31	46	47
R9	602488	7255946	Unoccupied location northwest of proposed Whale Tail Pit; noise environment dominated by wind and activities associated with existing Whale Tail Exploration Camp	31	31	47	47

NAD = North American Datum; dBA = A-weighted decibel; dBC = C-weighted decibel; m = metre.

Ambient noise levels measured at R7, R8, and R9 are representative of existing conditions in the LSA/RSA. As such, the noise levels measured at these monitoring locations were averaged and used to represent existing ambient noise levels for the Project NIA. Table 4.4-2 presents the average of R7, R8, and R9 measured noise levels, which were used to represent existing ambient noise levels in the Project NIA.

Table 4.4-2: Representative Existing Ambient Noise Levels

Area of Applicability	Existing Ambient Noise Levels [dBA]		Existing Ambient Noise Levels [dBC]	
	Daytime	Nighttime	Daytime	Nighttime
LSA and RSA	30	30	45	46

dBA = A-weighted decibel; dBC = C-weighted decibel; LSA = local study area; RSA = regional study area.

4.4.3 Potential Project-related Effects Assessment

Pathway analysis is provided in Volume 3, Section 3.4. Primary pathways that require further effects analysis to determine the environmental significance from the Project are provided below. Pathways determined to have no linkage or those that are considered secondary are not predicted to result in environmentally significant effects are provided in Volume 3, Appendix 3-C, Table 3-C-1.

The following primary pathways were identified for the Project NIA:

- Haul Road Construction:

- noise emissions from construction equipment can increase ambient noise levels;
- if required, blasting can result in ground vibration and increase ambient noise levels;

- Pit Operations:
  - noise emissions from mining equipment can increase ambient noise levels;
  - blasting can result in ground vibration and increase ambient noise levels;
- Haul Road Operations:
  - noise emissions from vehicles on the haul road can increase ambient noise levels.

4.4.3.1 Haul Road Construction

4.4.3.1.1 Conventional Noise Sources

In the absence of Nunavut-specific regulatory guidance, noise from conventional sources associated with haul road construction (i.e., noise sources – like excavators, loaders, and trucks – which emit noise continuously) were assessed in accordance with methods and limits described in Alberta Energy Regulator (AER) Directive 038 (AER 2007). Haul road upgrades and construction noise levels were predicted using the ISO 9613-2 technical standard (ISO 1996) and were compared to PSL and Low Frequency Noise (LFN) limits set out in AER Directive 038. The AER Directive 038 PSL values are not strictly applicable to construction activities. However, when assessing haul road construction it was still instructive to compare predicted noise level to PSL values, since they represent acceptable noise levels in other contexts (i.e., Project operations). An earlier version of AER Directive 038 was used to assess potential noise effects from the Meadowbank Mine (Cumberland 2005a; Cumberland 2005b) as part of the original regulatory process for this facility. Additional discussion on the use of AER Directive 038 in the Project NIA is provided in Volume 4, Appendix 4-E, Section 4.E-3.

Figure 4.4-1 presents predicted Project noise levels for haul road construction under summertime and wintertime conditions. As discussed in Volume 4, Appendix 4-E, the Project NIA considered road construction for a representative 140 m section of road and predicted noise levels across an LSA and RSA surrounding these activities. Similar noise levels can be expected at comparable distances from other sections of the Project haul road.

LEGEND

ENERGY EQUIVALENT SOUND LEVEL (L_{eq}) (dBA)

- < 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- > 55

REFERENCE

1 0 1

KILOMETRES

PROJECT	AGNICO EAGLE MINES LIMITED: MEADOWBANK DIVISION WHALE TAIL PIT PROJECT
TITLE	**HAUL ROAD CONSTRUCTION NOISE LEVEL PREDICTIONS: SUMMER AND WINTER**

PROJECT		1541520	FILE No.
DESIGN	VY	01 Mar. 2016	SCALE AS SHOWN — REV. 0
GIS	CDB	20 Apr. 2016	**FIGURE 4.4-1**
CHECK	JR	06 May 2016	
REVIEW	LY	06 May 2016	

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As shown in Figure 4.4-1, haul road construction Project noise levels are predicted to be less than 30 A-weighted decibel (dBA) at 5 km and 7 km from the haul road for both summertime and wintertime. In other words, for all periods, haul road construction Project noise levels are predicted to be less than the existing ambient noise level (see Table 4.4-2) at the boundary of the LSA and at the boundary of the RSA.

As discussed in Volume 4, Appendix 4-E, the PSL values used to assess broadband Project noise are cumulative limits. As such, to assess potential Project noise effects using PSL values, it was necessary to calculate cumulative noise levels associated with haul road construction by summing predicted Project noise levels with existing ambient noise levels.

In the interest of assessing potential Project noise effects conservatively, the PSL assessment was focused on that point on the LSA boundary with maximum predicted Project noise level (Rmax). The PSL assessment for Rmax is presented in Table 4.4-3.

The results presented in Table 4.4-3 show that for both summertime and wintertime haul road construction, cumulative noise levels on the LSA boundary are predicted to be less than the relevant PSL value.

Table 4.4-3: Haul Road Construction - Permissible Sound Level Assessment

Assessment Location	Period	Existing Ambient Noise Level [dBA]	Haul Road Construction Project Noise Level [dBA]	Haul Road Construction Cumulative Noise Level[a] [dBA]	Permissible Sound Level [dBA]
Rmax – point on LSA boundary with maximum predicted Project noise level	Summertime / Daytime	30	21	31	50
	Summertime / Nighttime	30	21	31	40
	Wintertime / Daytime	30	21	31	55
	Wintertime / Nighttime	30	21	31	45

[a] Calculated as the logarithmic sum of the existing ambient noise level and the haul road construction Project noise level.
dBA = A-weighted decibel; LSA = local study area; RSA = regional study area; Rmax = maximum predicted Project noise level.

As discussed in Volume 4, Appendix 4-E, the Project NIA assessed the potential for LFN effects by comparing predicted noise levels expressed in C-weighted decibel (dBC) and dBA. Table 4.4-4 presents the results of the haul road construction LFN assessment for Rmax – the point on the LSA boundary with maximum predicted Project noise level. Again, it should be noted that AER Directive 038 does not require the LFN test to be applied to construction noise; however it is still instructive to do so.

Table 4.4-4: Haul Road Construction – Low Frequency Noise Assessment

Assessment Location	Period	Existing Ambient Noise Level [dBC]	Haul Road Construction Project Noise Level [dBC]	Haul Road Construction Cumulative Nosie Level [dBC]	Haul Road Construction Cumulative Noise Level [dBA]	Difference: dBC minus dBA
Rmax – point on LSA boundary with maximum predicted Project noise level	Summertime / Daytime	45	36	46	31	15
	Summertime / Nighttime	46	36	46	31	15
	Wintertime / Daytime	45	38	46	31	15
	Wintertime / Nighttime	46	38	47	31	16

Rmax = maximum predicted Project noise level; dBA = A-weighted decibel; dBC = C-weighted decibel; LSA = local study area.

The results presented in Table 4.4-4 show that the difference between dBC and dBA Project noise levels is predicted to be less than 20 at Rmax. Based on the first LFN condition set out in AER Directive 038, this result suggests that there will be no LFN effect along the LSA boundary.

4.4.3.1.2 Blasting Noise and Vibration Sources

Haul road construction is not currently expected to require any blasting; however, in the interest of conservatism, haul road construction blasting was assessed in case it should become necessary once work on the Project begins. In the absence of Nunavut-specific regulatory guidance, noise and vibration from blasting activities associated with haul road construction were assessed in accordance with methods and limits described in the Ontario Ministry of Environment (OMOE) *Noise Pollution Control Publication 119* (OMOE 1978) – hereafter referred to as NPC-119 – and in the Department of Fisheries and Oceans (DFO) *Guidance for the Use of Explosives In or Near Canadian Fisheries Waters* (DFO 1998). In particular, ground vibration levels and airborne noise levels associated with haul road construction blasting were predicted using empirical formulae (ISEE 1998; DFO 1998) and were compared to limits set out in NPC-119 and the DFO guidance document.

Table 4.4-5 presents the predicted blasting vibration levels associated with haul road construction in the form of Peak Particle Velocity (PPV) at various distances from the blasting activity. Table 4.4-5 also presents predicted blasting noise levels associated with haul road construction in the form of Peak Pressure Level (PPL) at various distances from the blasting activity. Both PPV and PPL values were calculated using empirical formulae discussed in detail in Volume 4, Appendix 4-E (ISEE 1998). As discussed in Volume 4, Appendix 4-E, the haul road construction blasting assessment was based on the assumption that up to 45 kg of explosives will be detonated simultaneously.

Table 4.4-5: Haul Road Construction – Blasting Noise and Vibration Predictions

Distance from Blast [m]	Peak Particle Velocity – Ground Vibration [mm/s]	Peak Pressure Level – Airborne Noise [dBZ]
100	23	130
165	10 – NPC-119 limit[a,b]	125
200	8	123
300	4	120 – NPC-119 limit[a,c]
1000	1	108
5000 – LSA boundary	0	93

[a] OMOE (1978)

[b] The NPC-119 PPV limit is the maximum ground vibration level considered acceptable by the regulation. The results in this table show that PPV values are predicted to decay to below the NPC-119 limit for distances greater than 165 m from haul road construction blasting activities.

[c] The NPC-119 PPL limit is the maximum airborne noise level considered acceptable by the regulation. The results in this table show that PPL values are predicted to decay to below the NPC-119 limit for distances greater than 300 m from haul road construction blasting activities.

LSA = local study area; m = metre; mm/s = millimetres per second; dBZ = unweighted or linear decibels; PPL = Peak Pressure Level; PPV = Peak Particle Velocity.

The PPV results presented in Table 4.4-5 suggest that ground vibration associated with blasting as part of haul road construction will decay to the 10 mm/s limit established in NPC-119 (OMOE 1978) within 165 m of the blasting source and that PPV ground vibration will decay to below quantifiable levels at the LSA boundary. In other words, at the LSA boundary ground vibration levels from Project blasting are predicted to be well below the NPC-119 limit.

The PPL results presented in Table 4.4-5 suggest that airborne noise associated with blasting as part of haul road construction will decay to the 120 unweighted or linear decibels (dBZ) limit established in NCP-119 (OMOE 1978) within 300 m of the blasting source and that PPL airborne noise will decay to 93 dBZ at the LSA boundary. In other words, at the LSA boundary airborne noise levels from Project blasting are predicted to be well below the NPC-119 limit.

Table 4.4-6 presents predicted setback distances from haul road construction blasting activities required to achieve compliance with DFO PPV and PPL limits for the protection of spawning fish and fish habitat, respectively. Both of these setback distances were calculated using empirical formulae discussed in detail in Volume 4, Appendix 4-E (DFO 1998). As discussed above, the haul road construction blasting assessment was based on the assumption that up to 45 kg of explosives will be detonated simultaneously.

Table 4.4-6: Haul Road Construction –Fisheries and Oceans Canada Blasting Setback Predictions

Setback Criterion	Setback Distance [m]
Fish Spawning – Ground Vibration (PPV)	101
Fish Habitat – Airborne Noise (PPL)	22

m = metre; PPL = Peak Pressure Level; PPV = Peak Particle Velocity.

The results presented in Table 4.4-6 suggest that, to achieve compliance with DFO blasting limits, haul road construction blasting should not occur within 101 m of areas used for fish spawning and should not occur within 22 m of fish habitat.

4.4.3.2 Whale Tail Pit Operations

4.4.3.2.1 Conventional Noise Sources

In the absence of Nunavut-specific regulatory guidance, noise from conventional sources associated with Pit Operations were assessed in accordance with methods and limits described in AER Directive 038 (AER 2007). In particular, pit operations noise levels were predicted using the ISO 9613-2 technical standard (ISO 1996) and were compared to PSL and LFN limits set out in AER Directive 038.

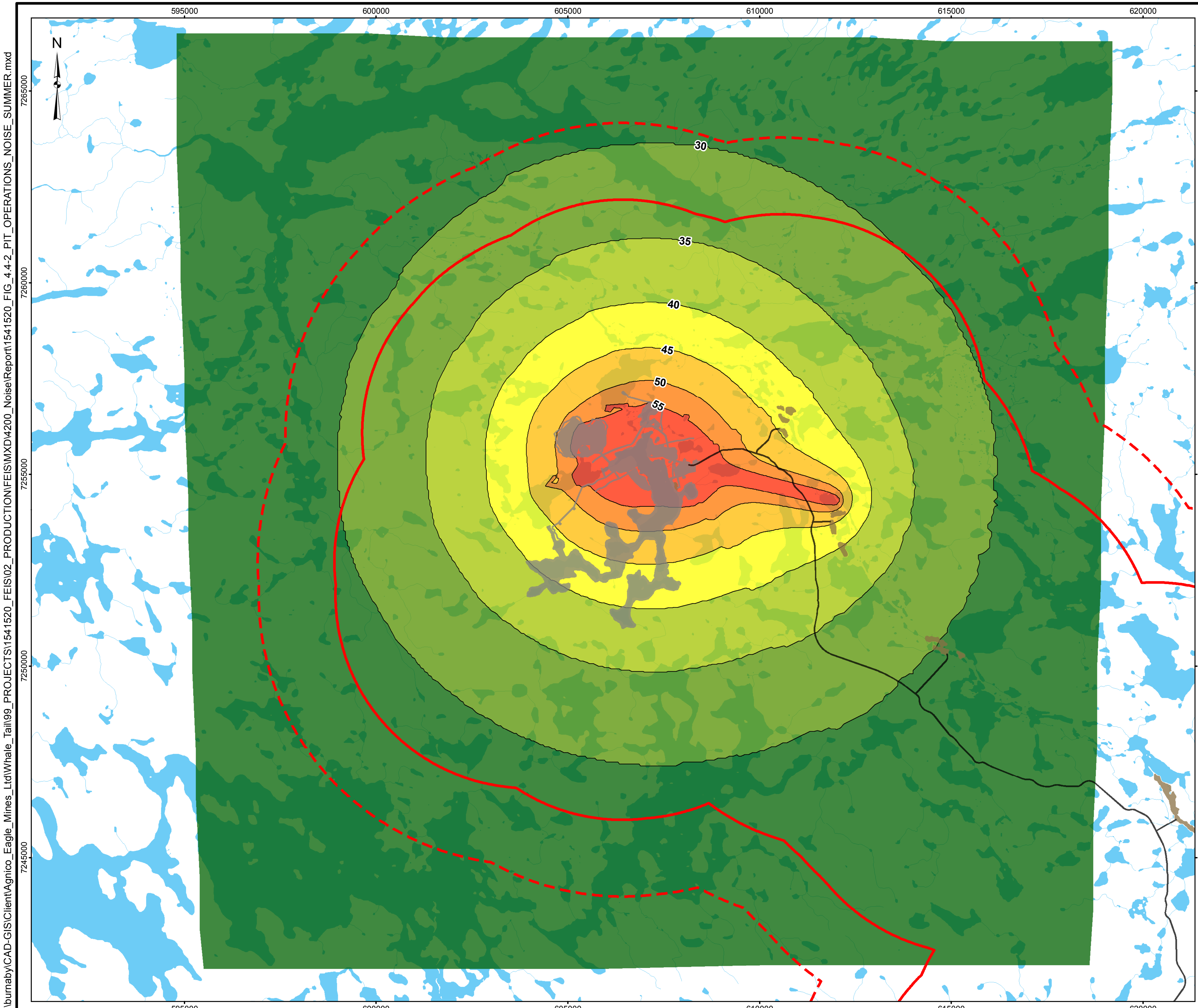
Figure 4.4-2 presents predicted Project noise levels for pit operations under summertime conditions. Figure 4.4-3 presents predicted Project noise levels for pit operations under wintertime conditions.

As shown in Figure 4.4-2 and Figure 4.4-3, pit operations Project noise levels are predicted to be less than 30 dBA at the RSA boundary for both summertime and wintertime. In other words, for all periods, pit operations Project noise levels are predicted to be less than the existing ambient noise level (see Table 4.4-2) at the boundary of the RSA.

Similarly, for all periods, pit operations Project noise levels are predicted to be less than the 30 dBA existing ambient noise level for most of the LSA boundary. There are areas of the LSA boundary north and west of the Whale Tail Pit where pit operations Project noise levels are predicted to exceed 30 dBA but, for all periods and all points on the LSA boundary, pit operations Project noise levels are predicted to be less than 35 dBA.

As discussed in Volume 4, Appendix 4-E, the PSL values used to assess broadband Project noise are cumulative limits. As such, to assess potential Project noise effects using PSL values, it was necessary to calculate cumulative noise levels associated with pit operations by summing predicted Project noise levels with existing ambient noise levels.

In the interest of assessing potential Project noise effects conservatively, the PSL assessment was focused on that point on the LSA boundary with maximum predicted Project noise level. This point was found to be north-northeast of the Whale Tail Pit – almost directly north of the point at which the haul road joins the pit infrastructure. The PSL assessment for this location, hereafter referred to as Rmax, is presented in Table 4.4-7.



LEGEND

- NOISE AND VIBRATION LOCAL STUDY AREA
- NOISE AND VIBRATION REGIONAL STUDY AREA

WHALE TAIL

- BORROW SOURCE
- INFRASTRUCTURE
- PROPOSED HAUL ROAD

ENERGY EQUIVALENT SOUND LEVEL (L_{eq}) (dBA)

- < 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- > 55
- WATERCOURSE
- WATERBODY

REFERENCE

1. WHALE TAIL INFRASTRUCTURE OBTAINED FROM AGNICO EAGLE MINES LIMITED ON DECEMBER 21, 2015.
2. MEADOWBANK INFRASTRUCTURE OBTAINED FROM AGNICO EAGLE MINES LIMITED ON NOVEMBER 12, 2015.
3. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
4. INSET MAP DATA OBTAINED FROM ESRI

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

2 0 2
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

WHALE TAIL PIT OPERATIONS
NOISE LEVEL PREDICTIONS: SUMMER

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	VY	01 Mar. 2016	SCALE AS SHOWN	REV. 0
GIS	CDB	20 Apr. 2016	**FIGURE 4.4-2**	
CHECK	JR	06 May 2016		
REVIEW	LY	06 May 2016		

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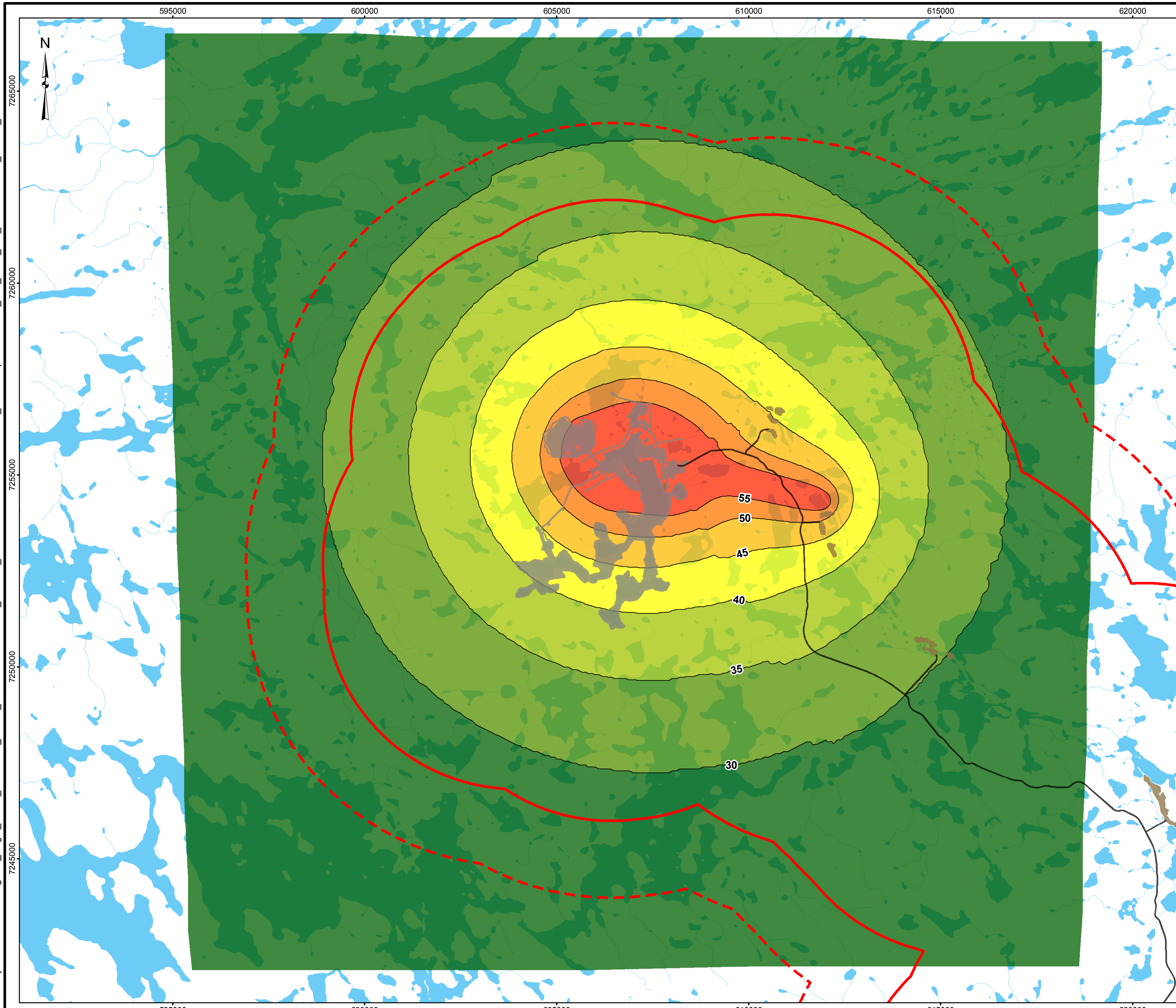


LEGEND

- NOISE AND VIBRATION LOCAL STUDY AREA
- NOISE AND VIBRATION REGIONAL STUDY AREA

WHALE TAIL
- BORROW SOURCE
- INFRASTRUCTURE
- PROPOSED HAUL ROAD

ENERGY EQUIVALENT SOUND LEVEL (L_{eq}) (dBA)
- < 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- > 55
- WATERCOURSE
- WATERBODY

REFERENCE

1. WHALE TAIL INFRASTRUCTURE OBTAINED FROM AGNICO EAGLE MINES LIMITED ON DECEMBER 21, 2015.
2. MEADOWBANK INFRASTRUCTURE OBTAINED FROM AGNICO EAGLE MINES LIMITED ON NOVEMBER 12, 2015.
3. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
4. INSET MAP DATA OBTAINED FROM ESRI

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

2 0 2

KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

WHALE TAIL PIT OPERATIONS
NOISE LEVEL PREDICTIONS: WINTER

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	VY	01 Mar. 2016	SCALE AS SHOWN	REV. 0
GIS	CDB	20 Apr. 2016	**FIGURE 4.4-3**	
CHECK	JR	06 May 2016		
REVIEW	LY	06 May 2016		

Table 4.4-7: Whale Tail Pit Operations - Permissible Sound Level Assessment

Assessment Location	Period	Existing Ambient Noise Level [dBA]	Pit Operations Project Noise Level [dBA]	Pit Operations Cumulative Noise Level[a] [dBA]	Permissible Sound Level [dBA]
Rmax – point on LSA boundary with maximum predicted Project noise level	Summertime / Daytime	30	33	35	50
	Summertime / Nighttime	30	33	35	40
	Wintertime / Daytime	30	34	35	55
	Wintertime / Nighttime	30	34	35	45

[a] Calculated as the logarithmic sum of the existing ambient noise level and the Pit Operations Project noise level.
Rmax = maximum predicted Project noise level; LSA = local study area; dBA = A-weighted decibel.

The results presented in Table 4.4-7 show that for both summertime and wintertime pit operations, cumulative noise levels on the LSA boundary are predicted to be less than the applicable PSL value. In other words, pit operations are predicted to comply with the AER Directive 038 PSL limit everywhere along the LSA boundary.

As discussed in Volume 4, Appendix 4-E, the Project NIA assessed the potential for LFN effects by comparing predicted noise levels expressed in dBC and dBA. Table 4.4-8 presents the results of the pit operations LFN assessment for Rmax – the point on the LSA boundary with maximum predicted Project noise level.

Table 4.4-8: Whale Tail Pit Operations – Low Frequency Noise Assessment

Assessment Location	Period	Existing Ambient Noise Level [dBC]	Whale Tail Pit Operations Project Noise Level [dBC]	Whale Tail Pit Operations Cumulative Nosie Level [dBC]	Whale Tail Pit Operations Cumulative Noise Level [dBA]	Difference: dBC minus dBA
Rmax – point on LSA boundary with maximum predicted Project noise level	Summertime / Daytime	45	53	54	35	19
	Summertime / Nighttime	46	53	54	35	19
	Wintertime / Daytime	45	53	54	35	19
	Wintertime / Nighttime	46	53	54	35	19

Rmax = maximum predicted Project noise level; LSA = local study area; dBC = C-weighted decibel; dBA = A-weighted decibel.

The results presented in Table 4.4-8 show that the difference between dBC and dBA Project noise levels is predicted to be less than 20 at Rmax for all periods. Based on the first LFN condition set out in AER Directive 038, this result suggests there will be no LFN effect along the LSA boundary.

While it is not appropriate to compare directly measured Meadowbank Mine noise levels and the model-predicted Whale Tail noise levels, due to the day to day variability in measured noise levels from changes in local meteorological conditions (i.e., wind speed and direction), a high-level general comparison can be done. In general, the noise levels that have been measured at Meadowbank in the last three years (i.e., 2012, 2013, and 2014 annual reports) are consistent with the model-predicted Whale Tail noise levels, taking into account the conservatism inherent in computer modelling (i.e., using downwind receptors 100% of the time). The Whale Tail model predictions are, generally-speaking, close to but slightly higher than the measured Meadowbank noise levels.

4.4.3.2.2 Blasting Noise and Vibration Sources

Table 4.4-9 presents the predicted blasting vibration levels associated with pit operations in the form of PPV at various distances from the blasting activity. Table 4.4-9 also presents predicted blasting noise levels associated with pit operations in the form of PPL at various distances from the blasting activity. Both PPV and PPL values were calculated using empirical formulae discussed in detail in Volume 4, Appendix 4-E (ISEE 1998). As discussed in Volume 4, Appendix 4-E, the pit operations blasting assessment was based on the assumption that up to 2150 kg of explosives will be detonated simultaneously (i.e., simultaneous detonation of ten blast holes each containing 215 kg of explosives).

Table 4.4-9: Whale Tail Pit Operations – Blasting Noise and Vibration Predictions

Distance from Blast [m]	Peak Particle Velocity – Ground Vibration [mm/s]	Peak Pressure Level – Airborne Noise [dBZ]
100	504	142
200	166	136
500	38	127
1000	13	120 – NPC-119 limit[a,c]
1150	10 – NPC-119 limit[a,b]	119
1500	7	117
2000	4	114
4000	1	107
5000 – LSA boundary	1	105

[a] OMOE (1978)

[b] The NPC-119 PPV limit is the maximum ground vibration level considered acceptable by the regulation. The results in this table show that PPV values are predicted to decay to below the NPC-119 limit for distances greater than 1150 m from pit operations blasting activities.

[c] The NPC-119 PPL limit is the maximum airborne noise level considered acceptable by the regulation. The results in this table show that PPL values are predicted to decay to below the NPC-119 limit for distances greater than 1000 m from pit operations blasting activities.

LSA = local study area; m = metre; mm/s = millimetres per second; dBZ = unweighted or linear decibels; PPL = Peak Pressure Level; PPV = Peak Particle Velocity.

The PPV results presented in Table 4.4-9 suggest that ground vibration associated with blasting as part of pit operations will decay to the 10 mm/s limit established in NPC-119 (OMOE 1978) within 1150 m of the blasting source and that PPV ground vibration will decay to 1 mm/s at the LSA boundary. In other words, at the LSA boundary ground vibration levels from Project blasting are predicted to be well below the NPC-119 limit.

Recent blast monitoring at the Vault Pit suggests that the empirical formula used to predict PPV ground vibration levels is highly conservative (Agnico Eagle 2014b) as it tends to overestimate PPV levels. At Vault Pit, PPV ground vibration levels are monitored at two locations: "Vault Pit Station #1", approximately 110 m southwest of the pit itself, and "Vault Pit Station #2", approximately 650 m northeast of the pit itself. Based on the results in Table 4.4-9, PPV ground vibration levels above 166 mm/s would be expected at "Vault Pit Station #1" but during the 2014 blast monitoring program, the maximum PPV level observed at this location was 23.8 mm/s (Agnico Eagle 2014b). Similarly, based on the results in Table 4.4-9, PPV ground vibration levels would be expected to be above 13 mm/s at "Vault Pit Station #2" but during the 2014 blast monitoring program, the maximum PPV level observed at this location was 4.13 mm/s (Agnico Eagle 2014b).

The PPL results presented in Table 4.4-9 suggest that airborne noise associated with blasting as part of pit operations will decay to the 120 dBZ limit established in NCP-119 (OMOE 1978) within 1000 m of the blasting source and that PPL airborne noise will decay to 105 dBZ at the LSA boundary. In other words, at the LSA boundary airborne noise levels from Project blasting are predicted to be well below the NPC-119 limit.

Table 4.4-10 presents predicted setback distances from pit operations blasting activities required to achieve compliance with DFO PPV and PPL limits for the protection of spawning fish and fish habitat, respectively. Both of these setback distances were calculated using empirical formulae discussed in detail in Volume 4, Appendix 4-E (DFO 1998). As discussed above, the pit operations blasting assessment was based on the assumption that up to 2150 kg of explosives will be detonated simultaneously.

Table 4.4-10: Pit Operations – Fisheries and Oceans Canada Blasting Setback Predictions

Setback Criterion	Setback Distance [m]
Fish Spawning – Ground Vibration (PPV)	700
Fish Habitat – Airborne Noise (PPL)	148

m = metre; PPL = Peak Pressure Level; PPV = Peak Particle Velocity.

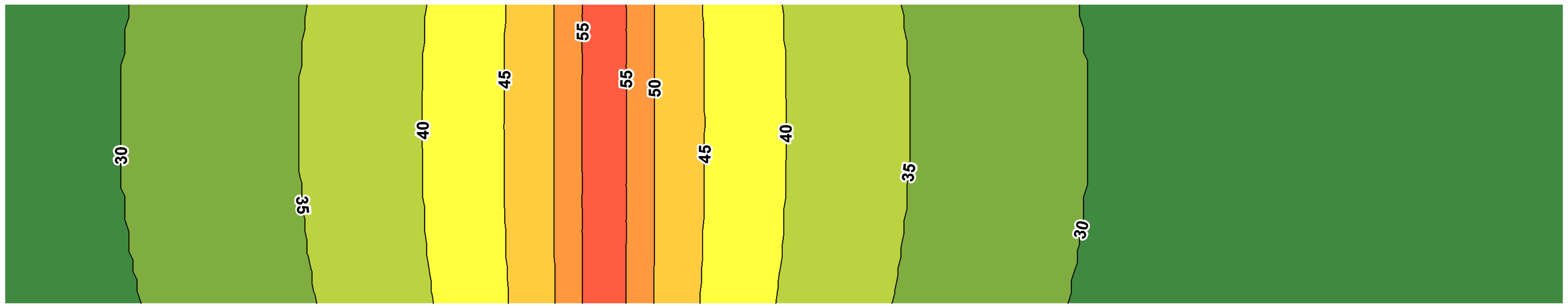
The setback predictions presented in Table 4.4-10 suggest that, to achieve compliance with DFO blasting limits, pit operations blasting should be carefully managed when it occurs within 700 m of areas used for fish spawning and/or within 148 m of fish habitat. However, recent blast monitoring conducted at the Meadowbank Vault Pit suggests that the setback predictions presented in Table 4.4-10 are highly conservative and that much smaller setbacks will be sufficient to achieve compliance with DFO blasting limits (Agnico Eagle 2014b). In particular, at "Vault Pit Station #1" (located approximately 110 from the pit) the DFO PPV limit was only exceeded on three occasions during 2014 and at "Vault Pit Station #2" (located approximately 650 m from the pit) the DFO PPV limit was never exceeded during 2014 (Agnico Eagle 2014b). Similarly, the DFO PPL limit was never exceeded at either "Vault Pit Station #1" or "Vault Pit Station #2" during 2014. The observed PPL levels were usually three orders of magnitude smaller than the DFO PPL limits (Agnico Eagle 2014b). During pit operations, blasting will be carefully managed and monitored in the context of DFO limits and appropriate setbacks will be established so that noise and vibration from pit operations blasting do not affect fish spawning or general habitat.

4.4.3.3 Haul Road Operations

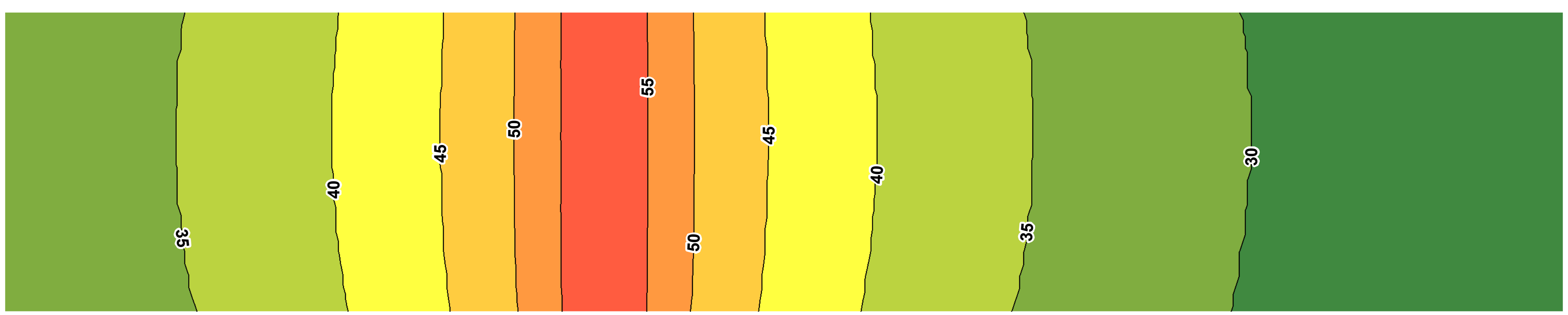
Haul road operations noise levels were predicted using the widely-accepted ISO 9613-2 technical standard (ISO 1996) and were compared to PSL and LFN limits set out in AER Directive 038. Figure 4.4-4 presents predicted Project noise levels for haul road operations under summertime conditions and wintertime conditions. As discussed in Volume 4, Appendix 4-E, the Project NIA considered a representative 5 km section of haul road and predicted noise levels across an LSA and RSA surrounding this representative section. Similar noise levels can be expected at comparable distances from other sections of the Project haul road.

As shown in Figure 4.4-4, haul road operations Project noise levels are predicted to be less than 30 dBA at 7 km from the haul road for both summertime and wintertime. In other words, for all periods, haul road operations Project noise levels are predicted to be less than the existing ambient noise level (see Table 4.4-2) at the boundary of the RSA. Similarly, for all periods, haul road operations Project noise levels are predicted to be less than 35 dBA at 5 km from the haul road – i.e., at the boundary of the LSA.

SUMMER



WINTER



LEGEND

ENERGY EQUIVALENT SOUND LEVEL (L_{eq}) (dBA)

- < 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- > 55

REFERENCE

1 0 1
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE
**HAUL ROAD OPERATIONS
NOISE LEVEL PREDICTIONS:
SUMMER AND WINTER**

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	VY	01 Mar. 2016	SCALE AS SHOWN REV. 0
GIS	CDB	20 Apr. 2016	FIGURE 4.4-4
CHECK	JR	06 May 2016	
REVIEW	LY	06 May 2016	

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As discussed in Volume 4, Appendix 4-E, the PSL values used to assess broadband Project noise are cumulative limits. As such, to assess potential Project noise effects using PSL values, it was necessary to calculate cumulative noise levels associated with haul road operations by summing predicted Project noise levels with existing ambient noise levels.

In the interest of assessing potential Project noise effects conservatively, the PSL assessment was focused on that point on the LSA boundary with maximum predicted Project noise level (Rmax). The PSL assessment for Rmax is presented in Table 4.4-11.

Table 4.4-11: Haul Road Operations - Permissible Sound Level Assessment

Assessment Location	Period	Existing Ambient Noise Level [dBA]	Haul Road Operations Project Noise Level [dBA]	Haul Road Operations Cumulative Noise Level[a] [dBA]	Permissible Sound Level [dBA]
Rmax – point on LSA boundary with maximum predicted Project noise level	Summertime / Daytime	30	28	32	50
	Summertime / Nighttime	30	28	32	40
	Wintertime / Daytime	30	31	34	55
	Wintertime / Nighttime	30	31	34	45

[a] Calculated as the logarithmic sum of the existing ambient noise level and the haul road operations noise level.
Rmax = maximum predicted Project noise level; LSA = local study area; dBA = A-weighted decibel.

The results presented in Table 4.4-11 show that for both summertime and wintertime haul road operations, cumulative noise levels on the LSA boundary are predicted to be less than the applicable PSL value. In other words, haul road operations are predicted to comply with the AER Directive 038 PSL limit everywhere along the LSA boundary.

As discussed in Volume 4, Appendix 4-E, the Project NIA assessed the potential for LFN effects by comparing predicted noise levels expressed in dBC and dBA. Table 4.4-12 presents the results of the haul road operations LFN assessment for Rmax – the point on the LSA boundary with maximum predicted Project noise level.

Table 4.4-12: Haul Road Operations – Low Frequency Noise Assessment

Assessment Location	Period	Existing Ambient Noise Level [dBC]	Haul Road Operations Project Noise Level [dBC]	Haul Road Operations Cumulative Nosie Level [dBC]	Haul Road Operations Cumulative Noise Level [dBA]	Difference: dBC minus dBA
Rmax – point on LSA boundary with maximum predicted Project noise level	Summertime / Daytime	45	49	50	32	18
	Summertime / Nighttime	46	49	51	32	19
	Wintertime / Daytime	45	50	51	34	17
	Wintertime / Nighttime	46	50	51	34	17

Rmax = maximum predicted Project noise level; LSA = local study area; dBA = A-weighted decibel; dBC = C-weighted decibel.

The results presented in Table 4.4-12 show that the difference between dBC and dBA Project noise levels is predicted to be less than 20 at Rmax. Based on the first LFN condition set out in AER Directive 038, this result suggests that there will be no LFN effect along the LSA boundary.

4.4.4 Residual Impact Classification

The key predictions of the Project NIA are as follows:

- Noise levels associated with haul road construction will decay to below existing ambient noise levels at the boundary of the LSA.
- Noise levels associated with haul road construction will be less than AER Directive 038 PSL limits at the boundary of the LSA.
- Based on AER Directive 038 criteria, there is no LFN effect from haul road construction at the LSA boundary.
- Noise and vibration levels associated with blasting during haul road construction will decay to levels below NPC-119 limits at the boundary of the LSA.
- Noise levels associated with pit operations will decay to below existing ambient noise levels at the boundary of the RSA.
- Noise levels associated with pit operations will be compliant with AER Directive 038 PSL limits at the boundary of the LSA.
- Based on AER Directive 038 criteria, there is no LFN effect from pit operations at the LSA boundary.
- Noise and vibration levels associated with blasting during pit operations will decay to levels below NPC-119 limits at the boundary of the LSA.
- Noise and vibration associated with blasting during pit operations will not affect fish spawning or fish habitat.
- Noise levels associated with haul road operations will decay to below existing ambient noise levels at the boundary of the RSA.
- Noise levels associated with haul road operations will be compliant with AER Directive 038 PSL limits at the boundary of the LSA.
- Based on AER Directive 038 criteria, there is no LFN effect from haul road operations at the LSA boundary.

Although primary pathways have been identified for noise, no residual impact predictions are made because noise does not have measurable assessment endpoints. Any potential effects associated with the primary pathways are captured in the assessment of potential effects to, and residual impact classifications for, other VCs, specifically in wildlife, birds and fisheries.

4.4.5 Cumulative Effects Assessment

The assessment methodologies and limits set out in AER Directive 038 are based on cumulative noise levels (i.e., Project noise levels combined with existing ambient noise levels). As such, the potential Project-related noise effects assessment presented in Section 4.4.3 includes the cumulative effects assessment. In particular, the noise level predictions and analysis presented in Table 4.4-3, Table 4.4-4, Table 4.4-7, Table 4.4-8, Table 4.4-11, and Table 4.4-12 include the contribution of existing ambient noise levels.

Because blasting is an extremely short-duration activity, the likelihood of cumulative effects from blasting activities (i.e., the temporal overlap of multiple blasting events occurring simultaneously) is small. As such, a cumulative effects assessment for blasting activities is not appropriate and was not conducted.

4.4.6 Uncertainty

According to the ISO 9613-2 standard, the overall accuracy of the propagation algorithm used in the Project models of conventional noise sources is plus or minus (+/-) 3 decibels (dB) for distances between source and receptor up to 1 km. The accuracy for propagation distances greater than 1 km is not stated in the standard. Model accuracy also depends on the accuracy of the noise emissions inputs, which is often +/- 2 dB for measured sources and larger for emissions values calculated from acoustics handbooks or technical standards. Accounting for both these sources of uncertainty, the overall accuracy of the conventional noise level predictions presented in the Project noise and vibration assessment is expected to be +/- 3.6 dB.

Conservative assumptions regarding the Project were made to account for the level of uncertainty inherent in the noise level predictions. Most importantly, all receptor points were assumed to be downwind from all sources 100% of the time. Because downwind conditions enhance noise propagation, this assumption tends to overestimate the noise effects of the Project. Likewise, the terrain in the Project area was assumed to be flat so that noise sources and receptors are located in effectively the same plane. This assumption eliminates the possibility of terrain-based screening and tends to overestimate the noise effects of the Project. Furthermore, the noise sources associated with pit operations were all modelled at grade level to match their position at the beginning of mining operations. As mining progresses the depth of the open pit will increase and the sides of the pit will provide screening for the noise sources inside. As such, modelling mining sources at grade level is conservative and will tend to overestimate noise effects for later years of Project operations.

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 predictions obtained using these formulae. Comparison with recent blast monitoring results from the Vault Pit suggest the empirical formulae used in the Project NIA are highly conservative (Agnico Eagle 2014b) and subsequently, tend to overestimate noise and vibration levels associated with blasting. However, the empirical formulae are useful for conservatively 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 regulatory 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 values must be predicted.

4.4.7 Monitoring and Follow-up

Follow-up noise monitoring for the Project will be conducted in general accordance with the regular noise monitoring currently being conducted as part of the Meadowbank Mine noise management plans (Cumberland 2005d; Agnico Eagle 2009, 2013b). In particular, yearly noise monitoring will be conducted at four locations in the vicinity of the Project. Specific monitoring locations will be selected and adjusted as Project activities evolve, but an appropriate starting point would be to monitor noise levels once each year at the same four receptor locations used for baseline monitoring (Volume 4, Appendix 4-D). Follow-up noise monitoring will be conducted in general accordance with methodologies described in AER Directive 038 and the monitoring results will be compared to the same target values considered in the Meadowbank Mine noise management plans and to model predictions presented in the Project NIA. If monitored noise levels exceed appropriate limits, Agnico Eagle will take appropriate actions to identify the specific cause of the exceedance and, if practical, to mitigate the relevant noise source.

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APPENDIX 4-A

Air Quality Baseline

4.A-1 INTRODUCTION

This document provides detailed technical information regarding the existing long-term weather and climate in the vicinity of the Whale Tail Pit Project (the Project). Baseline meteorological data are required as inputs to the air quality model used to predict potential Project-related effects to air quality.

There is very little information regarding existing ambient air quality in the Kivalliq Region of Nunavut. This document provides detailed analysis of the available air quality data relevant to the region. By necessity, this includes data from outside the Kivalliq Region, including data from the Northwest Territories. These data are the only known data relevant to Nunavut and the Canadian Arctic available for estimating existing air quality for the Project. Baseline air quality data are needed as supplementary information to predict the potential effects of the Project on ambient air quality.

4.A-2 EXISTING WEATHER AND CLIMATE

The Project is located in Canada's Northern Arctic ecozone. This ecoregion includes most of Canada's Arctic Archipelago and northern regions of continental Nunavut and the Northwest Territories. The ecoregion is classified as a polar desert and is characterized by long cold winters and short cool summers. Extreme winter cold, low precipitation, and persistent drying winds make this one of the harshest climates in Canada (McGill University 2016; University of Guelph 2016).

Climate refers to the long-term averages of weather measured using meteorology and can be estimated by using climate normal data derived from a 30 year period of observed data. Environment Canada operates a meteorological monitoring station at Baker Lake, Nunavut, approximately 125 kiometres (km) southeast of the Whale Tail Pit. This station provides climate information and hourly meteorological data. This assessment uses the 1981 to 2010 climate normal data for the Baker Lake A station calculated by Environment Canada (Environment Canada 2016).

AERMET is the meteorological processor used to generate meteorological data files for the AERMOD model that was used to assess potential effects of the Project on air quality. An AERMET dataset dictates the transport and dispersion of atmospheric emissions from the Project, as well as the predicted ground-level concentrations of criteria air contaminants considered in this assessment. The AERMET dataset was constructed using the latest five years (2005 to 2009) of surface observations and upper air data from the Environment Canada Baker Lake A meteorology station.

There is also an on-site meteorological station at the Meadowbank Mine located approximately 62 km southeast of the Whale Tail Pit. Two years of hourly and daily meteorology data (2013 and 2014) were available for meteorological parameters including temperature, pressure, relative humidity, wind speed and direction, and precipitation. However these data were not used to derive the AERMET dataset because this station does not monitor all of the parameters required to complete an AERMET dataset.

The following sections present the meteorology data from the Baker Lake A station and a comparison between the AERMET dataset and the Meadowbank Mine on-site meteorological dataset.

4.A-2.1 Temperature

The Environment Canada climate normals provide a means to assess the long-term temperature trends at the Project. As presented in Table 4-A-1: the annual daily average air temperature recorded at the Baker Lake A

Station was -11.3 degrees Celsius (°C), and daily averages ranged from -31.3°C in January to +11.6°C in July. The "Unfrozen" period, which for the purpose of this assessment is classified as months having daily average temperatures above 0°C, occurs from June through September. During this period, the daily average temperature is approximately 7°C. The "Frozen" period, which for the purpose of this assessment is classified as months having daily average temperatures below 0°C, occurs from October through May. During this period, the average daily temperature is approximately -20.6°C.

Table 4-A-1: Temperature Normals for the Baker Lake A Station (1981 to 2010)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
daily average (°C)	-31.3	-31.1	-26.3	-17.0	-6.4	4.9	11.6	9.8	3.1	-6.5	-19.3	-26.8	-11.3
daily maximum (°C)	-27.7	-27.4	-22.0	-12.3	-3.0	9.3	17.0	14.3	6.4	-3.4	-15.5	-23.1	-7.3
daily minimum (°C)	-34.8	-34.8	-30.6	-21.5	-9.8	0.5	6.1	5.3	-0.2	-9.5	-23.1	-30.5	-15.2

°C = degrees Celsius

Table 4-A-2 summarizes the AERMET-derived monthly temperatures for the five year assessment period (2005 to 2009). The AERMET-derived daily average monthly surface temperatures in the Project area ranged from -30.6°C in February to +11.1°C in July. The annual AERMET-derived daily average air temperature was -10.7°C and is comparable to the Baker Lake A observed average of -11.3 °C.

Table 4-A-2: AERMET-derived Temperature (2005 to 2009)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
daily average (°C)	-28.9	-30.6	-26.6	-15.0	-6.4	4.5	11.1	10.1	2.6	-4.8	-18.5	-25.3	-10.7
daily maximum (°C)	-25.1	-27.7	-22.8	-11.1	-3.9	8.7	16.0	14.0	5.6	-2.6	-15.4	-21.9	-7.2
daily minimum (°C)	-32.1	-33.6	-30.7	-19.7	-9.5	0.4	6.2	6.0	-0.4	-7.7	-22.1	-28.5	-14.3

°C = degrees Celsius

Table 4-A-3 summarizes the monthly temperatures monitored at the Meadowbank Mine site station from 2013 to 2014. The daily average monthly surface temperatures were -31.5°C in February to +12.6°C in July. The daily average temperature was -11.4°C at the Meadowbank Mine compared to the long-term average of -11.3 °C observed at the Baker Lake A meteorology station.

Table 4-A-3: On-Site Temperature Monitoring (2013-2014)

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Temperature													
daily average (°C)	-33.1	-31.5	-26.4	-17.8	-4.3	8.0	12.6	10.1	1.4	-6.0	-21.8	-27.7	-11.4
daily maximum (°C)	-30.4	-28.5	-23.1	-14.3	-1.1	12.3	16.4	13.3	3.5	-4.2	-18.9	-24.7	-8.3
daily minimum (°C)	-35.6	-34.2	-29.8	-21.7	-7.6	3.5	8.6	7.0	-0.6	-8.3	-24.6	-30.9	-14.5

°C = degrees Celsius

Figure 4-A-1 shows a comparison of AERMET-derived temperatures and the observed temperatures at the Baker Lake station. The AERMET derived temperature profile for the Project area is similar to the average climatic conditions at the Baker Lake station and to the Meadowbank Mine meteorological data.

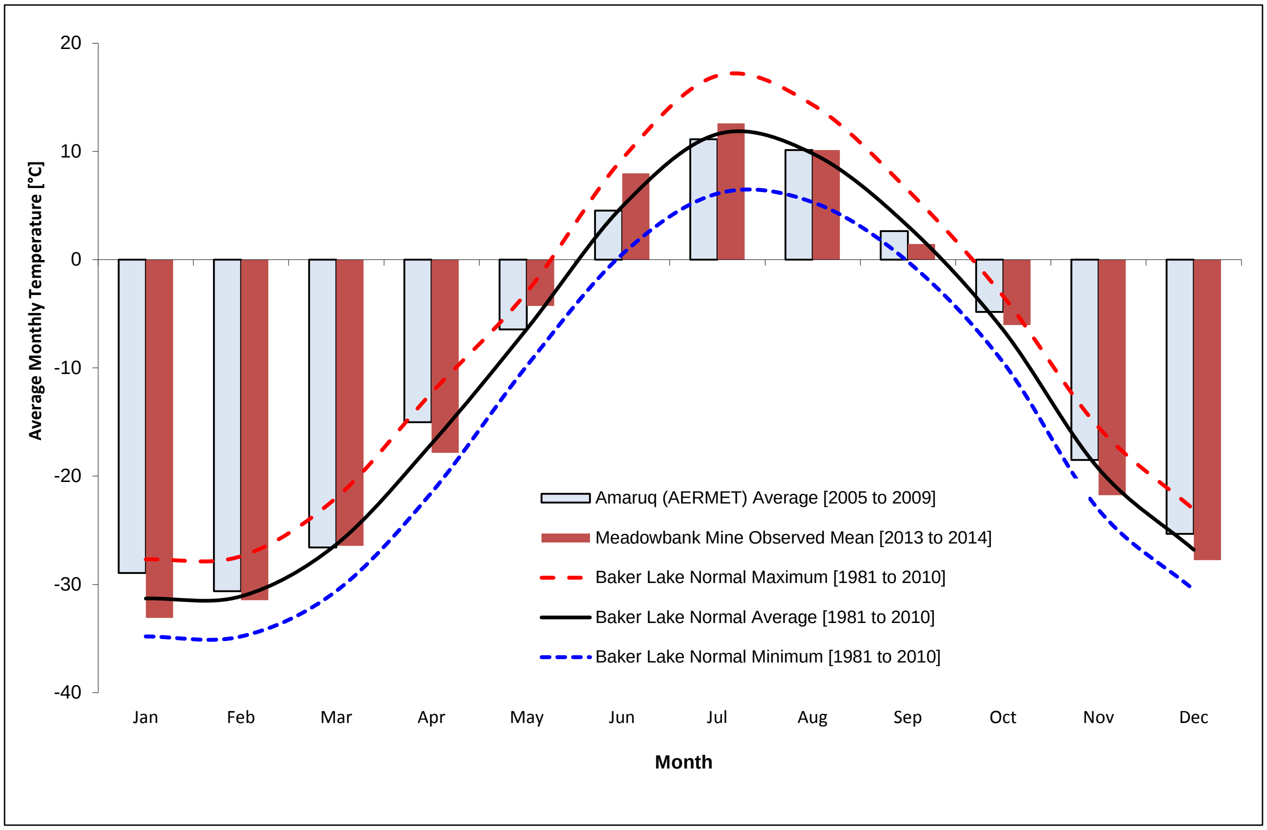

Figure 4-A-1: Comparison of AERMET-Derived and Observed Ambient Temperature

4.A-2.2 Wind

Windroses are useful for presenting wind speed, wind direction and frequency information in a single figure. A windrose consists of bars whose length indicates the frequency of winds blowing from a given direction referenced to a 16-point compass. The bars are also broken into sections, each of which defines a wind speed range. A longer section indicates that winds blow more frequently at a given speed for that compass direction.

Figure 4-A-2 presents a comparison of the windroses generated for the Project using AERMET and the data collected at the Meadowbank Mine meteorology station. The datasets are comparable and show that the winds were predominantly from the north-northwest.

For both datasets, the wind pattern is predominantly from the northwest quadrant. However, winds originating from the north-northwest and north are also common.

AERMET-derived Windrose (2005-2009) **Meadowbank Mine Observed Windrose (2013-2014)**

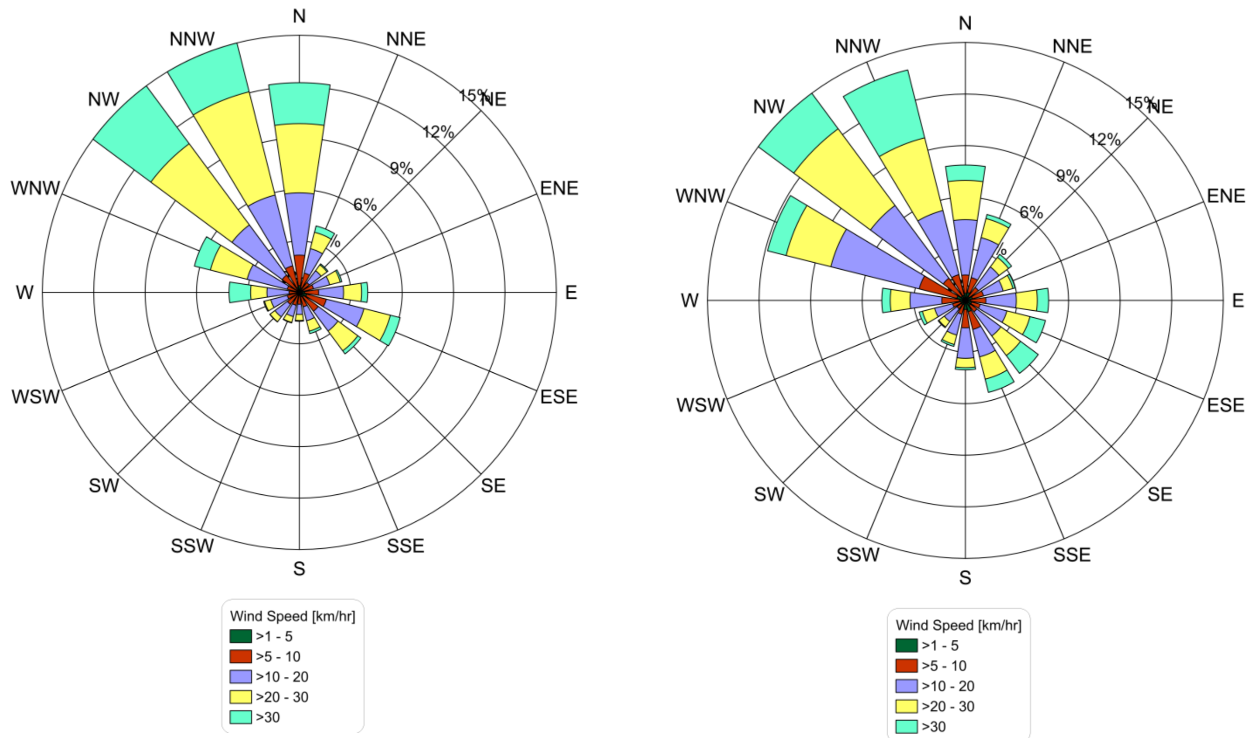

Figure 4-A-2: Comparison of AERMET-Derived (2005-2009) and Meadowbank Mine (2013-2014) Winds for the Project Area

Hourly wind data are required to generate a windrose, therefore a windrose cannot be created from monthly climate normal data. However, wind normals do provide insight into long term wind data trends. Over the period from 1981-2010, the average wind speed at the Baker Lake A station was 20 km/hr. Table 4.A-4 provides a summary of climate normals for wind at the Baker Lake A station, and indicates the predominant wind direction was from the northwest.

Table 4-A-4: Normal Surface Wind at the Baker Lake A Station

Period	Speed (km/h)	Most Frequent Direction	Maximum Hourly Speed (km/h)	Direction of Maximum Hourly Speed	Maximum Gust Speed (km/h)	Direction of Maximum Gust
Jan	22.8	NW	105	N	140	N
Feb	22.1	NW	124	SE	133	NW
Mar	20.9	NW	93	W	121	W
Apr	20.1	NW	91	NW	104	NW
May	19.5	N	91	NW	106	NW
Jun	16.4	N	121	W	177	W
Jul	15.4	N	67	N	91	N
Aug	17.4	N	81	W	137	W
Sep	19.1	N	78	N	103	W
Oct	21.4	NW	106	N	109	NW
Nov	21.9	NW	97	N	121	N
Dec	22.5	NW	100	NW	128	NW
Annual	20	NW	124	SE	177	W

4.A-2.3 Precipitation

Precipitation data is recorded at the Environment Canada Baker Lake A station. On average, the Baker Lake A station receives a total annual precipitation (Rainfall + Snowfall) of approximately 272.5 millimietres (mm). The average annual rainfall is approximately 163.4 mm, with most of the rainfall occurring from May through October. The average annual snowfall is approximately 1265 mm, with most snowfall occurring from October through May. Some months experience mixed precipitation. Figure 4-A-3 provides a summary of monthly and annual precipitation normals, including extremes. AERMET data for total precipitation, which have been derived from Environment Canada surface observations between 2005 and 2009, are also presented in Figure 4-A-3. Precipitation data are not recorded at the Meadowbank Mine meteorology station.

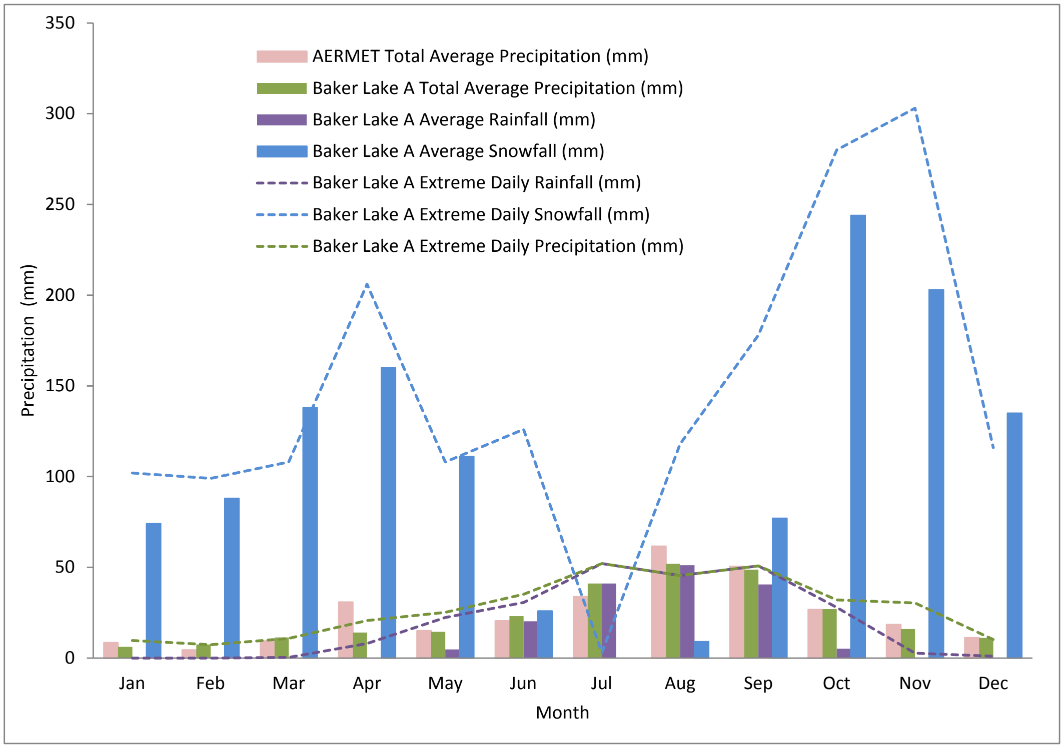

Figure 4-A-3: Precipitation at Baker Lake

4.A-3 EXISTING AIR QUALITY

This technical appendix summarizes background criteria air contaminant (CAC) concentrations that are used in the assessment to predict potential changes to regional air quality as a result of Project-related air emissions.

The Project will result in emissions to air that could change local or regional air quality. To determine whether Project-related emissions lead to air quality conditions that are consistent with existing Territorial and Federal air quality criteria, maximum predicted concentrations of CACs emitted from the Project must be added to the background concentrations of the CACs in the region. Background concentrations can be established through baseline measurements (Ontario MOE 2009; AESRD 2013), or prescribed by regulators based on regional airsheds (Saskatchewan MOE 2012). The CACs considered for the FEIS Amendement include the following:

- carbon monoxide (CO);
- oxides of nitrogen (NO, NO_2, NO_x);
- sulfur dioxide (SO_2); and
- particulate matter, including:
  - particulate smaller than 2.5 micrometres in aerodynamic diameter ($PM_{2.5}$);
  - particulate smaller than 10.0 micrometres in aerodynamic diameter (PM_{10}); and
  - total suspended particulate matter (TSP).

Project emissions of NO and NO_2 are combined as NO_x, with the photochemical conversion of NO to NO_2 being simulated by the air quality model. The conversion of NO to NO_2 requires information regarding the ambient concentrations of ozone (O_3), which have also been evaluated as part of this baseline air quality assessment (see Section 4.A-3.1). Model results are assessed against the relevant ambient air quality standards for NO_2. Since NO is relatively short-lived, only the background concentration of NO_2 needs to be added to the results of the model simulation to estimate potential Project-related effects.

Elevated ambient $PM_{2.5}$ concentrations have been linked to public health concerns, while TSP is relevant to aerial deposition of CAC's to terrestrial and aquatic ecosystems. National Air Pollution Surveillance (NAPS) stations and National Aeronautics and Space Administration (NASA) aircraft have both measured $PM_{2.5}$ concentrations in the region; however, there are no relevant air quality monitoring data for PM_{10} or TSP in the Arctic. As a result, ambient concentrations of PM_{10} and TSP have been assigned a value equal to that of $PM_{2.5}$ in this assessment.

In Nunavut, there are no prescribed background concentrations for CACs when performing air quality predictions for proposed developments. This technical appendix includes a statistical analysis of publicly available air quality monitoring data in the Western Arctic, and summarizes background CAC values that were used to predict the changes to regional air quality that may arise from Project-related air emissions.

4.A-3.1 Methods

Table 4-A-5 summarizes publicly available air quality data that are relevant to this study, including sampling locations, compounds measured, and dates that the compounds were measured.

Table 4-A-5: Available NAPS Station Data and NASA ARCTAS Data

Name	Territory	Compounds	Data Available	Notes
Sir John Franklin High School	NWT	CO, SO_2, $NO/NO_2/NO_x$, $PM_{2.5}$	2009-2013	Publicly available NAPS data.
Norman Wells NW Regional Office	NWT	SO_2, $NO/NO_2/NO_x$, $PM_{2.5}$	2009-2013	Publicly available NAPS data.
Fort Liard	NWT	SO_2, $NO/NO_2/NO_x$, $PM_{2.5}$	2009-2012	Publicly available NAPS data.
Samueal Hearne School	NWT	SO_2, $NO/NO_2/NO_x$, $PM_{2.5}$	2009-2011	Publicly available NAPS data.
Snare Rapids	NWT	Not available		
WildLife Services Garage Iqaluit	NU	$NO/NO_2/NO_x$, $PM_{2.5}$, O_3	2014 – 2015	One year of data obtained from Government of NU.
Water Quality Lab Iqaluit	NU	$NO/NO_2/NO_x$, $PM_{2.5}$, O_3	2012 – 2013	One year of data obtained from Government of NU.
Alert	NU	O_3	1992-2003	Special Studies Data - Ozone at ALERT
		Aerosols Chemistry (Chloride, Bromide, Nitrate, Sulfate, Sodium, Ammonium, Lead, Cooper, Aluminum, Iron, etc.)	1980-2006	Quality Controlled Weekly Data
		Black Carbon Data	1989-2012	Quality Controlled Hourly Data
NASA ARCTAS	AK, YT, NWT, NU	CO, SO_2, $NO/NO_2/NO_x$, $PM_{2.5}$	2008 (April/May)	NASA Airborne Science Mission

NWT = Northwest Territory; NU = Nunavut; AK = Alaska; YT = Yukon Territory; CO = carbon monoxide; SO_2 = sulphur dioxide; NO, NO_2, NO_x = oxides of nitrogen; $PM_{2.5}$ = particulate smaller than 2.5 micrometers in aerodynamic diameter; O_3 = ozone

The goal of the NAPS program is to provide accurate long-term air quality data of a uniform standard across Canada (EC 2015a). The NAPS program was established in 1969 to monitor and assess the quality of ambient (outdoor) air in the populated regions of Canada. The NAPS program is managed using a cooperative agreement among the provinces, territories and some municipal governments. Today there are 286 NAPS sites in 203 communities located in every province and territory. However, NAPS geographic coverage in the Canadian Territories is sparse, and NAPS stations in the Arctic do not measure all CAC's emitted by the Project.

For example, data collected at the Alert, Nunavut air quality monitoring station are not available from Canada's National Air Pollution Survey (NAPS; EC 2015a) database, but are archived separately under the Canadian Aerosol Baseline Measurements data (EC 2015b). Canadian Aerosol Baseline Measurements files for Alert did not contain trace gas concentrations or total aerosol mass. Instead the files include only specialized aerosol chemistry data and ozone data; data not relevant for this assessment. The Alert data are therefore excluded from this analysis. There were also no relevant, publicly available data for the NAPS locations at Snare Rapids in the Northwest Territories.

Data for the two NAPS stations located in Iqaluit, Nunavut are not publicly available via the NAPS web portal. To inform this assessment, Golder Associates Ltd. (Golder), on behalf of Agnico Eagle, signed a data sharing agreement with the Government of Nunavut. The Government of Nunavut then provided Golder with two years of air quality monitoring data from the Iqaluit NAPS stations to support this assessment.

In April and May of 2008, NASA conducted the *Arctic Research of the Composition of the Troposphere from Aircraft and Satellites* mission (ARCTAS; Jacob et al. 2010). ARCTAS was part of a larger interagency International Polar Year effort collectively identified as POLARCAT. While the aircraft data were only collected for a 2-month period, the data include atmospheric soundings from 100 metres (m) up to 12 km over most of the Western Arctic using state-of-the-art in-situ airborne instruments (McNaughton et al. 2011).

Publicly available NAPS data were quality assured (QA) and quality controlled (QC) by Environment Canada prior to publication on the Internet. Raw air quality monitoring data ($NO/NO_2/NOx$, $PM_{2.5}$ and O_3) from the Iqaluit NAPS stations were quality controlled by air quality experts at Golder prior to their use in this assessment.

To generate appropriate background estimates of CAC concentrations in the Kivalliq Region, the data must be screened to eliminate known event-based biases. Specifically, boreal forest fire smoke is seasonally transported into the Arctic where it episodically can affect air quality (Forster et al. 2001; Warneke et al 2009). Ambient 1-hour average concentrations of $PM_{2.5}$ during these events can exceed 200 or even 300 micrograms per cubic metre ($\mu g/m^3$). These concentrations are more than 10 times the 24-hr average $PM_{2.5}$ Canadian Ambient Air Quality Standard (CAAQS) of 28 $\mu g/m^3$. Including these events in background datasets results in 24-hr 90th percentile $PM_{2.5}$ concentrations and annual average $PM_{2.5}$ concentrations that exceed, or are a significant fraction of the CAAQS. To remove these events, concentrations that exceeded the 97.6th percentile of all data were removed from the dataset prior to generating statistics for background concentrations of $PM_{2.5}$. The 97.6th percentile was selected for $PM_{2.5}$ as this excludes only 1-hr concentrations greater than two standard deviations from the sample mean (i.e., greater than $\bar{u} + 2\sigma$) from a pooled dataset with more than 43,000 independent observations.

Appropriate 8-hour, 24-hour, and annual averages for each of the other CACs were generated by arithmetically averaging the 1-hr data. Background concentrations for 1-hour, 8-hour, and 24-hour averaging periods were assigned a value equal to the 90th percentile value from the available period of observations. Background concentrations for the annual averages were assigned the median (50th percentile) value of the available period of observations.

The background annual $PM_{2.5}$ concentration was not assigned the median annual average from the available period of observations. Instead, the annual average background $PM_{2.5}$ concentration was calculated as the geometric mean (50th percentile) of the available 24-hr average observations. This approach is required to eliminate bias associated with arithmetically averaging (rather than geometrically averaging) the variable ambient aerosol concentrations. This bias can result in elevated background concentration estimates (6.2 $\mu g/m^3$) that are a significant percentage (>70%) of the Canadian Ambient Air Quality Standard (8.8 $\mu g/m^3$).

NASA ARCTAS data were QA/QC'd by the NASA Principal Investigators prior to data submission to the NASA airborne science archive. These data have not been screened for any event-based biases. The available NASA ARCTAS data are 1-minute in-flight averages. Due to the speed of the airborne platform, the effective averaging time compared to a ground-based measurement is much longer than 1 minute.

True airspeeds of approximately 120 (NASA P-3B aircraft) to 150 metres per second (m/s) (NASA DC-8 aircraft) correspond to spatial averages of 7 to 9 km over a 1-minute sampling period. For an average surface wind speeds of 5.5 m/s, this corresponds to an effective sample integration time of 21 to 27 minutes for each data point (N). The two NASA aircraft recorded more than 132 hours of 1-minute average data over the Western Arctic in April and May of 2008. However, the statistics summarized in this assessment consider only the CAC concentrations measured below 1 km altitude. Airborne trace gas measurements obtained aboard the NASA aircraft are accurate and precise. Airborne particulate matter measurements are considered comparable to ground-based measurements of $PM_{2.5}$ (McNaughton et al. 2007).

To generate summary statistics relevant for comparison to the NAPS station data, no separate averaging of the aircraft data was applied to the 1-hr versus the 24-hr averages. Instead, the 1-hr and 24-hr averages were computed from the 90th percentile of the 1-minute flight average values, and the annual average was calculated based on the median (50th percentile) value.

4.A-3.2 Results

Figure 4-A-4 is a Google Earth image depicting the locations of the NAPS and Alert air quality monitoring stations in Arctic Canada. NASA P-3B and DC-8 aircraft ground tracks are also plotted, with data collected below 1-km shaded red and blue, respectively.

Table 4-A-6 summarizes the NAPS data completeness (hourly data) between January, 2009 and December, 2014 for the Norman Wells, Sir John Franklin High School, Fort Laird, and Samuel Hearne NAPS stations. For the Iqaluit data, the data completeness is calculated over the approximate 1-year of data provided by the Government of Nunavut. Table 4-A-6 also includes the number of valid 1-minute average ARCTAS data points used to generate the summary statistics. Table 4-A-7 provides summary statistics for the NAPS and ARCTAS data, a set of recommended background concentrations of CACs for the Kivalliq Region of the Western Arctic, and relevant Canadian ambient air quality standards for these CACs. Note that the monthly average concentrations of ozone are required as input to the air quality model and are not simulated by the model for comparison to the CAAQS. The background concentrations summarized in Table 4-A-7 are the ground-level CAC concentrations used to inform the air quality portion of the FEIS Amendment.

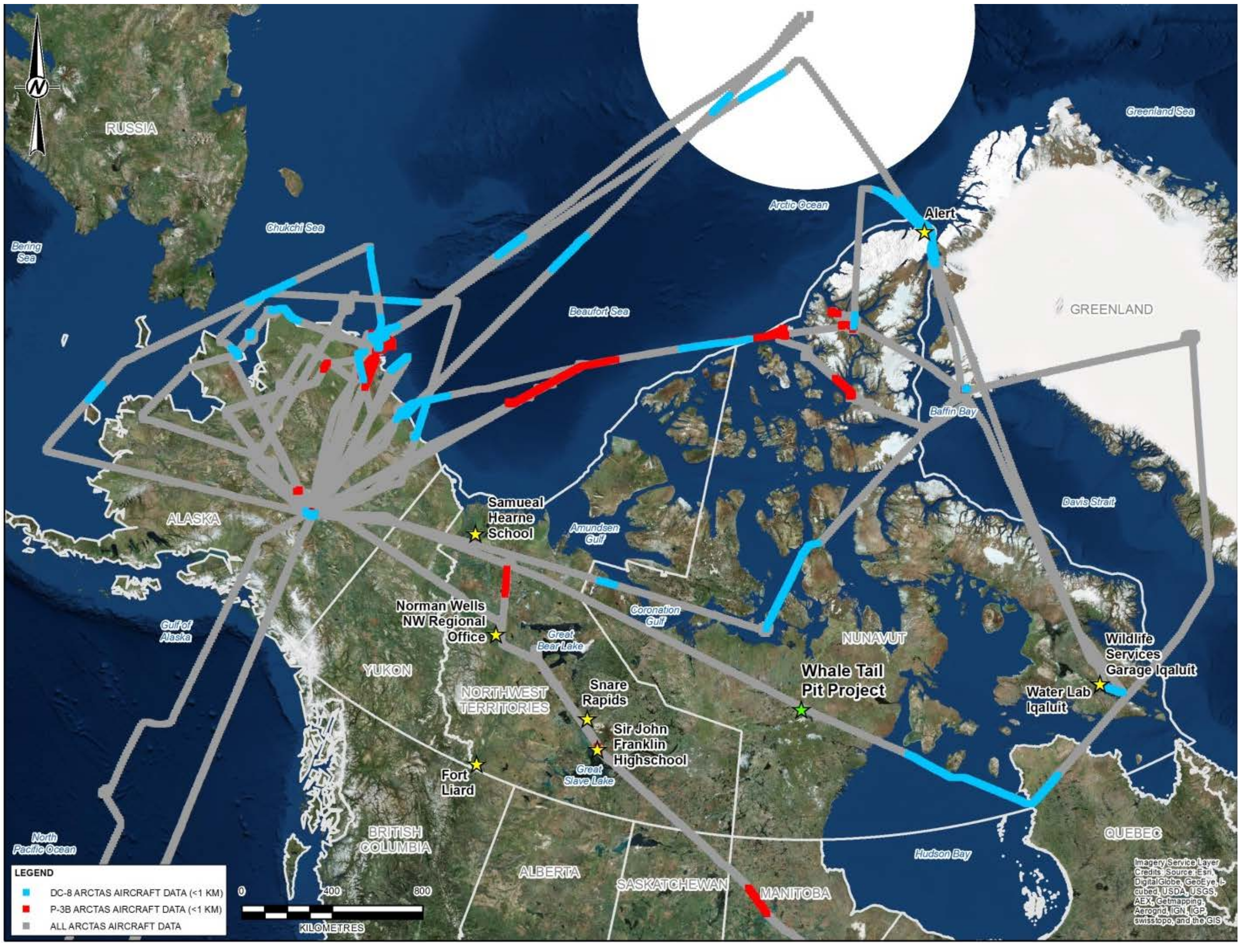

Figure 4-A-4: Location of NAPS stations and ARCTAS aircraft measurements in the Canadian Arctic

Table 4-A-6: Data Completeness Summary

Compound (units)	Normal Wells (NWT)	Sir John Franklin High School (NWT)	Fort Laird (NWT)	Samuel Hearne Station (NWT)	Iqaluit Water Services Garage (NU)	Iqaluit Water Quality Lab (NU)	NASA ARCTAS
CO (ppbv)	N/A	97%	N/A	N/A	N/A	N/A	N = 1206
NO_2 (ppbv)	90%	96%	46%	40%	76%	97%	N = 1183
SO_2 (ppbv)	88%	94%	76%	48%	N/A	N/A	N = 922
$PM_{2.5}$ (µg/m^3)	85%	92%	65%	42%	93%	81%	N = 2916

N/A = not available; NWT = Northwest Territories; CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; ppbv = parts per billion, volumetric; µg/m^3 = micrograms per cubic metre

Table 4-A-7: Summary Statistics for Criteria Air Contaminants

Compound (units)	Averaging Period	Percentile	Norman Wells (NWT)	Sir John Franklin High School (NWT)	Fort Laird (NWT)	Samuel Hearne Station (NWT)	Iqaluit Water Services Garage (NU)	Iqaluit Water Lab (NU)	NASA ARCTAS	Background Concentra-tions used in the FEIS	Air Quality Standard
CO (ppmv)	1-hr	90th	N/A	0.5	N/A	N/A	N/A	N/A	0.2	**0.3**	13
	8-hr	90th	N/A	0.5	N/A	N/A	N/A	N/A	0.2	**0.3**	5
NO_2 (ppbv)	1-hr	90th	4.0	7.0	6.0	8.0	4.7	16.4	0.11	**5.0**	159
	24-hr	90th	3.5	7.0	4.9	6.9	6.2	13.0	0.11	**4.5**	106
	Annual	50th	1.4	3.0	1.2	4.1	2.7	5.8	0.008	**1.9**	24
O_3 (ppbv)	1-hr	90th	35.0	36.0	38.0	N/A	32.5	39.9	49.2	**17.3 – 30.6**[b]	82
	8-hr	90th	34.1	35.4	37.9	N/A	24.6	39.3	34.2		63
SO_2 (ppbv)	1-hr	90th	1.0	1.0	1.0	1.0	N/A	N/A	0.2	**1.0**	172
	24-hr	90th	1.0	1.0	1.2	1.2	N/A	N/A	0.2	**1.0**	48
	Annual	50th	<1.0	<1.0	<1.0	<1.0	N/A	N/A	0.1	**0.1**	8
$PM_{2.5}$ (µg/m^3)	24-hr	90th	6.8	7.7	6.4	8.0	6.8	7.2	3.9	**6.6**	28
	Annual	50th	3.5[a]	4.5[a]	3.4[a]	4.3[a]	3.3	3.9	2.0	**3.6**	8.8

[a] Geometric average (median or 50th percentile) of 5-years of 24-hr average concentrations after removing zeros and hourly concentrations above the 97.6th percentile.

[b] Indicated values are the range in monthly average concentrations used as input for the conversion of NO_2 to NO in the air quality model.

N/A = not available; NWT = Northwest Territories; CO = carbon monoxide; NO_2 = nitrogen dioxide; SO_2 = sulfur dioxide; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; ppbv = parts per billion, volumetric; µg/m^3 = micrograms per cubic metre

The most complete baseline air quality data are those from the Sir John Franklin High School NAPS station and the ARCTAS airborne data. The Sir John Franklin High School station is also the closest to the Project, located at approximately the same latitude, but some 1,200 km due west of the Project. The available data from the Norman Wells NAPS station is also robust, but lacks measurements of CO. Measurements from the Fort Laird and Samuel Hearne Station NAPS stations contain large data gaps and lack CO data. The Iqaluit NAPS station data include NO_2, $PM_{2.5}$ and O_3 data and are short in duration (approximately one year each), but the available data are relatively complete and of high quality.

NAPS and ARCTAS CO data are consistent and indicate a background concentration of 0.2 parts per million volumetric (ppmv); a value less than 10% of the relevant 1-hr and 8-hr ambient air quality standards.

The ARCTAS measurements of NO_2 and SO_2 are more precise (approximately +/-0.001 ppbv) than the corresponding ground-based measurements (approximately +/-0.5 ppbv). However, airborne sampling below 300 m was infrequent aboard the DC-8 aircraft (only aircraft with NO_2 and SO_2 instruments) used during ARCTAS. Since Arctic atmosphere concentrations of these gases are often <0.5 ppbv, this results in ARCTAS background concentrations appearing much lower than concentrations observed at the surface NAPS stations. NAPS stations are also closer to the surface-based combustion emissions sources of these compounds.

Figure 4-A-5 shows the NO_2 time series data from the Sir John Franklin High School and the Norman Wells NAPS stations. These stations are presented as they contain the longest, most complete, publicly available records of ambient ground level NO_2 and $PM_{2.5}$ concentrations in Arctic Canada. However, all available station data were used to compute the statistics in Table 4-A-7.

Note the seasonal peak in spring associated with Arctic Haze events, and the photochemical destruction of NO_2 in the polar summer. When averaged, the NAPS and ARCTAS background concentrations for NO_2 and SO_2 are less than 10% of the relevant 1-hr, 24-hr, and annual average ambient air quality standards.

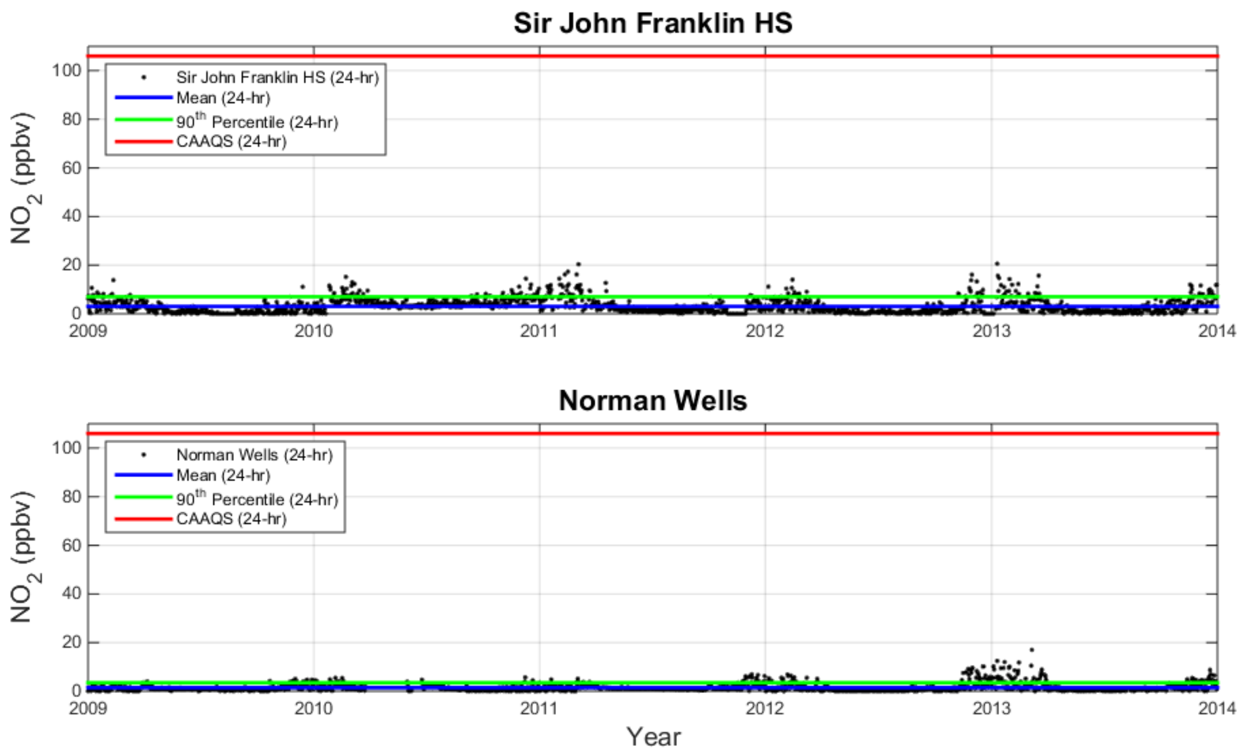

Figure 4-A-5: Time Series of NO2 Concentrations at Sir John Franklin High School (top) and Norman Wells (bottom) Stations

Particulate matter concentrations are highly variable and have been screened to eliminate bias introduced by $PM_{2.5}$ emissions from seasonal boreal forest fires. Figure 4-A-6 plots time series of the screened $PM_{2.5}$ data from the Sir John Franklin High School and Normal Wells NAPS stations. The 90th percentile for the 24-hr averages, the geometric mean (median or 50th percentile) and the relevant 24-hr ambient air quality standard are also indicated.

Results for the 90th and 50th percentile are consistent among the NAPS stations and with the ARCTAS data from April and May of 2008. Values from the NAPS stations and ARCTAS have been averaged to produce 24-hr and annual average background concentrations of 6.7 and 3.6 $\mu g/m^3$, respectively. These background concentrations represent 23% and 41% of the relevant ambient air quality standards (28 and 8.8 $\mu g/m^3$).

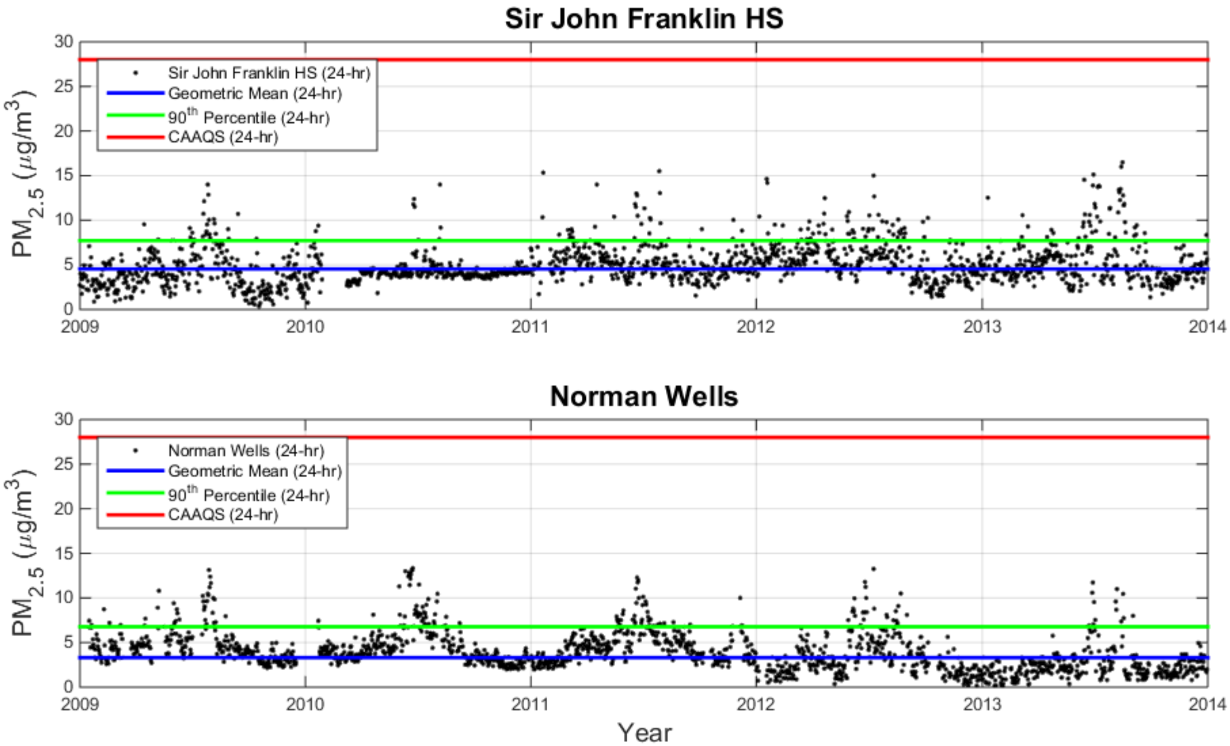

Figure 4-A-6: Time Series of $PM_{2.5}$ Concentrations at Sir John Franklin High School (top) and Norman Wells (bottom) Stations

4.A-3.3 Air Quality Summary

Publicly available Canadian Arctic air quality monitoring data were analyzed using statistics to estimate background concentrations of criteria air contaminants for the proposed Project. These background concentrations are needed as inputs to air quality models used to assess potential changes in air quality from the proposed Project. Background concentrations of particulate matter were 25 to 40% of the Canadian Ambient Air Quality Standards. Background concentrations for gases including carbon monoxide, nitrogen dioxide, and sulfur dioxide were less than 10% of the Canadian Ambient Air Quality Standards.

4.A-4 REFERENCES

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APPENDIX 4-B

Air Emissions Inventory

4.B-1 INTRODUCTION

This document provides detailed technical information regarding the methods used to estimate air emissions from the proposed Whale Tail Pit Project (the Project). The air emissions are used as input to the AERMOD air quality dispersion model to predict potential Project related effects on regional ambient air quality.

The air emission inventory includes the emissions from mining activities in the Whale Tail Pit and from vehicle traffic along the haul road from the Whale Tail Pit to the existing Meadowbank Mine. The primary sources of air emissions from Project operations include the following:

- in pit drilling and blasting;
- un-paved road dust from the pit;
- exhaust from off-road equipment operating in the pit;
- material handling;
- wind erosion from ore pad and Whale Tail Waste Rock Storage Facility (WRSF);
- power plant and camp heater;
- un-paved road dust from haul road; and
- exhaust from on-road vehicle travelling on the haul road.

The in pit unpaved road and the unpaved road inside the Project boundary will be watered twice a day in the unfrozen season (May – October) to mitigate the dust emission. A control efficiency of 70% was applied in the calculation of the unpaved road dust emission. This assessment assumes the haul road to transport ore from the Whale Tail Pit to Meadowbank Mill outside of the Project boundary is not mitigated.

4.B-2 IN PIT DRILLING, BLASTING, AND EXPLOSIVES COMBUSTION EMISSIONS

The following three subsections summarizes the methods used to estimate air emissions from drilling and blasting activities. Details used to estimate the emissions from drilling, blasting, and explosives use are as follows:

- drilling emissions factors are based on wet drilling operations;
- two blasts per day;
- implementation of a blasting plan that includes the following details:
    - blast hole diameter = 165 millimetre (mm);
    - drilled burden = 5.0 metre (m);
    - drilled spacing = 5.7 m;
    - explosives mass per hole = 215 kilogram (kg);
    - number of rows of holes = 5;

- number of holes per row = 10;
- holes per blast = 5 * 10 = 50;
- blasting area = Drilled burden x Drilled spacing x Number of holes = 5.0 x 5.7 x 50 = 1425 m^2; and
- explosives per blast = 215 kg/hole * 50 holes /1000 = 10.8 tonnes.

4.B-2.1 Drilling Emissions

The following Emission Factors were used to estimate the particulate matter (PM) emissions created from the drilling of explosive charge holes prior to blasting. The emission factors were taken from the Environment Canada NPRI toolbox (Environment Canada 2016).

- TSP Emission Factor (kg/hole) = *EF(TSP)* = 0.59 kg/hole
- PM_{10} Emission Factor (kg/hole) = $EF(PM_{10})$ = 0.31 kg/hole
- $PM_{2.5}$ Emission Factor (kg/hole) = $EF(PM_{2.5})$ = 0.31kg/hole

Portable internal combustion engine powered drills are used for drilling charge holes; however, these emissions are calculated separately in the off-road vehicle exhaust emission estimate. The hourly, daily, and annual emissions from drilling are summarized in Table 4-B-1.

Table 4-B-1: Particulate Matter Emissions from Drilling

Compounds	Emissions		
	Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
TSP	2.46	59.00	21.54
PM_{10}	1.29	31.00	11.32
$PM_{2.5}$	1.29	31.00	11.32

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-2.2 Emissions from Blasting

The following emissions factors (EF) were used to estimate PM emissions from the displacement (fracturing, loosening or shifting) of solid rock through the use of explosives (Environment Canada 2016). An estimate of emissions from the horizontal area displaced by blasting (A) is required:

TPM Emission Factor (kg/blast) = *EF(TPM)* = $0.00022\ (A)^{1.5}$

PM_{10} Emission Factor (kg/blast) = $EF(PM_{10})$ = $(0.00022\ (A)^{1.5}) \times 0.52$

$PM_{2.5}$ Emission Factor (kg/blast) = $EF(PM_{2.5})$ = $(0.00022\ (A)^{1.5}) \times 0.03$

Where,

A: horizontal area (m^2), with blasting depth ≤ 21 m.

EF: Emission factor for corresponding PM (kg/blast)

The same blasting plan details as outlined in Section 4.B-2.1 were used to estimate emissions from blasting. The hourly, daily, and annual emissions are summarized in Table 4.B-2.

Table 4-B-2: Particulate Matter Emissions from Blasting

Compounds	Emissions		
	Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
TSP	0.60	14.46	5.28
PM_{10}	0.31	7.52	2.74
$PM_{2.5}$	0.02	0.43	0.16

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-2.3 Emissions from Explosives Detonation

Table 13.3.1 of the US EPA document - AP 42, Fifth Edition, Volume I, Chapter 13.3: Explosives Detonation (US EPA 1980) provides emission factors according to the type of explosives and their uses. The emission factors for NO_x, CO, and SO_2 are available but no EFs for PM are listed. Particulate matter produced from the use of explosives will include primarily $PM_{2.5}$ material; however, these emissions will be small compared to total PM emissions from drilling and blasting (see previous Sections). Table 4-B-3 summaries the emission factors of CO, NO_x, SO_2 assuming the explosive used for the Project is an ammonium nitrate and fuel oil mixture (ANFO).

Table 4-B-3: Emissions from the Use of Explosives

Compounds	Emission Factor (kg/tonne)	Emissions		
		Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
CO	34	30.46	60.92	22.23
NO_x	8	7.17	14.33	5.23
SO_2	1	0.90	1.79	0.65

CO = carbon monoxide; NOx = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; kg/tonne = kilograms per tonne of explosives; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-3 MATERIAL HANDLING EMISSIONS

Material handling, such as loading ore and waste rock, into haul trucks will generate fugitive PM emissions. The PM emissions from this operation were estimated based on methods described in the US EPA document - AP 42, Fifth Edition, Volume I, Chapter 13.2.4 Aggregate Handling and Storage Piles (US EPA 2006a). The emission factor of material handling was calculated from the following equation:

$$E = k(0.0016)\frac{\left(\frac{U}{2.2}\right)^{1.3}}{\left(\frac{M}{2}\right)^{1.4}}$$

Where:

E = emission factor in kg per tonnes of material handled (kg/t);

k = particle size multiplier (k_{TSP} = 0.74; k_{PM10} = 0.35; $k_{PM2.5}$ = 0.053);

U = mean wind speed meters per second (m/s);

M = material moisture content (%).

The materials handled in pit include ore and waste rock. The ore tonnages from the Whale Tail Pit in maximum production years of 2020 and 2021 were used to estimate air emissions. The annual ore tonnages were 3,285,000 tonnes. The throughput of the ore from the open pit is 9,000 tonnes per day. The averaged strip ratio of the open pit mining is 6.25. Therefore the daily throughput of waste rock from the Whale Tail Pit is 56,250 tonnes. Material handling emissions are also generated from the ore pad and Whale Tail WRSF, which have material throughputs of 9,000 tonnes of ore and 56,250 tonnes of waste rock per day, respectively. The mean wind speed (U) and the ore moisture content (M) were assumed to be the same as those used in the Meadowbank Environmental Impact Statement (Cumberland 2005).

- mean wind speed (U) = 5.0 meters per second (m/s); and
- ore moisture content (M) = 5.0 percent (%).

The PM emissions from in pit material handling are listed in Table 4.B-4.

Table 4-B-4: Particulate Matter Emissions from In Pit Material Handling

Emission Source	Daily Emission rates (kg/day)		
	TSP	PM_{10}	$PM_{2.5}$
In pit material handling	2.59	1.23	0.18
Ore pad material handling	0.36	0.17	0.02
Waste Rock Storage Facility material handling	2.24	1.06	0.16

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; kg/day = kilograms per day.

4.B-4 IN PIT UN-PAVED ROAD DUST

The haul trucks travelling on the un-paved road within the Whale Tail Pit will generate fugitive road dust. These PM emissions were estimated using emission factors in the US EPA AP-42, Fifth Edition, Volume I, Chapter 13.2.2: Un-paved Roads (US EPA 2006b). The emission factors were calculated using the following equation.

$$E = \left[k\left(\frac{s}{12}\right)^{a}\left(\frac{W}{3}\right)^{b}\right] * 281.9$$

Where:

E = size specific emission factor in kilograms per vehicle kilometer travelled (kg/VKT);

k, a, b = empirical constants;

s = silt content (%); and

W = mean vehicle weight (tons).

The empirical constants are listed in Table 4-B-5.

Table 4-B-5: Empirical Constants for Un-paved Road Dust Emission Calculation

Constants	TSP	PM_{10}	$PM_{2.5}$
k (lb/VMT) :	4.9	1.5	0.15
a	0.7	0.9	0.9
b	0.45	0.45	0.45

VMT = vehicle miles travelled; TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter.

Table 4-B-6 summarizes equipment expected to operate within the Whale Tail Pit. This inventory is based on the current equipment inventory from Meadowbank Mine.

Table 4-B-6: In Pit Equipment

Vehicle Name	Quantity	Horse power (hp)	US EPA Emission Standard	Operating Hours Per Day	Operating Hours Per Year	% Time in Pit	Average Truck Weight (kg)
Excavator - Terex - RH120	2	1,400	Tier 3	20	7,300	1	175,000
Wheel Loader - Cat - 992G	2	880	Tier 3	20	7,300	1	94,927
Excavator - Cat - 390D L	1	1,080	Tier 3	20	7,300	1	86,190
Mining Truck - Caterpillar 777F	11	939	Tier 3	20	7,300	0.5	119,386
Prod. Drill - ATLAS-DM45	4	630	Tier 3	20	7,300	1	43,091
Motor Grader - Cat - 16M	3	297	Tier 3	20	7,300	1	26,959
Wheel Dozer - Cat - 834H	1	523	Tier 3	20	7,300	1	47,106
Track Dozer - Cat - D9T	4	464	Tier 3	20	7,300	1	47,900
Excavator - Cat - 345D	2	380	Tier 3	20	7,300	1	45,375
Water Truck - CAT - 773D	1	600	Tier 3	8	2,920	0.5	37,800

hp = horsepower; % = percent; kg = kilograms.

The following assumptions were made to calculate the production of in pit fugitive road dust:

- road silt content = 6.1%;
- daily watering of un-paved road will provide a control efficiency of 70%;
- natural mitigation of road dust was based on the days with precipitation > 0.2 mm in unfrozen season (Baker Lake meteorology station);
- a 90% natural mitigation efficiency was applied when there is snow cover on the ground; and
- one-way haul truck travel distance in pit = 1.5 km.

Road silt content (6.1%) is based on the average silt content of 11 assays of Esker material considered for use as haul road construction material for the Project (Englobe 2015). The estimated in pit road dust emissions are summarized in Table 4-B-7.

Table 4-B-7: In Pit Un-paved Road Dust Emissions

Compounds	Emissions		
	Hourly (kg/hour)	Daily (kg/day)	Annual (tonnes/year)
TSP	128	3,072	1,121
PM_{10}	34.2	822	300
$PM_{2.5}$	3.42	82.2	30.0

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; kg/hour = kilograms per hour; kg/day= kilograms per day; tonnes/year = metric tonnes per year.

4.B-5 IN PIT OFF-ROAD VEHICLES EXHAUST

The US EPA's NONROAD method was finalized in 2005 and provides the most current and representative method of calculating vehicle emissions (US EPA 2005). The NONROAD estimates emission rates for a single vehicle were based on the following equation:

$$\begin{aligned} Vehicle\ Emissions = \ & Vehicle\ Horsepower \times Steady\ State\ \ Emission\ Factor \times Gross\ Operating\ Hours \times \\ & Load\ \ Factor \times Transient\ \ Adjustment\ \ Factor \times Deterioration\ Factor \end{aligned}$$

The NONROAD method includes several key elements. First, it has developed emission factors for different vehicle types and ratings representing steady-state vehicle operation. Second, NONROAD includes a load factor, accounting for the fact that off-road vehicles cannot constantly operate at their maximum rated horsepower. Last, it incorporates the emissions profile for a mobile engine during transient operating conditions and takes into consideration the engine's deterioration over time.

The steady-state emission factors, transient adjustment factors, and deterioration factors from NONROAD are summarized in Table 4-B-8 through Table 4.B-10. The off-road mobile equipment exhaust emissions are summarized in Table 4.B-11.

Table 4-B-8: Steady-State Emission Factors for Off-road Diesel Engines

Category of Vehicle	Emission Factors (zero-hour, steady-state) (g/bhp-hr)		
	NO_X	CO	PM
Vehicles 300 to 600 bhp			
tier 1	6.015	1.306	0.201
tier 2	4.335	0.843	0.132
tier 3	2.500	0.843	0.150
tier 4 final	0.276	0.084	0.009
Vehicles 600 to 750 bhp			
tier 1	5.822	1.327	0.220
tier 2	4.100	1.327	0.132
tier 3	2.500	1.327	0.150
tier 4 final	0.276	0.133	0.009
Vehicles >750 bhp			
tier 1	6.153	0.764	0.193
tier 2	4.100	0.764	0.132
tier 3	4.100	0.764	0.132
tier 4 final	2.392	0.076	0.069[a]

Source: US EPA (2004).

[a] Tier 4 transitional emission factors that are more conservative than tier 4 final emission factors are used for PM emissions.

g/bhp-hr = grams per brake horsepower hour; - = No criteria available; PM = particulate matter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2).

Table 4-B-9: Transient Adjustment and Deterioration Factors for Off-road Diesel Engines

Category of Vehicle	NO_X	CO	PM
Transient adjustment factors			
tier 1	0.95	1.53	1.23
tier 2	0.95	1.53	1.23
tier 3	1.04	1.53	1.47
tier 4[a]	–	–	–
Deterioration factors[b]			
tier 1	1.024	1.101	1.473
tier 2	1.009	1.101	1.473
tier 3	1.008	1.151	1.473
tier 4	1.008	1.151	1.473

Source: US EPA (2004).

[a] There is no transient adjustment factor for tier 4 engines since transient emission control is expected to be an integral part of all tier 4 engines.

[b] Engines are assumed to be at the end of their median life to have conservative deterioration factors in calculations.

Table 4-B-10: Load Factors for Off-road Diesel Engines

Category of Vehicle	Load Factor[a]
Agricultural Tractor	0.78
Crawler Dozer	0.58
Rubber-tired Loader	0.48
Excavator	0.53
Backhoe Loader	0.21
Skid-steer Loader	0.23
Arc Welder	0.19
Generator set	0.43
Bore Drill Rig	0.43
Grader	0.59

Source: US EPA (2004).

[a] If an equipment specific load factor is not present in the above table, the crawler dozer load factor must be utilized.

Table 4-B-11: Off-road Mobile Equipment Exhaust Emissions

Off-Road Vehicle Exhaust	Hourly Emissions (kg/hr)	Daily Emissions (kg/day)	Annual Emissions (tonnes/year)
TSP	3.19	62.6	22.8
PM_{10}	3.19	62.6	22.8
$PM_{2.5}$	3.09	60.7	22.2
NOx	49.0	969	354
SO_2	0.06	1.26	0.46
CO	13.3	259	94.4

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; kg/hour = kilograms per hour; kg/day = kilogram per day; tonnes/year = metric tonnes per year.

4.B-6 WIND EROSION EMISSIONS FROM ORE PAD AND WASTE ROCK STORAGE FACILITY

The wind erosion dust emission from the ore pad and Whale Tail WRSF was calculated with the methods described in the US EPA document - AP 42, Fifth Edition, Volume I, Chapter 13.2.5 Industrial Wind Erosion (US EPA 2006c). The emission factor for wind-generated particulate emission from mixtures of erodible and nonerodible surface material subject to disturbance is expressed in units of grams per square metre (g/m^2) per year as follows:

$$Emission\ factor = k \sum_{i=1}^{N} P_i$$

Where:

k = particle size multiplier (k =1 for TSP; k = 0.5 for PM_{10}, and k = 0.075 for $PM_{2.5}$);

N = number of disturbances per year;

P_i = erosion potential corresponding to the observed (or probable) fastest mile of wind for the i^{th} period between disturbances, g/m^2.

The erosion potential function for a dry, exposed surface is:

$$P = 58\ (u^* - u_t^*)^2 + 25(u^* - u_t^*)$$

$$P = 0\ for\ u^* \leq u_t^*$$

Where:

u^* = friction velocity (m/s)

u_t^* = threshold friction velocity (m/s)

The following information and assumptions were used to calculate the wind erosion emission from the ore pad and Whale Tail WRSF:

- the threshold friction velocity (1.33 m/s) of both ore and waste were taken from the AP-42 document (US EPA 2006c, Table 13.2.5-2) for Scoria (roadbed material);
- the hourly friction velocity was calculated from the hourly wind speed derived from the Project AERMET data:
  - the hourly wind speed was converted into gust 3-second wind speed by a factor of 1.52 (Durst 1960);
  - the gust 3-second wind speed was converted into fastest mile wind speed by a factor of 1.2 (Simiu et al. 2003); and
  - the friction velocity was calculated from the fasted mile wind speed from the following equation:

$$u^* = 0.4\, u(z)/\ln(\frac{z}{z_0})$$

where:

u(z) = fastest mile wind speed at z level (z = 10m); and

z_0 = surface roughness length (m).

- snow mitigation was applied assuming there is no erosion emission potential when there is snow cover on the ground; the snow cover data from the Baker Lake climate normal data were used;
- the ore pad was assumed to be disturbed every hour;

- the Whale Tail WRSF was separated into active and inactive:
  - the active Whale Tail WRSF was assumed to be 18,000 m^2 while the rest of Whale Tail WRSF was assumed to be inactive;
  - the active Whale Tail WRSF was assumed to be disturbed every hour; and
  - the inactive Whale Tail WRSF was assumed to be disturbed once every year. The maximum hourly wind erosion emission factor was used for the active area.

The wind erosion dust emissions calculated for the ore pad and Whale Tail WRSF are listed in Table 4-B-12.

Table 4-B-12: Wind Erosion Emissions from Ore Pad and Whale Tail Waste Rock Storage Facility

Storage Pile	Area (m^2)	TSP ($g/m^2/s$)	PM_{10}, ($g/m^2/s$)	$PM_{2.5}$, ($g/m^2/s$)
Ore pad	79,564	2.0E-05	9.9E-06	1.5E-06
Whale Tail WRSF, active	18,000	2.0E-05	9.9E-06	1.5E-06
Whale Tail WRSF, inactive	1,075,000	4.1E-07	2.0E-07	3.1E-08
Total waste	**1,093,000**	**7.3E-07**	**3.6E-07**	**5.4E-08**

WRSF = waste rock storage facility; m^2 = square meters; $g/m^2/s$ = grams per square meter per second; TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter.

4.B-7 POWER PLANT AND CAMP HEATER

There will be four Caterpillar 3516 generators installed in the power plant to provide power for the mine site: two running and two on standby. The generators to be installed will be 1,825 kilowatt (kW) units, each expected to normally produce 1,551 kW of electricity with a power factor of 85%. The diesel fuel consumption was calculated with a diesel heating value of 19,300 British thermal units per pound (Btu/lb).

The emissions from the power plant were estimated from US EPA AP-42 Chapter 3.4 Large Stationary Diesel and All Stationary Dual-fuel Engines (US EPA 2006d). The emission factors and the emission rates are summarized in Table 4-B-13.

Table 4-B-13: Emissions Factors and Emission Rates of Generators

Contaminant	Emission Factor (g/HP-hr)	Daily Emission Rate (kg/day)
NO_x	10.9	1,102
CO	2.49	252
SO_2	0.06	5.57
TSP	0.32	32.1
PM_{10}	0.32	32.1
$PM_{2.5}$	0.31	31.2

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; g/hp-hr = gram per horse power per hour; kg/day = kilogram per day.

A 500 kW diesel-fired heater will be used to heat the camp at the Project. Fuel consumption was calculated assuming a consumption rate of 0.25 liters per kilowatt-hour (L/kWh). The emissions from the diesel-fired heater were calculated using the emission factors presented in US EPA AP-42 Chapter 1.3 Fuel oil combustion (US EPA

2006e). The emission factors for distillate oil fired boilers with a capacity of less than 100 million Btu/hr were used. The emission factors and the daily emission rates are listed in Table 4.B-14.

Table 4-B-14: Emissions Factors and Emission Rates of Camp Heater

Contaminant	Emission Factor (lb/10^3 gal)	Daily Emission Rate (kg/day)
NO_x	20.00	7.19
CO	5.00	1.80
SO_2	2.13	0.77
TSP	2.00	0.72
PM_{10}	1.00	0.36
$PM_{2.5}$	0.25	0.09

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; lb/10^3 gal = pound per 1000 gallon; kg/day = kilogram per day.

4.B-8 HAUL ROAD EMISSIONS

The proposed haul road links the Whale Tail Pit to the Meadowbank Mine and has a length of 63 km. The estimated number of days per year that there will be traffic on the road is 337 days. The anticipated range of daily vehicle traffic for each type of vehicle using the haul road is presented in Table 4-B-15 (SNC 2015). The higher end (the Upper 95%) of daily vehicle passages data was used when calculating the daily emissions from haul road to be conservative, while the average daily vehicle passages was used for calculating the annual emissions. Additional information concerning vehicle types using the haul road is summarized in Table 4.B-16.

Table 4-B-15: Daily Vehicle Traffic on the Haul Road

Category	Lower 5%	Average	Upper 95%
Long haul	64	154	173
Explosive	2	4	5
Fuel	1	2	4
Cargo	4	7	10
Pickup	12	20	26
Bus	0	2	4
Oversize	0	1	4
Maintenance	0	2	4

Table 4-B-16: Vehicle Information

Make	Model	Year	Weight Empty	Weight Loaded	Type
Cat	777F	2008	450,000 lbs	1,000,000 lbs	Tow haul
Western Star	4800SB	2012	66,000 lbs	92,048 lbs	Explosive truck
Blue Bird	VISION SL	2014	27,507 lbs	+ 54 passenger	Bus
Kenworth	T800	2013	40,000 lbs	126,000lbs	Fuel truck
Ford	F250	2013	10,000 lbs	+4 passengers +light equipment	Pickup
Kenworth	C500B	2006	128,000 lbs	172,000 lbs	Truck w/float
Western Star	6900XD	2015	188,100 lbs	573,100 lbs	Road haul truck

lbs = pounds.

Un-paved road dust emissions from the haul road were estimated using the emission factors in the US EPA AP-42 Chapter 13.2.2: Un-paved Roads (US EPA 2006b). The following assumptions were made in order to calculate the estimated road dust emissions from the haul road:

- silt content = 6.1% (Englobe 2015);
- natural mitigation of road dust was based on the days with precipitation > 0.2 mm (Baker lake meteorology station) in unfrozen season;
- for frozen season with snow cover, it is assumed a 90% of natural mitigation efficiency; and
- one-way trip haul truck travel distance = 63 km.

The overall road dust emission factor for the haul road is 5,213 grams per vehicle kilometre travelled (g/VKT). The total fleet travels 11,860 km/day. The daily un-paved road dust emissions are listed in Table 4-B-17.

Table 4-B-17: Daily Un-paved Road Dust Emissions

Particulate Matter	Emission factor (g/VKT)	Fleet distance (km)	Emission rates (kg/km)
TSP	5,213	11,860	990
PM_{10}	1,394		265
$PM_{2.5}$	139		26

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; g/VKT = grams per vehicle kilometer travelled; km = kilometer; kg/km = kilograms per kilometer.

The on-road vehicle exhaust emissions are estimated based on the traffic data presented in Table 4-B-15 and Table 4-B-16, and emission factors derived from the Mobile Source Emission Factor Model (MOBILE) software (US EPA 2002). The MOBILE program was developed by the US EPA to address the need for a consistent on-road vehicle emission estimation approach across jurisdictions.

A series of MOBILE models have been developed by the US EPA and adopted for use in Canada by Environment Canada. The MOBILE version 6.2C was used in the air quality assessment, where “C” denotes the vehicular and emissions profiles have been modified to incorporate Canadian regulations and traffic conditions.

The MOBILE6.2C outputs emission rates based on a multitude of vehicle specific inputs. The following information was entered:

- vehicle fleet age;
- fleet composition;
- vehicle speed; and
- climatic conditions, such as average air temperature.

The daily road dust and exhaust emission factors are listed in Table 4-B-18 and Table 4-B-19, respectively.

Table 4-B-18: Daily Haul Road Emission for the Unfrozen Season (June – October)

Vehicle Type	Maximum Daily Travel Distance, km	Exhaust Factors (kg/day)					
		TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Long-haul	9,613	1.4	1.4	1.2	44.8	0.1	12.1
Explosive	250	0.0	0.0	0.0	1.2	0.0	0.3
Fuel Truck	125	0.0	0.0	0.0	0.5	0.0	0.1
Cargo	437	0.1	0.1	0.1	2.0	0.0	0.5
Pickup	1,248	0.1	0.1	0.1	1.6	0.0	0.4
Bus	125	0.0	0.0	0.0	0.8	0.0	0.2
Oversize	62	0.0	0.0	0.0	0.3	0.0	0.1
Total Exhaust Emissions	**11,860**	**1.6**	**1.6**	**1.4**	**51.2**	**0.1**	**13.7**
Total Road Dust Emissions		**61824**	**16530**	**1,653**	**0.0**	**0.0**	**0.0**
Total Emissions		**61826**	**16532**	**1654**	**51.2**	**0.1**	**13.7**

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; km = kilometre; kg/day = kilogram per day.

Table 4-B-19: Daily Haul Road Emissions for the Frozen Season (November – May)

Vehicle Type	Maximum Daily Travel Distance, km	Exhaust Factors (kg/day)					
		TSP	PM_{10}	$PM_{2.5}$	NO_X	SO_2	CO
Long-haul	9,613	1.5	1.5	1.2	48.3	0.1	12.9
Explosive	250	0.0	0.0	0.0	1.3	0.0	0.3
Fuel Truck	125	0.0	0.0	0.0	0.5	0.0	0.1
Cargo	437	0.1	0.1	0.1	2.2	0.0	0.6
Pickup	1,248	0.1	0.1	0.1	1.7	0.0	0.4
Bus	125	0.0	0.0	0.0	0.8	0.0	0.2
Oversize	62	0.0	0.0	0.0	0.3	0.0	0.1
Total Exhaust Emissions	**11,860**	**1.7**	**1.7**	**1.4**	**55.1**	**0.1**	**14.6**
Total Road Dust Emissions		**6182**	**1653**	**165.3**	**0.0**	**0.0**	**0.0**
Total emissions		**6184**	**1655**	**166.7**	**55.1**	**0.1**	**14.6**

TSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; CO = carbon monoxide; NO_x = oxides of nitrogen, nitrogen oxide (NO) and nitrogen dioxide (NO_2); SO_2 = sulfur dioxide; km = kilometre; kg/day = kilogram per day.

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APPENDIX 4-C

Air Quality Modelling Technical Summary

4.C-1 INTRODUCTION

This document provides detailed technical information regarding the methods and results used to assess Project-related effects to air quality from the Whale Tail Pit and Haul Road Project (the Project). Specifically, information on the air quality dispersion model, meteorology, terrain, the method for converting oxides of nitrogen (NO_x) to nitrogen dioxide (NO_2), particulate matter and gas deposition, and the modelling results is provided. The air quality modelling was conducted separately for the Whale Tail Pit and the haul road to the Meadowbank Mine. The emission sources associated with the mine site include emissions from the open pit (drilling and blasting, material handling, road dust), wind erosion from the ore pad and waste rock storage facility, road dust from transportation of waste-rock and ore, the power plant, and camp's diesel-fired heater. The haul road was modelled as a representative 1 kilometre (km) section of the road between the Whale Tail Pit and the Meadowbank Mine. The haul road section selected for modelling is aligned along a southwest to northeast direction, which is perpendicular to the dominant wind direction in the region.

4.C-2 AIR QUALITY MODELLING METHODS

The air quality modelling was completed using the AERMOD model, which is a plume dispersion model developed by the United States Environmental Protection Agency (US EPA 2004). The AERMOD model was selected for the air quality assessment because it has been accepted in many jurisdictions in Canada and the United States. In addition, this dispersion model is capable of local scale modelling of less than 50 km.

The air quality assessment is focused on predicting the change in air quality due to Project operations. Potential effects of the Project on air quality during the construction and decommissioning phases are not assessed as emissions during these periods are predicted to be well below emissions during the operations phase. Project air emissions for the year 2020 were selected as the basis for the air quality modelling. Year 2020 is predicted to have the highest ore production and therefore provides a conservative estimate of emissions for all years, including construction and operations phases of the Project. The air quality assessment for the Project includes the following steps:

1) establishing the existing background concentrations of criteria air contaminants in the region (see Appendix 4-A);

2) creating an air emissions inventory for the Whale Tail Pit and the haul road to the Meadowbank Mine for year 2020 (see Appendix 4-B);

3) using the AERMOD model to predict ambient concentrations of criteria air contaminants and dust deposition as a result of the Project; and

4) comparing the ambient air quality and dust deposition predictions to existing federal, provincial and territorial air quality standards and/or guidelines.

The criteria air contaminants (CACs) considered in this assessment include the following:

- carbon monoxide (CO);
- nitrogen dioxide (NO_2);
- sulfur dioxide (SO_2);

- particulate matter, including:
  - total suspended particulate (TSP);
  - particulate matter with aerodynamic diameters less than 10 micrometers (µm) (PM_{10}); and
  - particulate matter with aerodynamic diameters less than 2.5 µm ($PM_{2.5}$).

4.C-2.1 Existing Air Quality Concentrations

Publicly available and Government of Nunavut Arctic air quality monitoring data were evaluated to estimate background concentrations of criteria air contaminants in the Kivalliq region of Nunavut (see Appendix 4-A). For compounds with 1-hour, 8-hour, and 24-hour averaged periods, the 90th percentiles of historic air quality observations were used as the background regional concentrations for CAC's. For the annual averaged period, the 50th percentile values were used (Table-C-1). Because there are no existing TSP and PM_{10} data, TSP and PM_{10} background concentrations were assumed to be the same as the $PM_{2.5}$ background concentrations.

Table 4-C-1: Background Air Quality Concentrations

Compound	Averaging Period	Percentile	Background Concentration	
			µg/m^3	ppbv
CO	1-hr	90th	389	**0.3**
	8-hr	90th	385	**0.3**
NO_2	1-hr	90th	12.6	5.0
	24-hr	90th	11.4	4.5
	Annual	50th	5.0	1.9
SO_2	1-hr	90th	2.7	1.0
	24-hr	90th	2.7	1.0
	Annual	50th	0.3	0.1
$PM_{2.5}$	24-hr	90th	6.6	—
	Annual	50th	3.6	—

4.C-2.2 Ambient Air Quality Standards

A range of effects can result from air emissions introduced into the atmosphere by mining activities. The emissions can have direct and indirect effects on humans, animals, vegetation, soil, and water. For these reasons, federal and provincial environmental regulatory agencies have established ambient air quality standards and/or guidelines.

The Environmental Guideline for Ambient Air Quality was revised by the Department of Environment's Environmental Protection Division and approved by the Minister of Environment, Government of Nunavut in 2011 (Government of Nunavut 2011). The guideline established ambient air quality guidelines for criteria air contaminants including: fine particulate matter, total suspended particulate, nitrogen dioxide, sulfur dioxide and ground level ozone. Guidelines adopted by the Government of Nunavut are based on comparable standards established by the Federal Government and standards and/or guidelines in other Provinces and Territories. For the criteria air contaminants (CACs) that are not included in the Guideline, the Federal ambient air quality criteria or ambient air quality standards from other Provinces and Territories were adopted (Table 4.C-2).

Table 4-C-2: Applicable Ambient Air Quality Criteria

Parameter	Nunavut Ambient Air Quality Standards[a]		Other Ambient Air Quality Standards or Guideline	
	µg/m³	ppbv	µg/m³	ppbv
SO_2				
1-hour	450	172	—[b]	—
24-hour	150	48	—	—
Annual	30	8	—	—
NO_2				
1-hour	400	159	—	—
24-hour	200	106	—	—
Annual	60	24	—	—
CO				
1-hour	—	—	15,000[c]	13000
8-hour	—	—	6,000[c]	5000
TSP				
24-hour	120	—	—	—
Annual	60	—	—	—
PM_{10}				
24-hour	—	—	50[d]	—
$PM_{2.5}$				
24-hour	30	—	28[e] 27[f]	—
Annual	—	—	10[g], 8.8[h]	—
Dustfall mg/cm²/30-day				
1-month	—	—	0.51 to 1.58[d]	—
Annual	-	-	0.46[d]	

[a] Environmental Guideline for Ambient Air Quality (Government of Nunavut 2011).

[b] "—" No criteria are available.

[c] Alberta Ambient Air Quality Objectives and Guidelines Summary (Government of Alberta 2013)

[d] Range for AB, BC and ON nuisance guidelines (Alberta Environment 2013; B.C. Ministry of Environment 2016; Ontario Ministry of the Environment 2012)

[e] 2015 achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years (CCME 2013).

[f] 2020 achievement is based on the 98th percentile ambient measurement annually, averaged over 3 consecutive years (CCME 2013).

[g] 2015 achievement is based on 3-year average of the annual average concentrations (CCME 2013).

[h] 2020 achievement is based on 3-year average of the annual average concentrations (CCME 2013).

µg/m³: microgram per cubic metre

4.C-2.3 Meteorological Data

The use of the AERMOD model requires that an AERMET data set be created to simulate the meteorology in the region of the Project. This meteorology dictates the transport and dispersion of atmospheric emissions from the Project, as well as the resulting ground-level concentrations of CACs. The AERMET dataset was constructed using 2005 to 2009 hourly surface observations from the Environment Canada Baker Lake station, and upper air data from the Baker Lake station from the National Oceanic & Atmospheric Administration/Earth System Research Laboratory (NOAA/ESRL) Radiosonde Database.

Albedo, Bowen ratio, and surface roughness are AERMET preprocessor input parameters that are site-specific and dependent on the land use of the region around the facility to be modelled (e.g., urban area, farmland, woodlot, forest, swamp). The albedo is the fraction of total incident radiation reflected by the surface back to space without absorption. Typical values range from 0.1 for heavily forested areas (little solar radiation is reflected) to 0.9 for fresh snow (most radiation is reflected back to space). The daytime Bowen Ratio is the ratio of the sensible heat flux (transfer of heat upwards from the ground due to surface heating) to the latent heat flux (energy loss at the ground and gain aloft, due to evaporation and condensation of water). The surface roughness length is related to the height of obstacles that interfere with the wind flow. In general, trees and buildings have a high surface roughness, while sand and water have a low surface roughness. The AERMET component allows these surface parameters to be defined in all directions around the site being modelled. The surface parameters used in AERMET are listed in Table 4-C-3. The values of the surface parameters were based on a mixture of four land types (Swamp: 10%; Water: 25%; Grassland: 30%; Desert shrubland:35%) with values of each land type given in the Alberta air quality modelling guideline (Government of Alberta 2009).

Appendix 4-A includes comparisons of AERMET and baseline meteorology for air temperature, wind speed and direction, and precipitation. The following subsections document mixing heights and atmospheric stability classes, which are additional meteorological inputs required by the AERMOD model.

Table 4-C-3: Surface Parameters Used in AERMET

Month	Albedo	Bowen Ratio	Roughness Length
January	0.418	3.075	0.058
February	0.418	3.075	0.058
March	0.201	1.205	0.140
April	0.201	1.205	0.140
May	0.201	1.205	0.140
June	0.191	1.675	0.155
July	0.191	1.675	0.155
August	0.191	1.675	0.155
September	0.209	2.435	0.128
October	0.209	2.435	0.128
November	0.209	2.435	0.128
December	0.418	3.075	0.058

4.C-2.3.1 Mixing Height

Mixing height or boundary layer depth is the depth of the surface layer in which the majority of air dispersion will occur. The depth of this well-mixed layer is a function of surface (convective) heating and wind (mechanical) turbulence. Low boundary layer depths provide little vertical room for dispersion and can result in elevated concentrations at ground level. Convective and mechanical boundary layer depths were determined by AERMET from surface and upper level temperatures and winds, respectively.

Figure 4-C-1 provides a summary of the convective and mechanical boundary layer depths calculated by AERMET. Convective boundary layer depths were calculated only for daytime hours that have convective meteorological conditions (i.e., 31.7% of the time), while mechanical boundary layer depths were calculated for every hour, except for hours with missing meteorological data. AERMOD uses the mechanical boundary layer depth in the absence of a convective boundary layer depth.

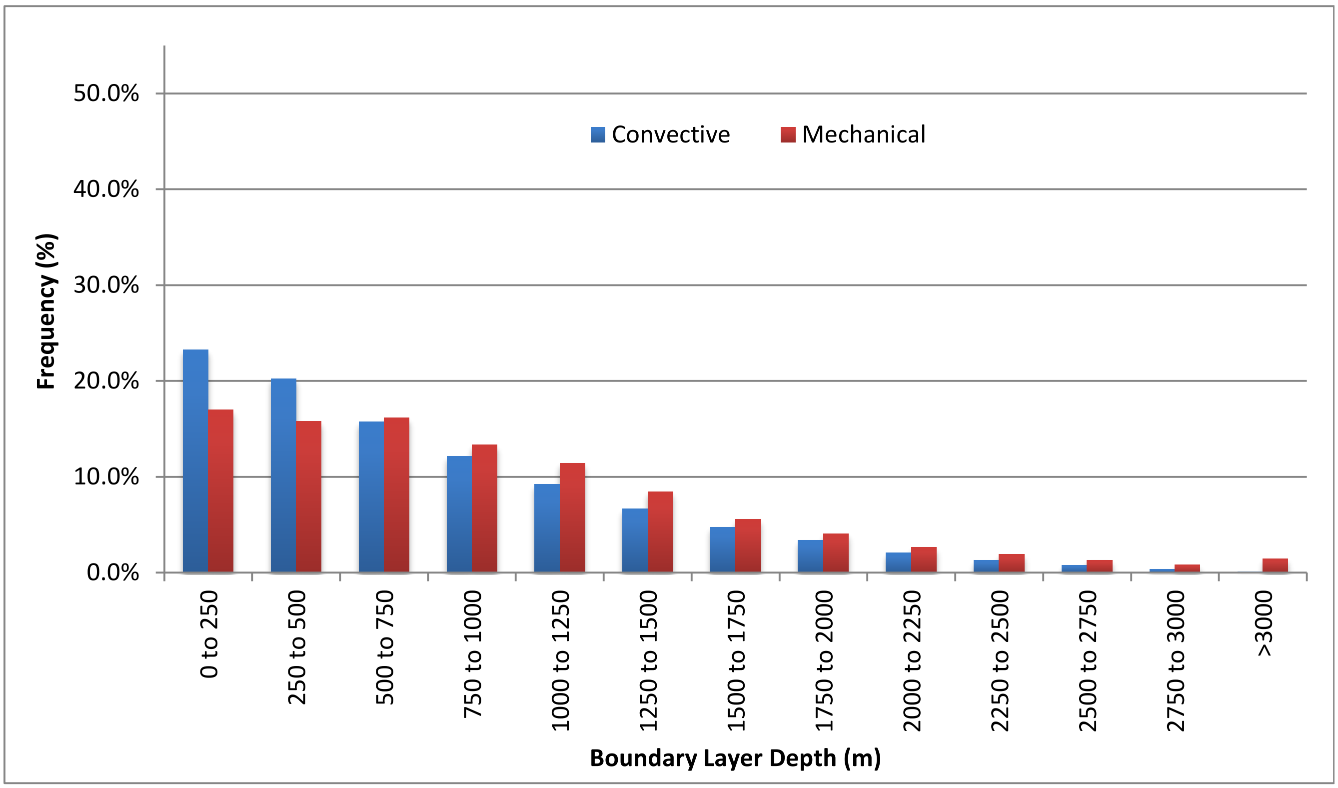


Figure 4-C-1: AERMET Derived Mixing Heights

4.C-2.3.2 Stability Class

Atmospheric stability can be viewed as a measure of the atmosphere's capability to disperse air pollutants. The amount of turbulence in the atmosphere plays an important role in the dilution of a plume as it is transported by the wind. Turbulence can be generated by either thermal or mechanical processes. Surface heating or cooling by radiation contributes to the generation or suppression of thermal turbulence, while high wind speeds contribute to the generation of mechanical turbulence.

The Pasquill-Gifford stability classification scheme is one classification of the atmosphere. The classification ranges from Unstable (Stability Classes A, B, and C) to Neutral (Stability Class D) to Stable (Stability Classes E and F). Unstable conditions are primarily associated with daytime heating conditions, which result in enhanced turbulence levels (enhanced dispersion). Stable conditions are associated primarily with nighttime cooling conditions, which result in suppressed turbulence levels (more limited dispersion). Neutral conditions are primarily associated with higher wind speeds or overcast conditions.

The stability conditions predicted for the Project site are presented in Figure 4-C-3 and summarized as follows:

- Unstable (A, B and C) conditions are predicted to occur 12.9% of the time.
- Neutral (D) conditions are predicted to occur 64.5% of the time.
- Stable (E and F) conditions are predicted to occur 22.5% of the time.

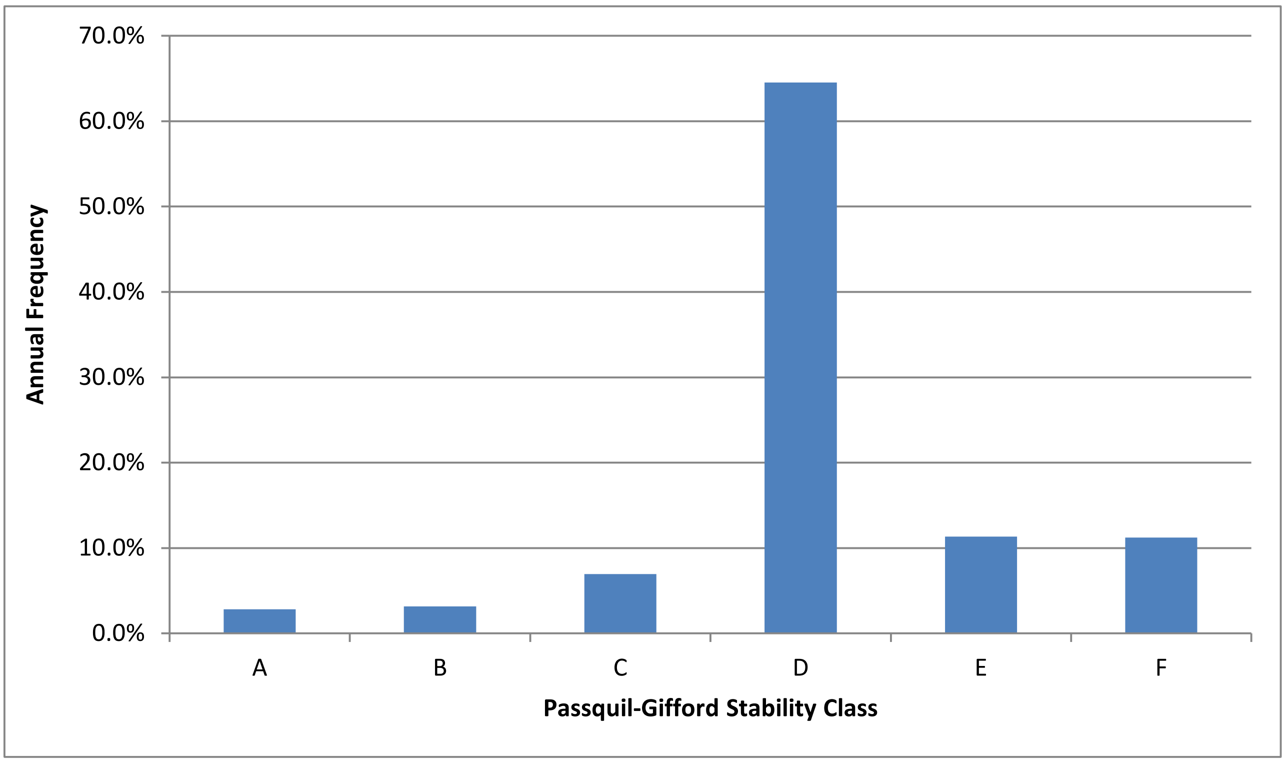
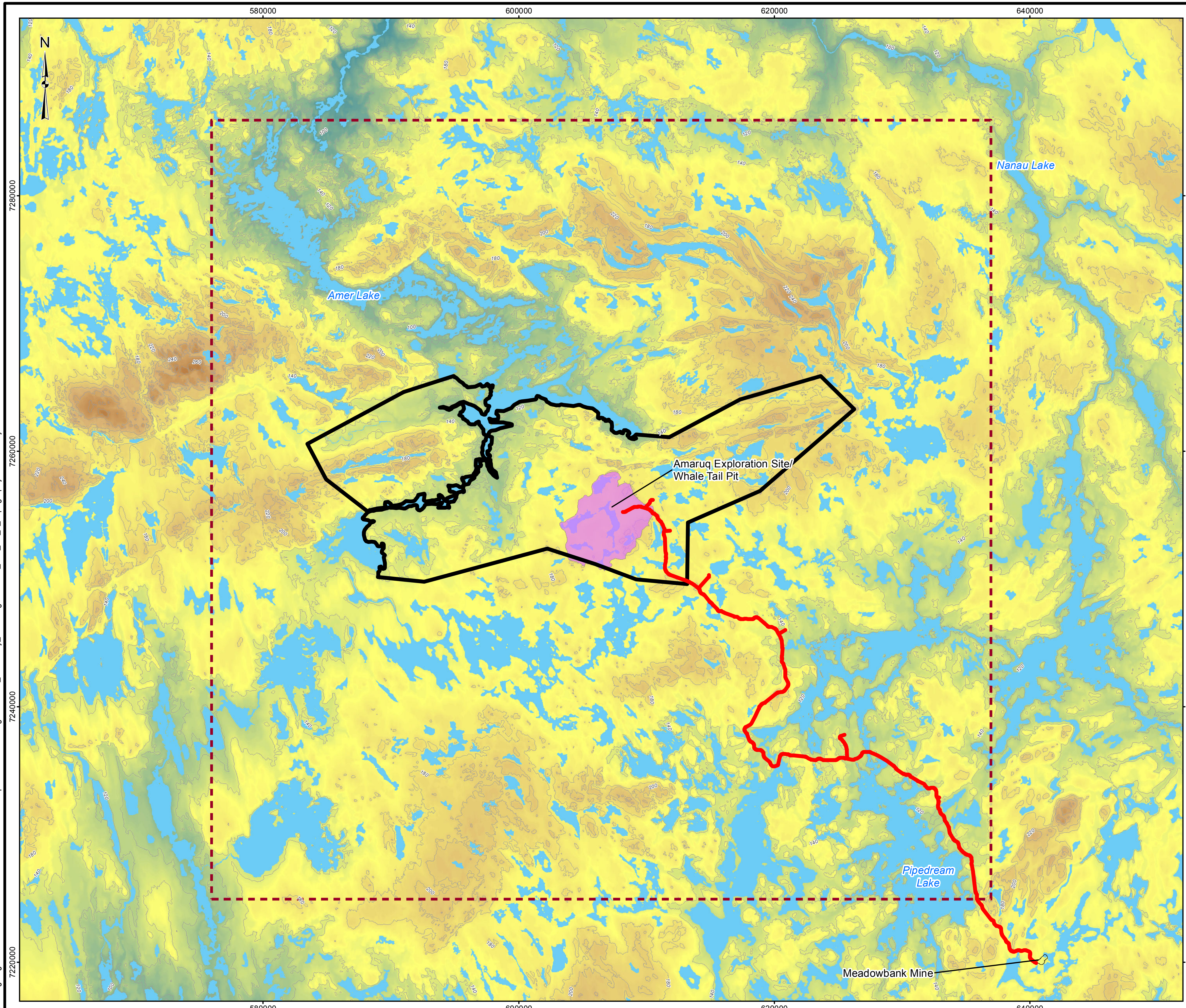


Figure 4-C-2: AERMET Derived Stability Classes

4.C-3 TERRAIN DATA

The terrain information required by the AERMOD dispersion model is generated by the AERMAP pre-processor. An AERMAP file was developed based on 1:250,000 Digital Elevation Model (DEM) data for the Project study area obtained from Geobase (Geobase 2015). The terrain in the effects study area is relatively flat with elevations ranging from approximately 315 to 544 metres above sea level (masl). The topography in the effects study area is shown in Figure 4-C-3.



\\golder.gds\gal\Saskatoon\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_3_Topography within Study Area.mxd

LEGEND

- CONTOUR (20m INTERVAL)
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- PROJECT DISTURBANCE AREA
- WATERBODY

ELEVATION (MASL)
361
282
203
124
45

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE, WATERBODY AND TOPOGRAPHIC DATA OBTAINED FROM CANVEC

6 0 6
KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

TOPOGRAPHY WITHIN THE STUDY AREA

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11	FIGURE 4-C-3	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

4.C-4 NO_X TO NO_2 CONVERSION

The oxides of nitrogen (NO_x) emissions from the Project are a mixture of nitrogen oxide (NO) and nitrogen dioxide (NO_2). However, NO is an unstable molecule and reacts quickly in the atmosphere to form NO_2. Since ambient air quality criteria are based on NO_2 concentrations, estimating the fraction of NO that has transformed into NO_2 is necessary. The AERMOD model's Ozone Limiting Method (OLM) was used to convert NO_x to NO_2. Background monthly ozone (O_3) concentrations are needed as input to the OLM calculations. Monthly average O_3 concentrations were calculated from National Air Pollution Station (NAPS) data for the Kivalliq region of Nunavut (see also Section 4.A-3.2 of Appendix 4-A). The background monthly O_3 concentrations used in the model are summarized in Table 4-C-4.

Table 4-C-4: Background Monthly Ozone Concentrations

Month	O_3 (ppbv)
January	24.0
February	25.5
March	25.5
April	30.6
May	30.4
June	25.7
July	20.0
August	17.7
September	17.3
October	19.1
November	22.7
December	22.8

4.C-5 PARTICULATE MATTER DEPOSITION

The AERMOD model includes two methods for predicting dry and/or wet deposition of particulate matter emissions. Method 1 is used when the particle size distribution is known or when a significant fraction (greater than about 10%) of the total particulate mass has an aerodynamic diameter of 10 micrometers (µm) or larger. Method 2 is used when the particle size distribution is not well known and when a small fraction (less than 10% of the mass) has a diameter of 10 µm or larger (US EPA, 2004). Method 2 was used in this assessment to model the deposition of TSP, PM_{10}, $PM_{2.5}$. The mass-mean aerodynamic particle diameters assumed for TSP, PM_{10}, and $PM_{2.5}$ in this assessment are: 5 µm, 2.5 µm, and 1.25 µm, respectively. For TSP and PM_{10}, the fractions of particles with size less than 2.5 µm were calculated by dividing the $PM_{2.5}$ emission rates by the TSP and PM_{10} emission rates.

4.C-6 GAS DEPOSITION

The gas deposition algorithms incorporated into AERMOD are based on the draft Argonne National Laboratory (ANL) report (Wesely et al. 2002). The general gas deposition parameters specified for SO_2 and NO_x are as follows:

- pollutant reactivity factor: 0.1;
- fraction of maximum green LAI (Autumn): 0.5; and
- fraction of Maximum green LAI (Transition Spring): 0.25.

The gas deposition algorithms of AERMOD include gas deposition resistance terms based on seasons and land use type (US EPA, 2004). Months of the year were separated into seasonal categories based on the Baker Lake climate normal data. The separation of months into seasons are as follows:

- Midsummer: July and August;
- Late Autumn: September and October;
- Winter: November, December, January, February, March, April, and May; and
- Transitional Spring: June.

The land use category of the region was classified as '8 – Barren land, mostly desert'. This determination is consistent with the Northern Arctic ecozone of Canada being classified as a 'Polar Desert' (see Section 4.A-2 of Appendix 4-A). Specific gas deposition parameters for SO_2 and NO_x are listed in Table 4-C-5 (Carbonell et al. 2010).

Table 4-C-5: AERMOD Gas Deposition Parameters for SO_2 and NO_x

Parameters	SO_2	NO_x
Diffusivity in air, cm^2/s	0.1509	0.1656
Diffusivity in water, cm^2/s	$1.83x10^{-5}$	$1.4x10^{-5}$
Cuticular resistance, s/cm	80	200
Henry's Law constant (Pa-m^3/mol)	72.37	$84.43x10^3$

SO_2 = sulfur dioxide; NO_x = oxides of nitrogen; cm^2/s = centimeters squared per second; s/cm = seconds per centimeter; Pa-m^3/mol = Pascal meters cubed per mol

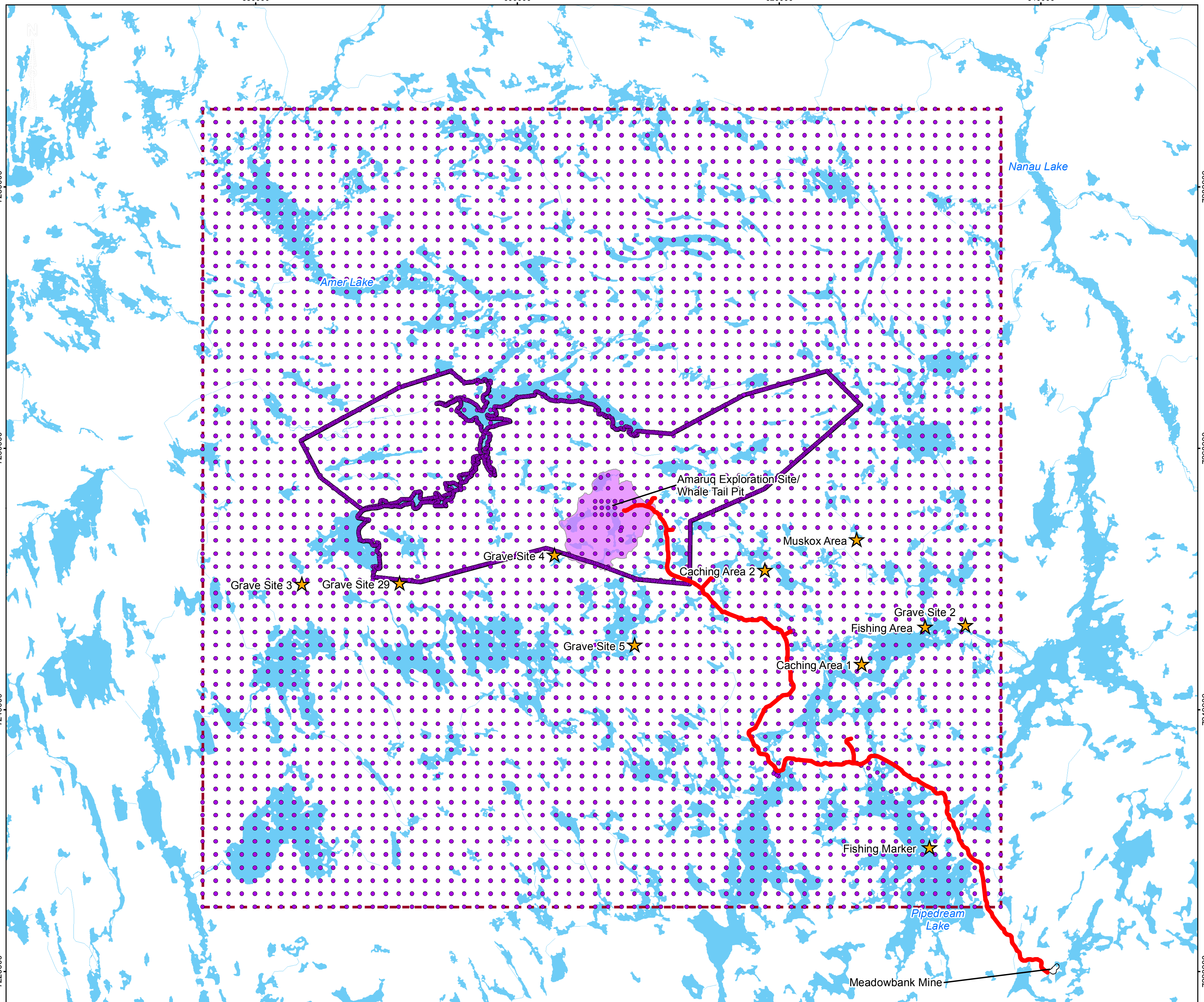
4.C-7 AIR QUALITY MODELLING FOR THE WHALE TAIL OPEN PIT

4.C-7.1 Study Area and Air Quality Receptors

A 60 km x 60 km study area centered at the Whale Tail Pit was created to assess the effects of the Project on air quality. Receptors with 100 m spacing were placed along the Project boundary and a receptor grid with 1000 m spacing was used in the remainder of the domain. The boundary of the property owned by Agnico Eagle was used as the Project boundary where model-predicted concentrations of CACs are compared to the applicable ambient air quality guidelines or standards. Ground-level concentrations are also modelled at selected other locations (i.e., receptors) in the air quality study area. These discrete potential receptors include sites of historical and cultural significance to local Inuit including grave sites and locations representing traditional fishing and food caching areas located outside of the Project boundary. These receptors were identified based on Inuit Qaujimajatuqangit (IQ) workshops. These additional discrete receptors are listed in the Table 4-C-6 and plotted along with the other receptors in Figure 4-C-4.

Table 4-C-6: Selected Discrete Potential Receptors

Name	UTM Easting, m	UTM Northing, m
Grave site 2	634234.21	7246485.51
Grave site 3	583533.29	7249634.93
Grave site 4	602839.54	7251874.51
Grave site 5	608952.28	7244984.88
Grave site 29	590991.49	7249714.39
Fishing marker	631472.21	7229489.38
Muskox area	625924.90	7253042.95
Fishing area	631153.61	7246367.03
Caching area 1	626295.73	7243523.39
Caching area 2	618910.00	7250697.00



LEGEND

- MODEL GRID RECEPTORS
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY
- DISTURBANCE AREA

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

6 0 6
KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

STUDY AREA, GRID RECEPTORS AND SELECTED DISCRETE RECEPTORS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-13		
CHECK	CMc	2016-05-13	FIGURE 4-C-4	
REVIEW	CM	2016-05-13		

G:\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_4_Study Area, Grid Receptors and Discreet receptors.mxd

4.C-7.2 Emission Sources Modelled for the Whale Tail Open Pit

The primary sources of air emissions from Project operations include the following:

- Whale Tail Pit, including:
  - in pit drilling and blasting;
  - in pit material handling;
  - un-paved road dust from the pit; and
  - exhaust from off-road equipment operating in the pit.
- wind erosion from ore pad and waste storage pile;
- power plant and camp heater; and
- un-paved road dust and vehicle exhaust from the section of haul road within the Project boundary;

Detailed methods associated with the Project's air emissions inventory are summarized in Appendix 4-B. The emission rates of the primary sources associated with the operation of the Whale Tail Pit are summarized in Table 4-C-7.

Snow cover and frozen ground during winter months provides natural mitigation of windblown fugitive dust and fugitive road dust from un-paved roads. Therefore, monthly variable emission rates for the Whale Tail Pit, haul road, and the road from Whale Tail Pit to the waste storage pile were used in the air quality model. The months classified as unfrozen season are June to October; months classified as the frozen season are November to May.

Table 4-C-7: Emission Rates Associated with Operation of the Whale Tail Pit

Source ID	Total Emission Rate in Unfrozen Season, g/s						Total Emission Rate in Frozen Season, g/s					
	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	TSP	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
Hal_ROAD_IN	33.04	8.84	0.89	0.09	0.00	0.02	3.31	0.89	0.09	0.10	0.00	0.03
WHLPIT	37.36	10.84	1.88	15.60	0.27	12.15	5.36	2.28	1.03	15.60	0.27	12.15
ORE_PAD	2.04	1.04	0.23	1.30	0.00	0.33	2.04	1.04	0.23	1.30	0.00	0.33
ROAD2W	12.42	3.57	0.66	6.11	0.01	1.40	1.55	0.67	0.36	6.11	0.01	1.40
WASTE_PAD	1.42	0.69	0.10	0.00	0.00	0.00	1.42	0.69	0.10	0.00	0.00	0.00
POWERP1	0.19	0.19	0.18	6.38	0.03	1.46	0.19	0.19	0.18	6.38	0.03	1.46
POWERP2	0.19	0.19	0.18	6.38	0.03	1.46	0.19	0.19	0.18	6.38	0.03	1.46
Heater	0.01	0.00	0.00	0.08	0.01	0.02	0.01	0.00	0.00	0.08	0.01	0.02

g/s = grams per secondTSP = total suspended particulate; PM_{10} = particulate matter smaller than 10 micrometers in aerodynamic diameter; $PM_{2.5}$ = particulate matter smaller than 2.5 micrometers in aerodynamic diameter; NO_x = oxides of nitrogen; SO_2 = sulfur dioxide; CO = carbon monoxide

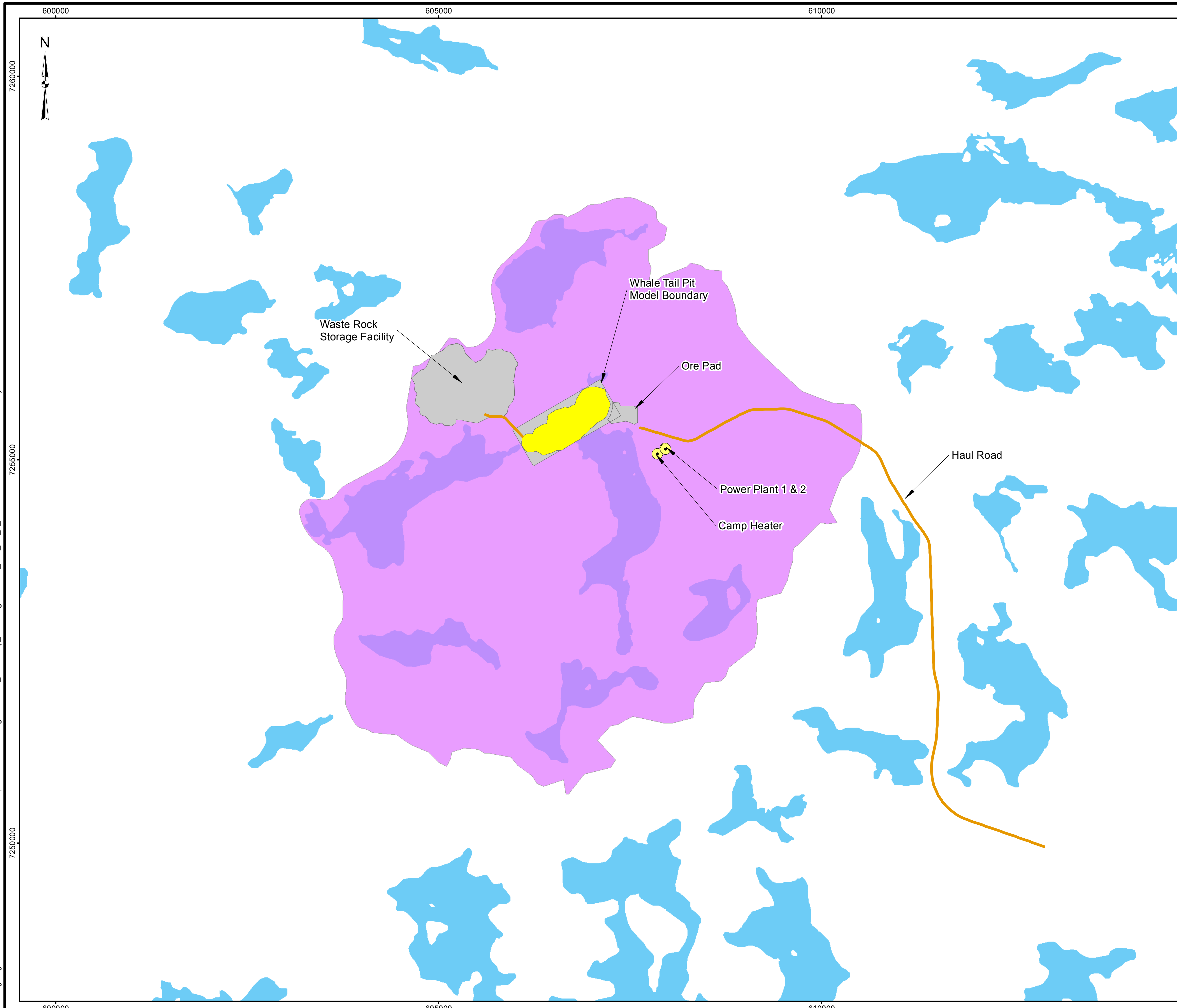
Figure 4-C-5 illustrates the locations of the emission sources associated with the operation of the Whale Tail Pit. Within the AERMOD model, these emissions are modelled as “open pit”. The depth of the open pit in 2020 is planned at 50 m. The total volume of the open pit is 25,235,546 m^3. As AERMOD can only model a rectangular open pit, the Whale Tail Pit was modelled as a rectangle (1320m x 540m). The model pit’s rectangle was then rotated 30 degrees to enclose and better represent the actual Whale Tail Pit. By conserving the overall volume of the pit, the effective depth of the modelled pit is 35.4 m. Since the actual pit will be approximately 50 m, not 35.4 m, emissions from the Whale Tail open pit are modelled relatively conservatively (i.e., less emissions are expected to leave the pit than those predicted in the assessment)

The haul road inside the Project boundary and the haul road from the pit to waste storage pile were modelled as a series of volume sources. The volume sources parameters were calculated from the vehicle height (5.1 m) and road width (9.5 m) (US EPA 2012). The volume source parameters are as follows:

- emissions release height: 4.33 m;
- initial vertical dimension: 4.03 m; and
- initial lateral dimension: 14.39 m and 14.09 m for haul road and road from the pit to waste storage pile, respectively.

The ore pad and waste storage piles were modelled as area polygon sources. It was assumed that the emissions occur at the ground level. The power plant and camp heater emissions were modelled as point sources. The stack parameters for these sources are as follows:

- Release height: 30.5 m;
- Gas exit temperature: 600 K;
- Stack inside diameter: 1.2 m; and
- Gas exit velocity: 17.3 m/s.



LEGEND

- EMISSION POINT SOURCE
- EMISSION LINE SOURCE (MODEL)
- WHALE TAIL PIT
- EMISSION AREA SOURCE (MODEL)
- PROJECT DISTURBANCE AREA
- WATERBODY

REFERENCE

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. INSET MAP DATA OBTAINED FROM ESRI

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

1 0 1
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

EMISSION SOURCES FOR THE AIR QUALITY MODELING OF WHALE TAIL PIT

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SBM	2016-05-11	
CHECK	CMc	2016-05-11	
REVIEW	CM	2016-05-11	

FIGURE 4-C-5

\\golder.gds\gal\Saskatoon\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_5_Emission Sources for the Air Quality Model.mxd

4.C-7.3 Air Quality Model Results for the Whale Tail Open Pit

To aid in interpretation of the air quality dispersion modelling results, the results are presented in tabular format. The summary tables include model predictions, model predictions plus background concentrations of the relevant CAC's, and the ambient air quality criteria for the CAC. In addition, isopleth maps showing the 1-hour, 8-hour, 24-hour, or annual maximum predictions are included in the assessment. For clarity, the isopleth maps for most compounds present contour levels for 100%, 50%, and 25% of the applicable air quality guideline or standard. For those compounds that have low model predicted concentrations compared to air quality standards, contour levels that best represent the spatial patterns of the model results were used.

The following sections present the predicted CO, NO_2, SO_2, $PM_{2.5}$, PM_{10}, and TSP concentrations from the AERMOD model. For each compound, the peak model predicted concentration refers to the highest 1-hour, 8-hour, and 24-hour concentration over the 5-year simulation. The maximum model predicted concentration refers to the following:

- For 1-hour predictions, the maximum concentrations represent the maximum 9th highest concentration over the 5-year simulation.
- For 8-hour predictions, the maximum concentrations represent the maximum 5th highest concentration over the 5-year simulation.
- For the 24-hour (daily) predictions of $PM_{2.5}$, the maximum concentrations represent the maximum 98th percentile of model predicted concentration over the 5-year simulation.
- For the 24-hour (daily) predictions of all other pollutants, the maximum concentrations represent the maximum 2nd highest concentration over 5-year simulation; and
- For averaging times longer than 24-hours, no modelled concentrations are eliminated from the maximum predicted value. The maximum concentrations represent the maximum 1st highest concentration over the 5-year simulation.

The maximum modelled predicted concentrations outside the Project boundary for each averaging period were then compared with the applicable ambient air standards outlined in Table 4.C-2. This means of expressing the maximum predicted concentrations is consistent with reporting requirements from other jurisdictions within Canada, for example the Alberta and Saskatchewan Air Quality Modelling Guidelines.

4.C-7.3.1 Carbon Monoxide (CO) Predictions

The model predicted 1-hour and 8-hour CO concentrations are summarized in Table 4-C-8 and shown in Figures 4-C-6 and 4-C-7. The peak and maximum CO concentrations outside the Project boundary are all lower than the ambient air standards. The maximum 1-hour and 8-hour CO concentrations occur at the southern Project boundary. Both the 1-hour and 8-hour maximum concentrations are less than 10% of the ambient standards. The 1-hour and 8-hour CO concentrations at the selected receptors (Table 4-C-9) are all lower than the respective air quality standards.

Table 4-C-8: Summary Table of Model Predicted CO Concentrations Outside Project Boundary

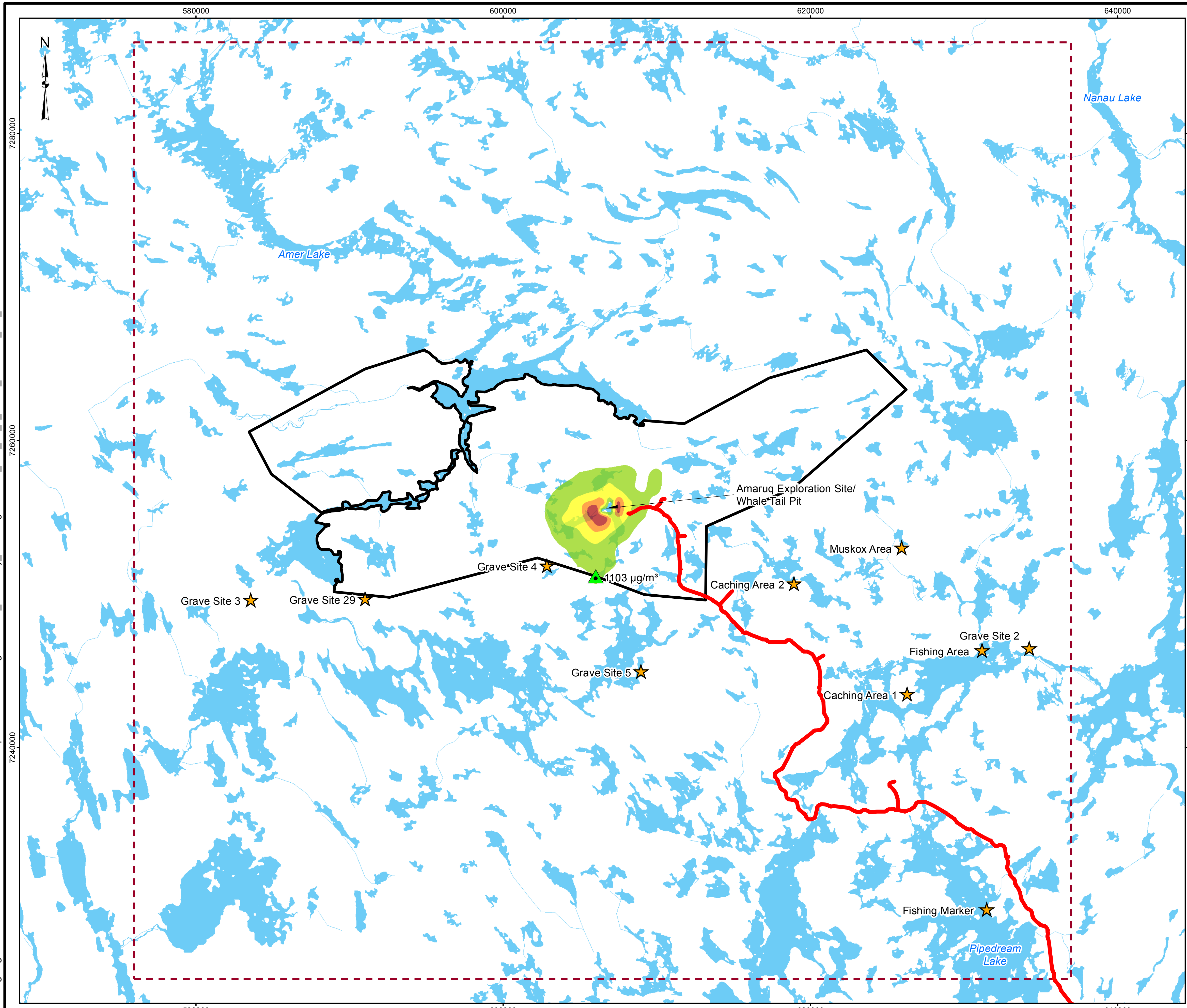
Results	1-hour	8-hr
Peak CO Concentration (µg/m³)	2181	391
Maximum CO Concentration (µg/m³)	714	174
Project Contribution Combined With Background Concentration		
Peak CO Concentration (µg/m³)	2,570	776
Maximum CO Concentration (µg/m³)	1,103	559
Number of occurrences above criteria	0	0
Distance (km)	3.8	3.8
Direction	S	S
Ambient Air Quality Standards (µg/m³)	**15,000**	**6,000**

µg/m³ = micrograms per cubic metre; km = kilometre

Table 4-C-9: Model Predicted CO Concentration at Selected Potential Receptor Locations

Health Receptor	1-hour Peak (µg/m³)	1-hour Maximum (µg/m³)	8-hour Peak (µg/m³)	8-hour Maximum (µg/m³)
Grave site 2	633	416	426	390
Grave site 3	593	432	436	394
Grave site 4	1,615	604	583	454
Grave site 5	1,113	590	522	438
Grave site 29	900	432	470	401
Fishing marker	485	418	401	391
Muskox	581	440	412	399
Fishing area	491	420	400	393
Caching area 1	489	429	403	392
Caching area 2	676	499	424	405

µg/m³ = micrograms per cubic metre



\\golder.gds\gal\Saskatoon\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_6_Model_Predicted_1hr_CO.mxd

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 1,000 (BLANK)
- 1,000 - 1,500
- 1,500 - 2,000
- 2,000 - 2,500
- > 2,500

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT

AGNICO EAGLE

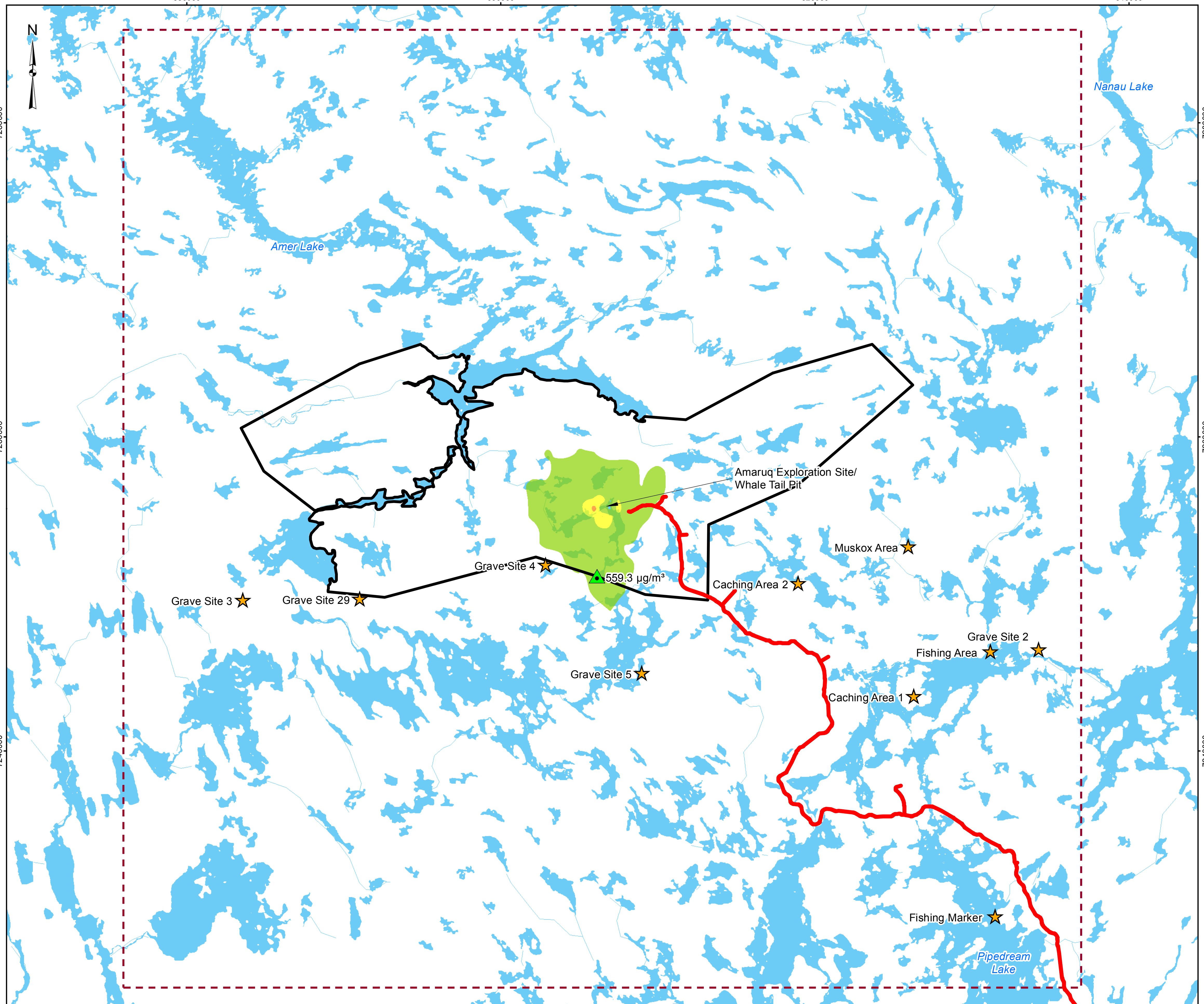
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 1-HOUR CO CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11	**FIGURE 4-C-6**	
REVIEW	CM	2016-05-11		



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 500
- 500 - 1,000
- 1,000 - 1,500
- 1,500 - 2,000
- 2,000 - 2,500

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 8-HOUR CO CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11	**FIGURE 4-C-7**	
REVIEW	CM	2016-05-11		

\\golder.gds\gal\Saskatoon\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_7_Model_Predicted_8hr_CO.mxd

4.C-7.3.2 Nitrogen Oxidie (NO_2) Predictions

The model predicted 1-hour, 24-hour, and annual NO_2 concentrations are summarized in Table 4-C-10 and shown in Figures 4-C-8 to 4-C-10. The maximum model predicted 1-hour, 24-hour, and annual NO_2 concentrations outside the Project boundary are 150, 57.9, and 8.5 µg/m^3, respectively. The maximum 1-hour, 24-hour, and annual NO_2 concentrations occur along the southern Project boundary. The maximum 1-hour, 24-hour, and annual NO_2 concentrations and the concentrations at the selected receptors (Table 4.C-11) are all lower than the respective air quality standards.

Table 4-C-10: Summary Table of Model Predicted NO_2 Concentrations

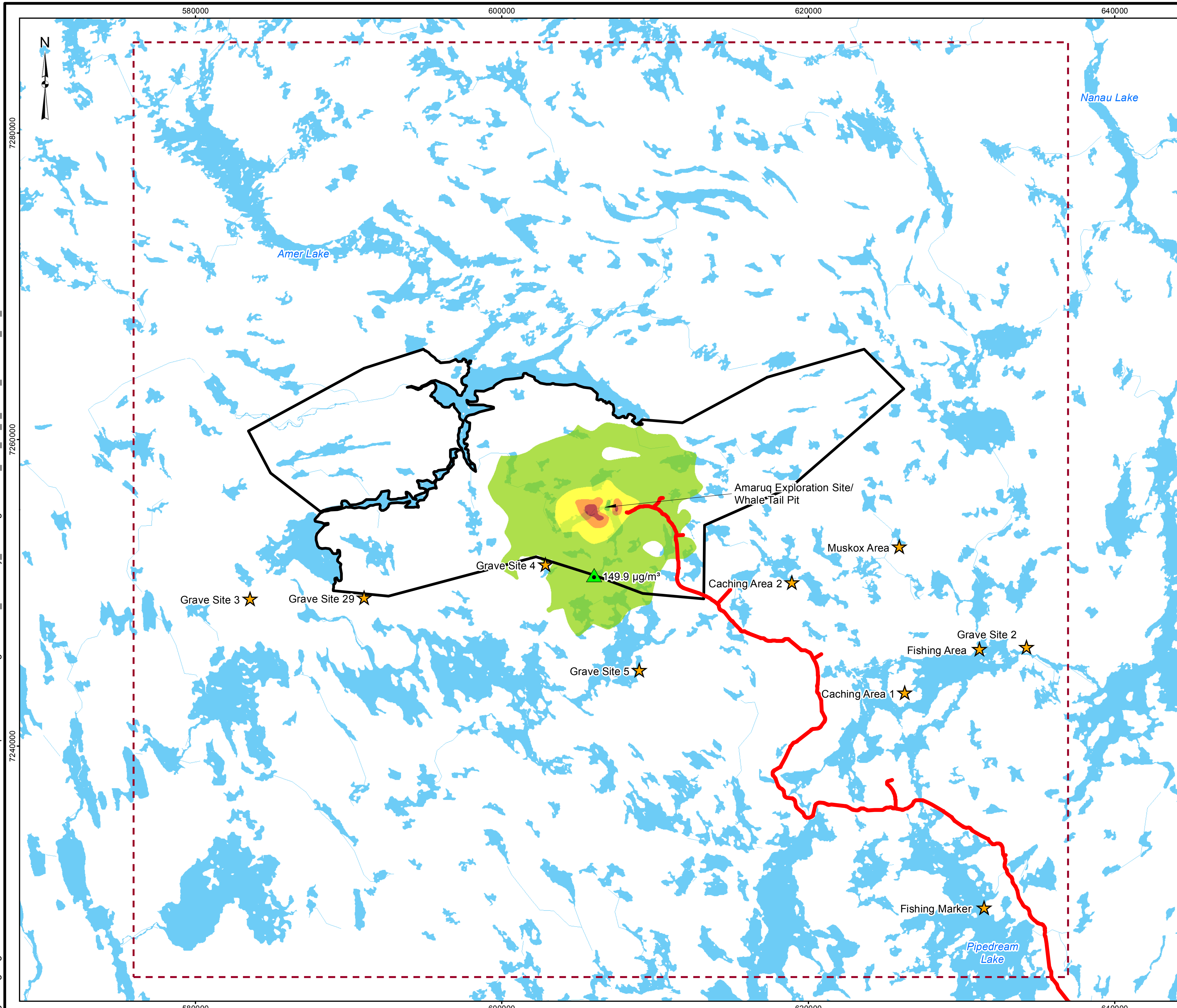
Results	1-hour	24-hour	Annual
Peak NO_2 Concentration (µg/m^3)	329	53.2	—
Maximum NO_2 Concentration (µg/m^3)	137	46.5	3.5
Project Contribution Combined With Background Concentration			
Peak NO_2 Concentration (µg/m^3)	342	64.6	—
Maximum NO_2 Concentration (µg/m^3)	150	57.9	8.5
Number of occurrences above criteria	0	0	0
Distance (km)	3.8	4.1	4.1
Direction	S	S	S
Ambient Air Quality Standards (µg/m^3)	**400**	**200**	**60**

µg/m^3 = micrograms per cubic metre; km = kilometre

Table 4-C-11: Model Predicted NO_2 Concentrations at Selected Potential Receptor Locations

Health Receptor	1-hour Peak (µg/m^3)	1-hour Maximum (µg/m^3)	24-hour Peak (µg/m^3)	24-hour Maximum (µg/m^3)	Annual (µg/m^3)
Grave site 2	87.9	50.0	16.1	15.0	5.1
Grave site 3	89.9	60.0	23.2	17.3	5.1
Grave site 4	215	94.5	26.5	24.0	5.6
Grave site 5	156	85.2	29.5	27.3	6.1
Grave site 29	120	60.8	17.3	17.3	5.2
Fishing marker	74.8	54.1	18.4	18.1	5.2
Muskox	86.6	63.8	15.9	15.8	5.2
Fishing area	79.7	54.1	15.8	14.9	5.1
Caching area 1	72.5	56.2	17.7	17.1	5.2
Caching area 2	100	75.8	20.6	17.6	5.4

µg/m^3 = micrograms per cubic metre



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 100
- 100 - 200
- 200 - 300
- 300 - 400
- > 400

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 1-HOUR
NO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11	**FIGURE 4-C-8**	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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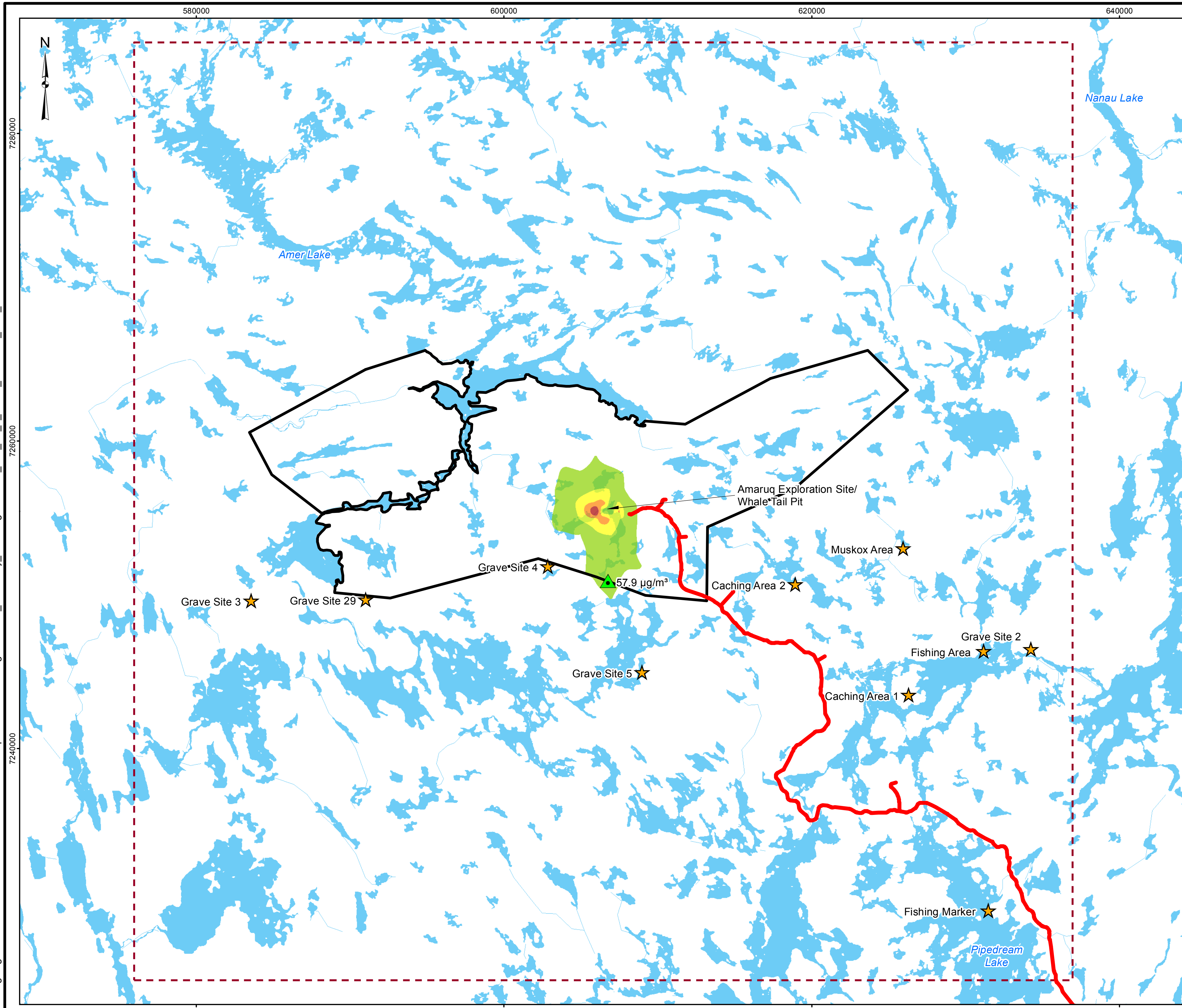

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 50
- 50 - 100
- 100 - 150
- 150 - 200
- > 200

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR
NO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SM/LS	2016-05-11	
CHECK	CMc	2016-03-10	**FIGURE 4-C-9**
REVIEW	CM	2016-05-11	

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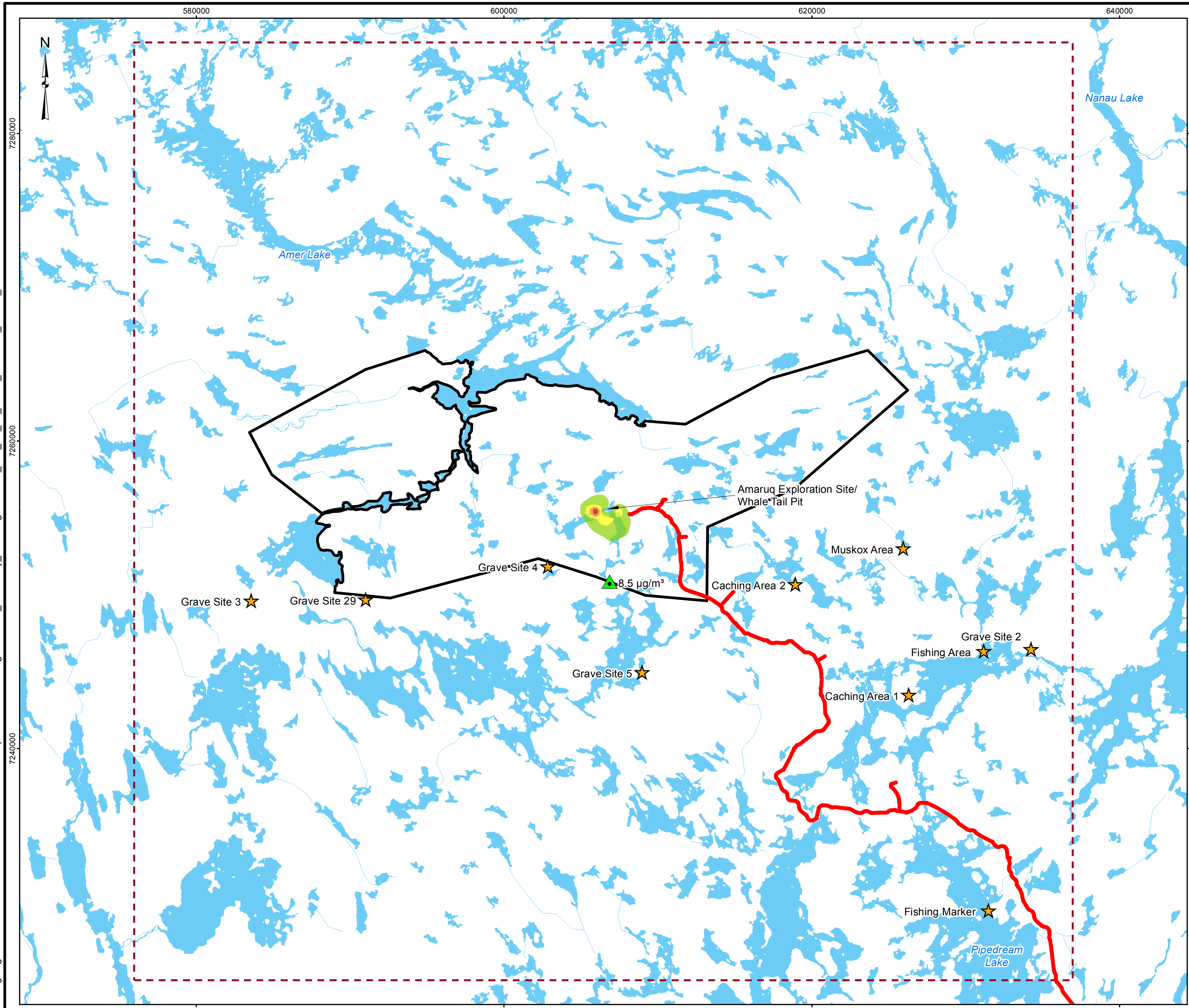

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL NO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11		
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

FIGURE 4-C-10

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4.C-7.3.3 Sulfur Dioxide (SO_2) Predictions

The model predicted 1-hour, 24-hour, and annual SO_2 concentrations are summarized in Table 4-C-12 and shown in Figures 4-C-11 to 4-C-13. The maximum model predicted 1-hour, 24-hour, and annual SO_2 concentrations outside the Project boundary are 17.8, 5.8, and 0.4 µg/m^3, respectively. The maximum 1-hour, 24-hour, and annual SO_2 concentrations occur along the southern Project boundary. The maximum 1-hour, 24-hour, and annual SO_2 concentrations and the concentrations at the selected receptors (Table 4-C-13) are all lower than the respective air quality standards.

Table 4-C-12: Summary Table of Model Predicted SO_2 Concentrations

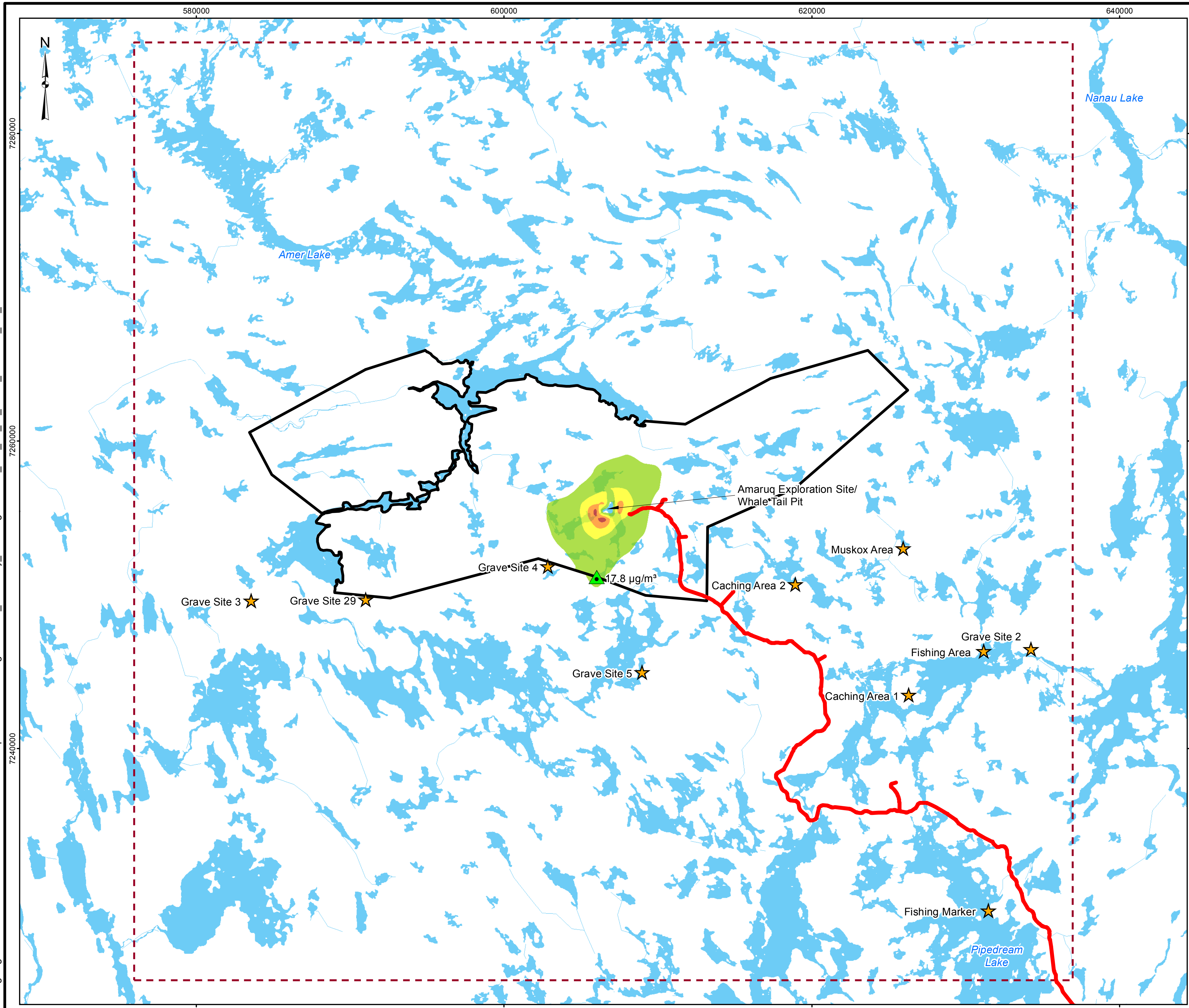
Results	1-hour	24-hr	Annual
Peak SO_2 Concentration (µg/m^3)	47.8	3.7	—
Maximum SO_2 Concentration (µg/m^3)	15.1	3.2	0.1
Project Contribution Combined With Background Concentration			
Peak SO_2 Concentration (µg/m^3)	50.4	6.3	—
Maximum SO_2 Concentration (µg/m^3)	17.8	5.8	0.4
number of occurrences above criteria	0	0	0
Distance (km)	3.8	3.8	4.1
Direction	S	S	S
Current Ambient Air Quality Standards (µg/m^3)	**450**	**150**	**30**

µg/m^3 = micrograms per cubic metre; km = kilometre

Table 4-C-13: Model Predicted SO_2 Concentrations at Selected Potential Receptor Locations

Health Receptor	1-hr Peak (µg/m^3)	1-hr Maximum (µg/m^3)	24-hr Peak (µg/m^3)	24-hr Maximum (µg/m^3)	Annual (µg/m^3)
Grave site 2	6.8	3.2	2.9	2.7	0.27
Grave site 3	7.0	3.5	3.2	2.9	0.27
Grave site 4	29.5	7.1	4.4	3.7	0.29
Grave site 5	18.3	6.9	3.6	3.4	0.30
Grave site 29	11.2	3.6	3.1	2.8	0.27
Fishing marker	4.7	3.3	2.8	2.8	0.27
Muskox	6.6	3.7	2.9	2.8	0.27
Fishing area	4.8	3.3	2.8	2.8	0.27
Caching area 1	4.8	3.5	2.8	2.8	0.27
Caching area 2	8.7	4.9	3.0	2.9	0.28

µg/m^3 = micrograms per cubic metre;



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- 60 - 75

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 1-HOUR
SO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11		
CHECK	CMc	2016-05-11	FIGURE 4-C-11	
REVIEW	CM	2016-05-11		

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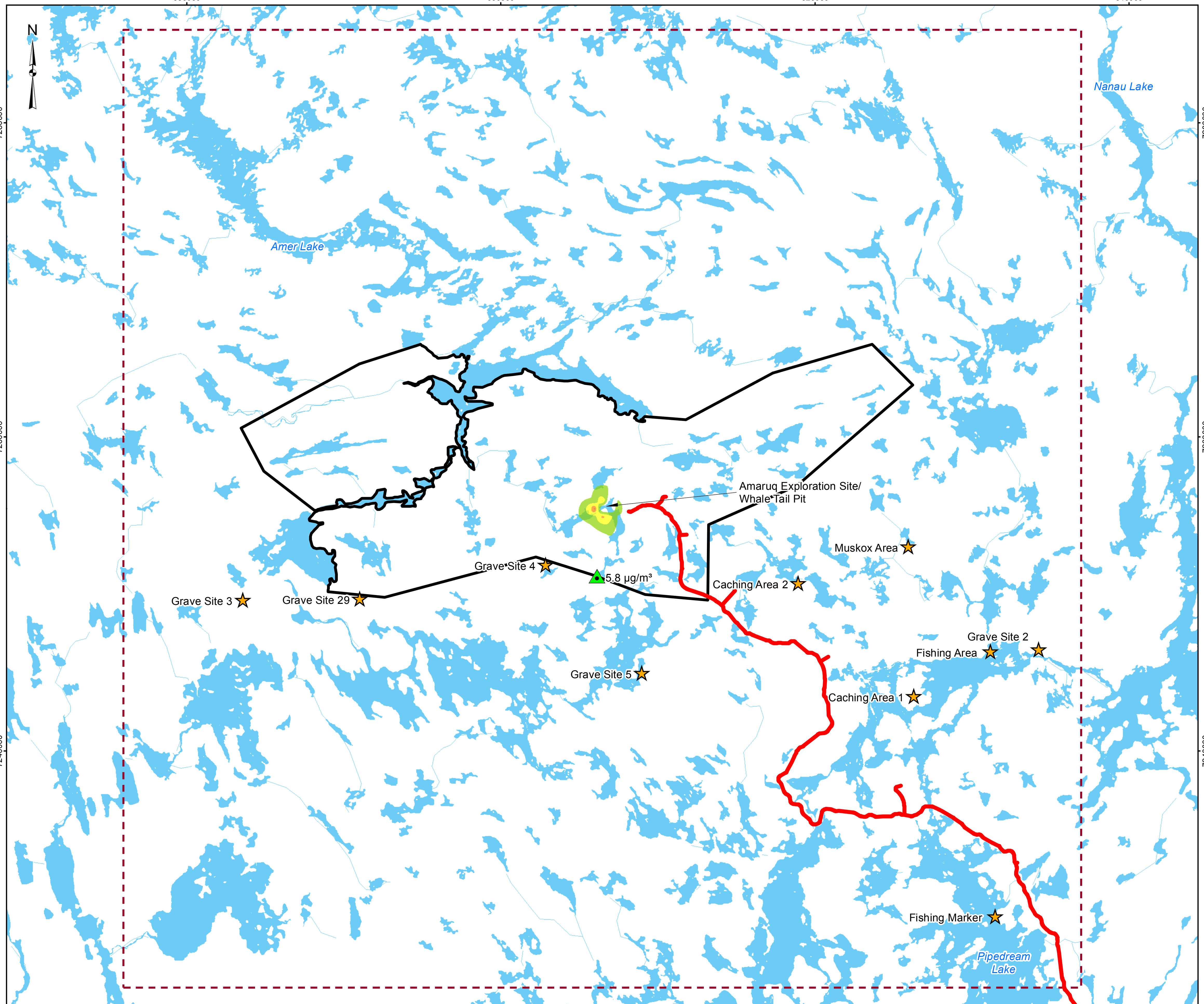

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 10
- 10 - 15
- 15 - 20
- 20 - 25
- > 25

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE
MODEL PREDICTED 24-HOUR
SO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11	FIGURE 4-C-12	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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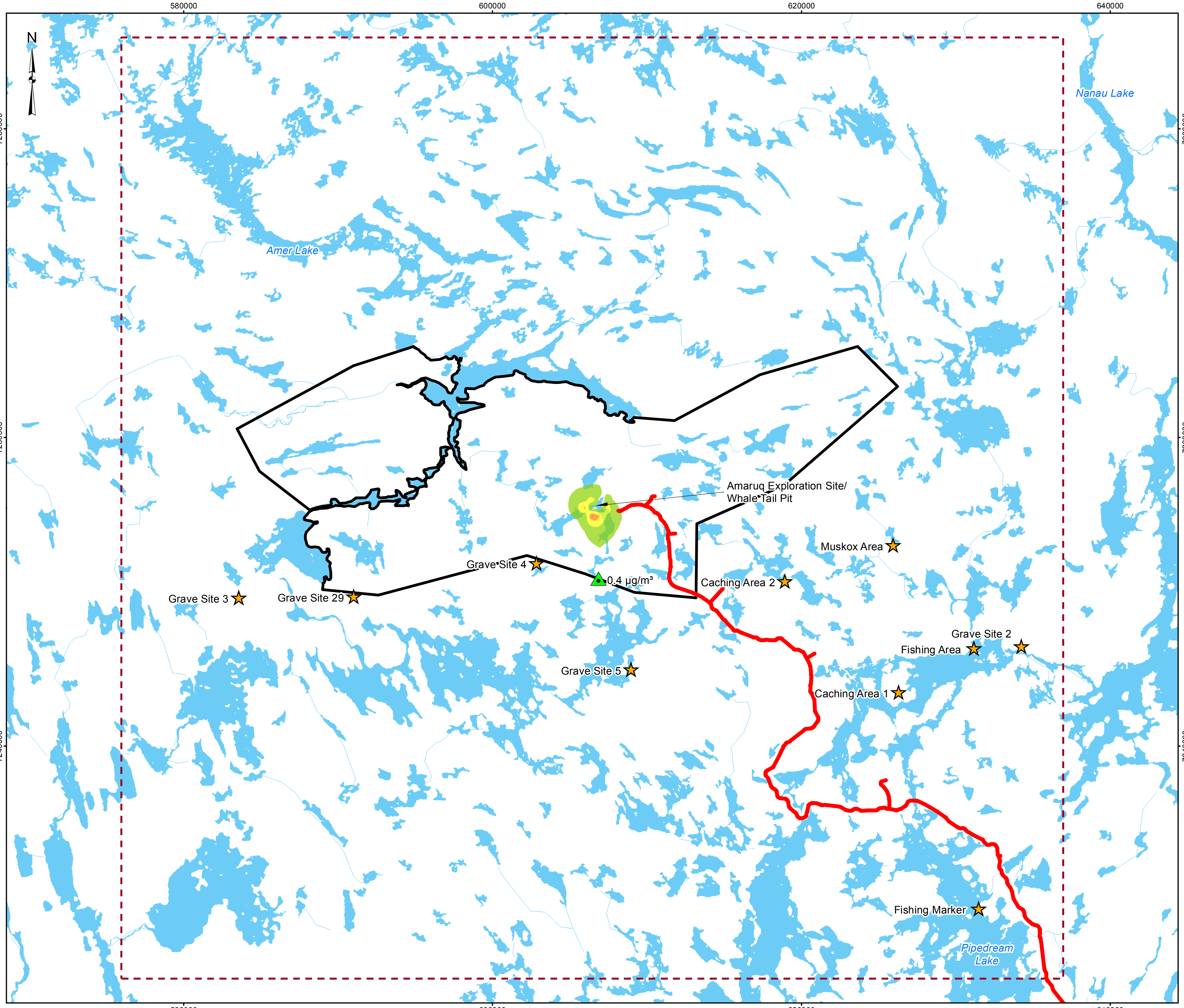

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 0.5
- 0.5 - 1
- 1.0 - 1.5
- 1.5 - 2.0
- 2.0 - 2.5

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL
SO_2 CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11		
CHECK	CMc	2016-05-11	FIGURE 4-C-13	
REVIEW	CM	2016-05-11		

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4.C-7.3.4 Total Suspended Particulate Predictions

The model predicted 24-hour and annual TSP concentrations are summarized in Table 4-C-14 and shown in Figures 4-C-14 and 4-C-15. The maximum model predicted 24-hour and annual TSP concentrations outside the Project boundary are 174 and 16.9 µg/m^3, respectively. The predicted maximum plus background 24-hour TSP concentrations exceed the ambient air quality standard of 120 µg/m^3. The maximum annual TSP concentrations and the maximum 24-hr and annual average concentrations at the selected receptors (Table 4-C-15) are all lower than the respective air quality standards.

The maximum TSP concentration outside of the Project boundary occurs for meteorology observed in 2005 at a receptor 8.5 km southeast of the Whale Tail Pit (Figure 4-C-14). At this receptor, there is a total of three days that the TSP concentrations are predicted to exceed the air quality standard of 120 µg/m^3. The two small areas outside of the Project boundary that have TSP concentrations that exceed ambient air quality standards are near the southern Project boundary and the southeast corner of the Project boundary near the location where the haul road to the Meadowbank Mine leave the Project boundary.

The small areas outside the Project boundary that have concentrations that are predicted to exceed the 24-hour TSP air quality standard are not likely to present a risk to human health. There are no residences within the areas predicted to have high TSP concentrations, nor is it likely that people will be present within these areas for more than 24 consecutive hours.

Table 4-C-14: Summary Table of Model Predicted TSP Concentrations

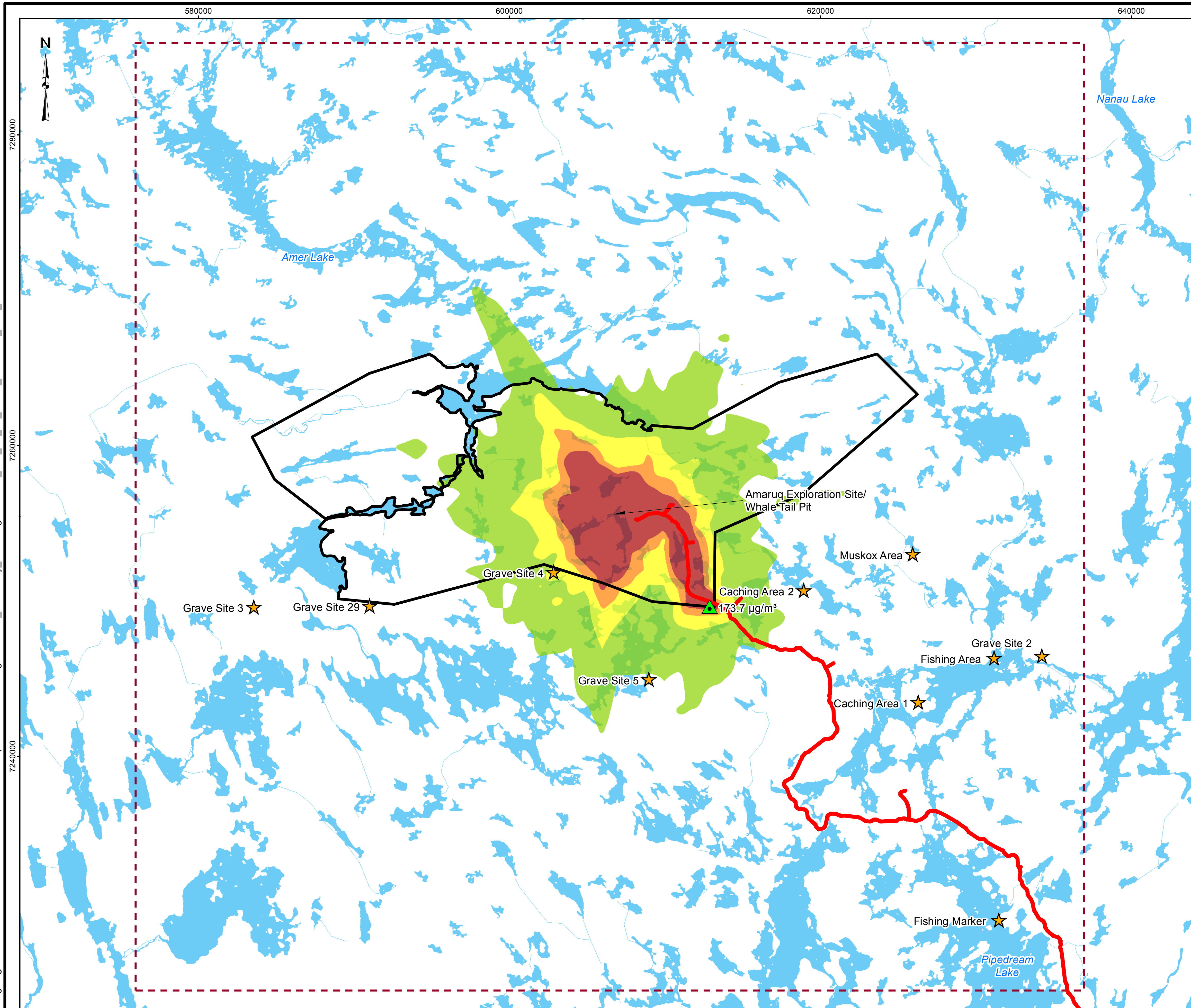
Results	**24-hr**	**Annual**
Peak TSP Concentration (µg/m^3)	225	—
Maximum TSP Concentration (µg/m^3)	167	13.3
Project Contribution Combined With Background Concentration		
Peak TSP Concentration (µg/m^3)	231	—
Maximum TSP Concentration (µg/m^3)	174	16.9
Number of occurrences above criteria	3	0
Distance (km)	8.5	8.2
Direction	SE	SE
Ambient Air Quality Standards(µg/m^3)	**120**	**60**

µg/m^3 = micrograms per cubic metre; km = kilometre

Table 4.C-15: Model predicted TSP concentrations at Selected Potential Receptor Locations

Health Receptor	24-hour Peak ($\mu g/m^3$)	24-hour Maximum ($\mu g/m^3$)	Annual ($\mu g/m^3$)
Grave site 2	12.2	10.1	3.7
Grave site 3	13.9	10.3	3.7
Grave site 4	78.5	74.7	5.0
Grave site 5	34.9	27.5	5.2
Grave site 29	19.5	16.8	3.9
Fishing marker	12.5	9.8	3.8
Muskox	13.4	11.5	3.8
Fishing area	14.3	12.2	3.8
Caching area 1	18.8	15.2	3.9
Caching area 2	26.6	22.2	4.3

$\mu g/m^3$ = micrograms per cubic metre



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 30
- 30 - 60
- 60 - 90
- 90 - 120
- > 120

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

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KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR TSP CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SM/LS	2016-05-11	
CHECK	CMc	2016-05-11	FIGURE 4-C-14
REVIEW	CM	2016-05-11	

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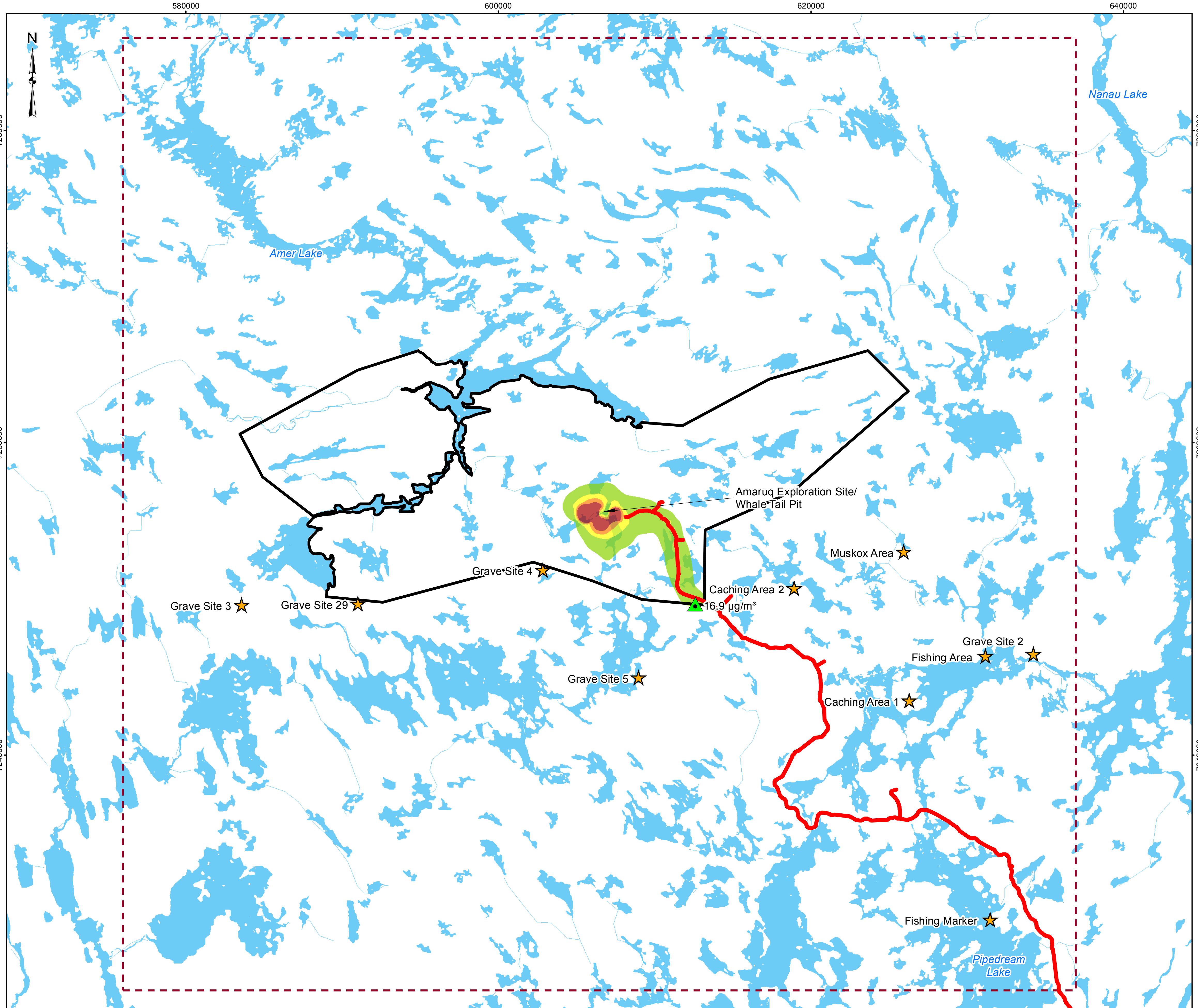

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 15
- 15 - 30
- 30 - 45
- 45 - 60
- > 60

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
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PROJECT

AGNICO EAGLE

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MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL TSP CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SM/LS	2016-05-11	**FIGURE 4-C-15**	
CHECK	CMc	2016-05-11		
REVIEW	CM	2016-05-11		

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4.C-7.3.5 PM_{10} Predictions

The model predicted 24-hour PM_{10} concentrations are summarized in Table 4-C-16 and shown in Figure 4.C-16. The maximum model predicted 24-hour outside the Project boundary is 52.4 µg/m³. The maximum 24-hour PM_{10} concentrations occur along the southern Project boundary. The maximum PM_{10} concentration outside of the Project boundary occurs at a receptor 3.8 km south of the Whale Tail Pit. At this receptor, there is only 1 day that the PM_{10} concentrations are predicted to exceed the relevant ambient air quality standard (i.e., 50 µg/m³). The area outside of the Project boundary that has a predicted PM_{10} exceedance is very small and there are no residences or community receptors identified within this area.

The maximum 24-hour PM_{10} concentrations at the selected receptors (Table 4-C-17) are all lower than the respective air quality standard.

Table 4-C-16: Summary Table of Model Predicted PM_{10} Concentrations

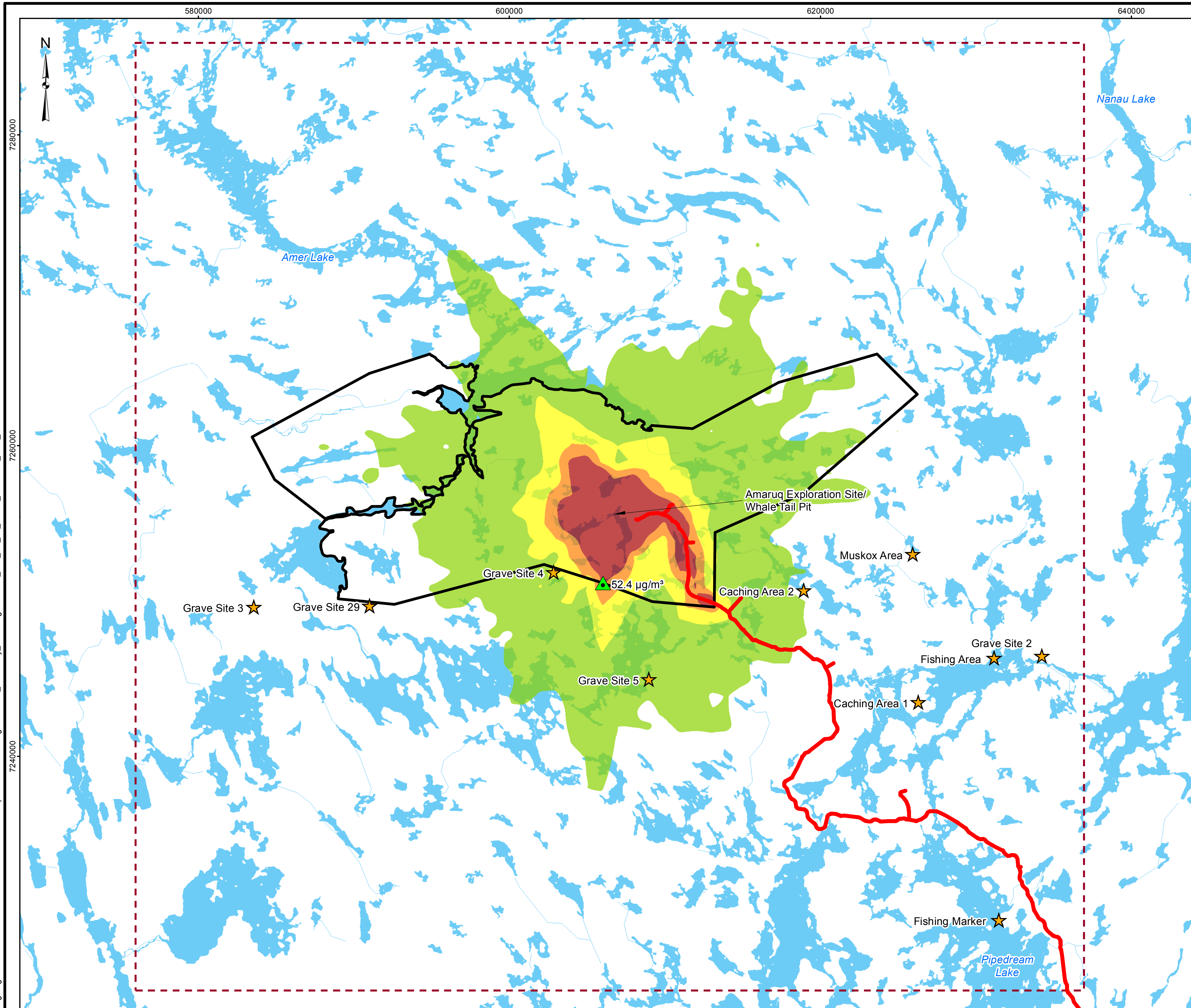
Results	**24-hour**
Peak PM_{10} Concentration (µg/m³)	63.1
Maximum PM_{10} Concentration (µg/m³)	45.7
Project Contribution Combined With Background Concentration	
Peak PM_{10} Concentration (µg/m³)	69.8
Maximum PM_{10} Concentration (µg/m³)	52.4
Number of occurrences above criteria	1
Distance (km)	3.8
Direction	S
Ambient Air Quality Standards (µg/m³)	**50**

µg/m³ = micrograms per cubic metre; km = kilometre

Table 4.C-17: Model predicted PM_{10} concentrations at Selected Potential Receptor Locations

Health Receptor	**24-hour Peak (µg/m³)**	**24-hour Maximum (µg/m³)**
Grave site 2	8.5	7.9
Grave site 3	9.1	8.9
Grave site 4	30.4	28.8
Grave site 5	18.5	13.2
Grave site 29	10.9	10.2
Fishing marker	8.5	7.8
Muskox	9.5	8.4
Fishing area	9.2	8.6
Caching area 1	10.6	9.4
Caching area 2	13.0	11.7

µg/m³ = micrograms per cubic metre



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 12.5
- 12.5 - 25.0
- 25.0 - 37.5
- 37.5 - 50.0
- > 50

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5 0 5
KILOMETRES

PROJECT
AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR
PM_{10} CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11	**FIGURE 4-C-16**	
REVIEW	CM	2016-05-11		

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4.C-7.3.1 $PM_{2.5}$ Predictions

The model predicted 24-hour and annual $PM_{2.5}$ concentrations are summarized in Table 4-C-18 and shown in Figures 4-C-17 and 4-C-18. Compliance with territorial and national 24-hour ambient air quality standards is based on the 98th percentile value over three years. For the Project, this value is 13.5 µg/m³, which is below the air quality standard (i.e., 28 µg/m³). The maximum 24-hour (20.1 µg/m³) and annual (4.3 µg/m³) $PM_{2.5}$ concentrations are also predicted to be below the 28 µg/m³ (3-year, 98th percentile) 24-hour and 8.8 µg/m³ annual air quality standards, respectively.

The maximum 24-hour, annual $PM_{2.5}$ concentrations, and the concentrations (Table 4-C-19) at the selected receptors are also all lower than their respective air quality standards.

Table 4.C-18: Summary Table of Model Predicted $PM_{2.5}$ Concentrations

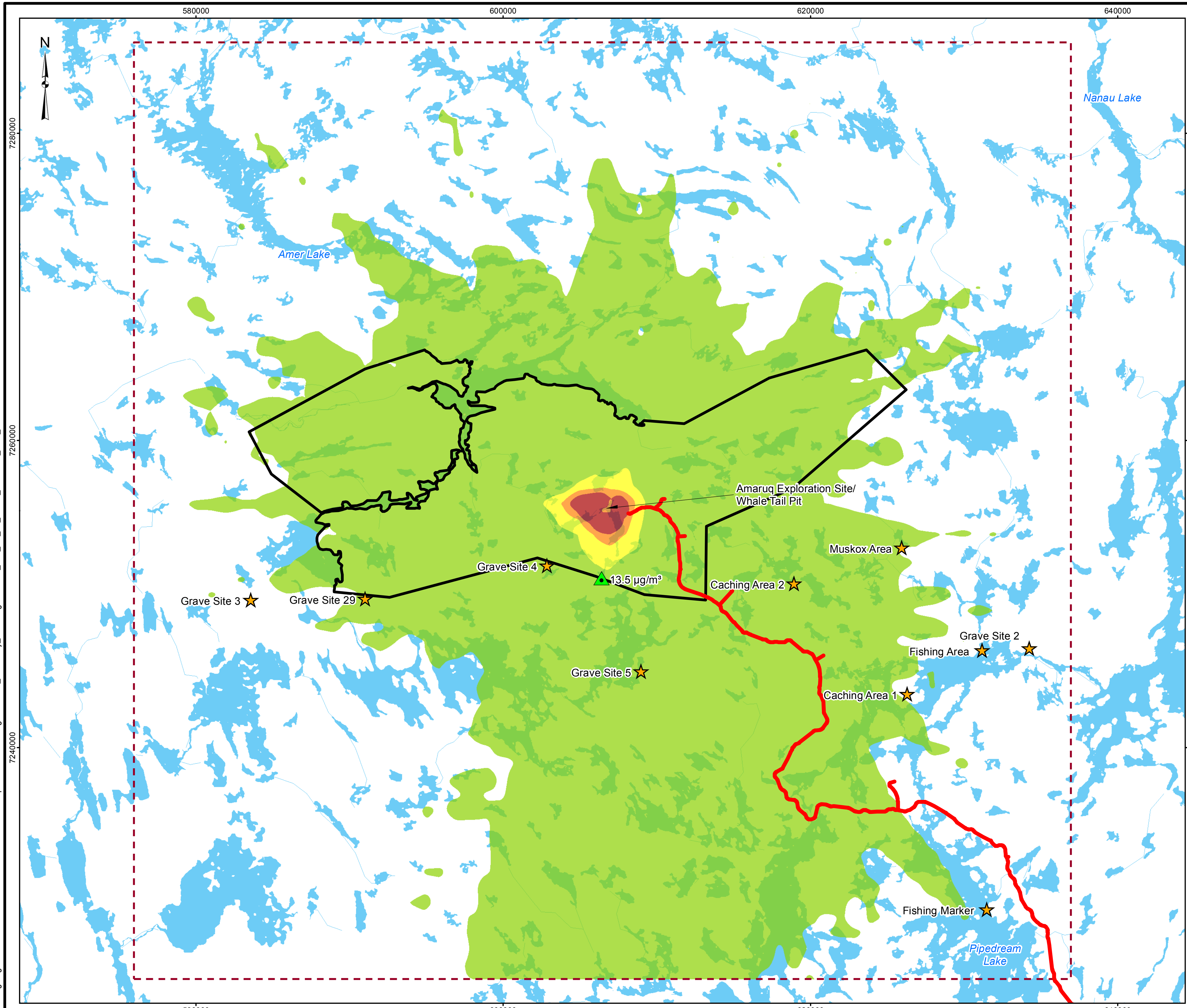
Results	24-hr	Annual
Peak $PM_{2.5}$ Concentration (µg/m³)	15.8	—
Maximum $PM_{2.5}$ Concentration (µg/m³)	13.4	0.7
98th percentile $PM_{2.5}$ Concentration (µg/m³)	6.8	—
Project Contribution Combined With Background Concentration		
Peak $PM_{2.5}$ Concentration (µg/m³)	22.5	—
Maximum $PM_{2.5}$ Concentration (µg/m³)	20.1	4.3
98th percentile $PM_{2.5}$ Concentration (µg/m³)	13.5	—
Number of occurrences above criteria	0	0
Distance (km)	3.9	4.0
Direction	S	S
Current Ambient Air Quality Standards (µg/m³)	**28**	**8.8**

µg/m³ = micrograms per cubic metre; km = kilometre

Table 4.C-19: Model Predicted $PM_{2.5}$ Concentrations at Selected Potential Receptor Locations

Health Receptor	24-hour Peak (µg/m³)	24-hour Maximum (µg/m³)	Annual (µg/m³)
Grave site 2	7.1	6.8	3.6
Grave site 3	8.0	6.9	3.6
Grave site 4	13.5	8.4	3.8
Grave site 5	10.2	8.6	3.8
Grave site 29	8.1	7.1	3.6
Fishing marker	7.2	6.9	3.6
Muskox	7.6	7.0	3.6
Fishing area	7.2	7.0	3.6
Caching area 1	7.4	7.0	3.6
Caching area 2	8.0	7.5	3.7

µg/m³ = micrograms per cubic metre



\\golder.gds\gal\Saskatoon\GIS\2015\1524321 AEM Amaruq Whale Tail EIS\Figures\1400_AirQuality_Modeling\1541520_FIG_4C_17_Model_Predicted_24hr_PM25.mxd

LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- 0 - 7
- 7 - 14
- 14 - 21
- 21 - 28
- > 28

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5 0 5

KILOMETRES

PROJECT

AGNICO EAGLE

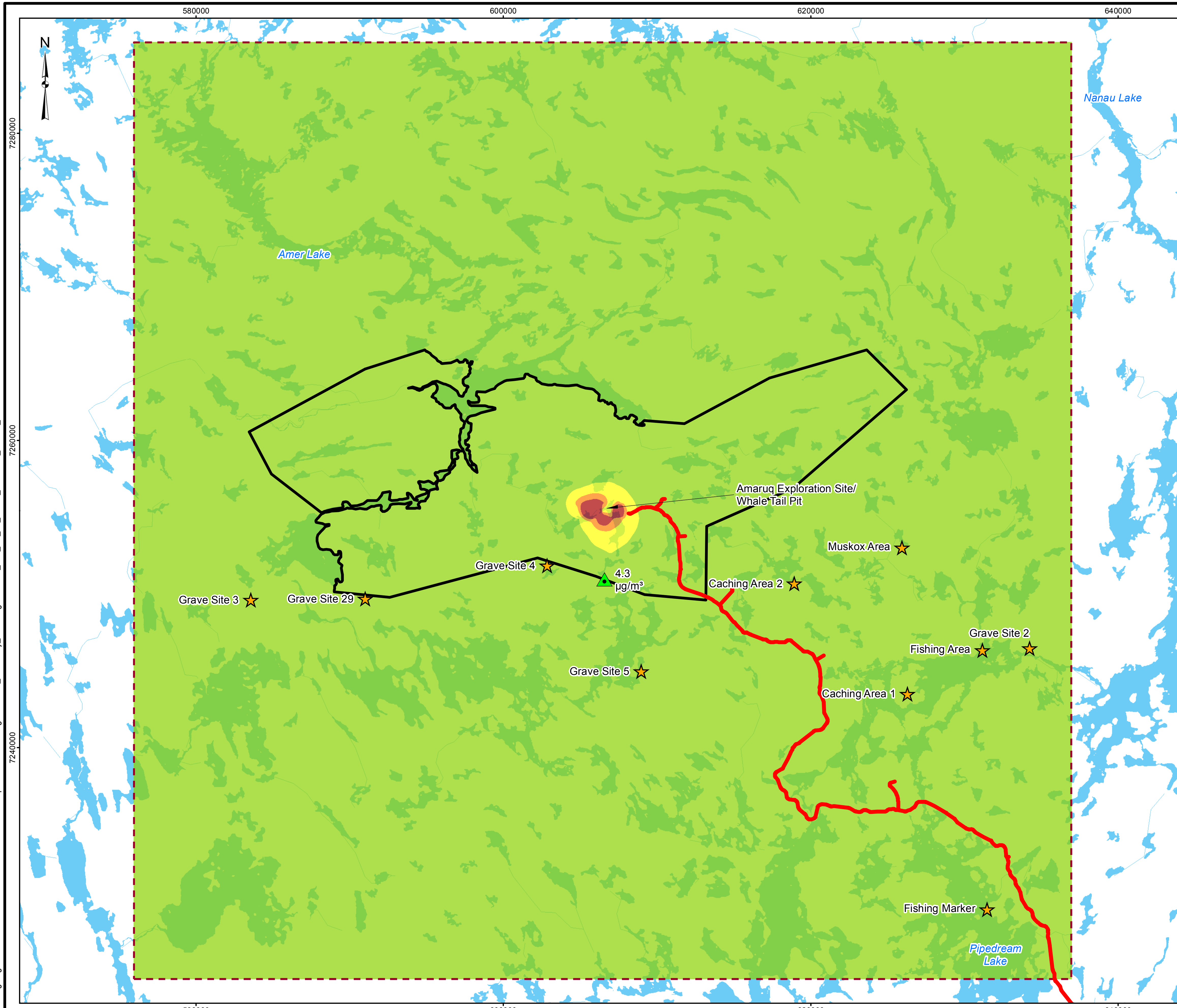
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED 24-HOUR
$PM_{2.5}$ CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.	
DESIGN	ZY	2016-03-02	SCALE AS SHOWN	REV. A
GIS	SBM	2016-05-11		
CHECK	CMc	2016-05-11	**FIGURE 4-C-17**	
REVIEW	CM	2016-05-11		



LEGEND

- MAXIMUM POINT OF IMPINGEMENT
- DISCRETE RECEPTOR
- PROPERTY BOUNDARY
- MODEL BOUNDARY
- PROPOSED WHALE TAIL PIT HAUL ROAD
- WATERCOURSE
- WATERBODY

CONCENTRATION (µg/m³)

- < 3.6 (BASELINE)
- 3.6 - 5.0
- 5.0 - 7.5
- 7.5 - 10.0
- > 10

REFERENCE

1. PROJECT BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED.
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

5 0 5
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

MODEL PREDICTED ANNUAL $PM_{2.5}$ CONCENTRATIONS

Golder Associates

PROJECT		1541520	FILE No.
DESIGN	ZY	2016-03-02	SCALE AS SHOWN REV. A
GIS	SBM	2016-05-11	
CHECK	CMc	2016-05-11	FIGURE 4-C-18
REVIEW	CM	2016-05-11	

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4.C-8 AIR QUALITY MODELLING FOR THE HAUL ROAD

The Whale Tail Pit is connected to the Meadowbank Mine by an un-paved, 62 km haul road. With the exception of $PM_{2.5}$, combustion related emissions (e.g., CO, NO_2, SO_2) from light and heavy duty gasoline and diesel vehicles travelling along the haul road have low potential to affect air quality because the amount of emissions is low. Fugitive road dust generated by these vehicles does have the potential to affect air quality adjacent to the road, and atmospheric deposition of fugitive road dust has the potential to affect soil and water quality adjacent to the road. This section of Appendix 4-C discusses the methods used to evaluate particulate matter concentrations and atmospheric deposition of particulate matter along the haul road, and the results of this analysis.

4.C-8.1 Methods

Air quality model predictions for the haul road were created to evaluate atmospheric concentrations and atmospheric deposition of particulate matter as a function of distance from the centre of the haul road. To evaluate potential Project related effects of the haul road on air quality, emissions along a representative 1 km long section of the haul road were simulated.

The representative section is aligned along a southwest to northeast transect, an orientation perpendicular to the prevailing winds. The emissions include particulate matter emissions from vehicle exhaust, and fugitive road dust from the un-paved road surface, which are summarized in Section 4.B-8 of Appendix 4-B. The simulation of the haul road is identical to the simulation of the portion of the haul road that resides within the Project boundary. However, the representative 1-km haul road simulation excludes the application of any dust mitigation measures (i.e., it excludes an assumed 70% reduction in fugitive dust due to road watering), and includes only a natural 90% reduction in fugitive dust during winter months when the road bed is frozen. Inclusion of natural wintertime mitigation reduces annual particulate matter concentrations and dust deposition, but does not affect predictions of the maximum 24-hour concentrations or daily dust deposition rates.

Air quality modelling receptors with 20 metre (m) intervals were placed along the road in rows with distances of 25 m, 50 m, 75 m, 100 m, 300 m, 500 m, 750 m, 1,000 m, 1,500 m, and 2,000 m from the centre of the haul road. Using the maximum daily emission estimates for the unfrozen season, the ground level concentrations of all CACs were predicted for the receptors using the air quality model.

4.C-8.2 Results

Low level emissions of CO, NO_2, and SO_2 will be produced by vehicles using the haul road. The model predicted ground level concentrations of CO, NO_2, and SO_2 are low compared to baseline and to their relevant ambient air quality standards. Thus, only model predictions for particulate matter are considered in further detail.

Table 4-C-20 summarizes maximum predicted particulate matter (TSP, PM_{10}, $PM_{2.5}$) concentrations as a function of distance from the haul road. All PM size classes will experience decreases in their concentration with distance due to atmospheric mixing (i.e., dilution). However, only PM_{10} and TSP have appreciable atmospheric deposition within a few 1000 meters from the haul road.

Figures 4-C-19 and 4-C-20 show the predicted decrease in maximum 24-hour and annual TSP concentrations with increasing distance from the haul road. In the near field, maximum TSP concentrations adjacent to the road are predicted to exceed the 24-hour average ambient air quality standard (120 $\mu g/m^3$) at distances of up to 1,500 m from the road. Maximum predicted 24-hour PM_{10} concentrations are predicted to exceed the ambient air quality standard (50 $\mu g/m^3$) at distances of up to 1,000 to 1,500 m from the road. Maximum predicted 24-hour $PM_{2.5}$

concentrations are only predicted to exceed the ambient air quality standard (28 µg/m³) within the first 100 m from the road. Maximum annual TSP concentrations are predicted to exceed the ambient air quality standard (60 µg/m³) within the first 100 to 300 meters from the road. Maximum annual $PM_{2.5}$ concentrations are not predicted to exceed the ambient air quality standard (8.8 µg/m³). There is no annual PM_{10} ambient air quality standard.

Table 4-C-20: Maximum Predicted PM Concentrations with Distance From the Haul Road

Distance (m)	Maximum predicted PM concentrations (µg/m³)				
	24-hour TSP	Annual TSP	24-hour PM_{10}	24-hour $PM_{2.5}$	Annual $PM_{2.5}$
25	1739	172	464	37.2	6.9
50	1330	118	354	28.6	5.0
75	1171	91.4	312	21.9	3.9
100	1041	73.5	277	17.9	3.2
300	499	26.7	134	8.3	1.2
500	358	15.4	95.6	4.5	0.7
750	254	9.7	68.9	3.3	0.4
1000	212	6.4	57.1	2.7	0.2
1500	92.4	3.2	25.5	1.2	0.1
2000	52.7	1.9	14.6	0.9	0.1
Ambient Air Quality Standards	**120**	**60**	**50**	**28**	**8.8**

m = metres; µg/m³ = micrograms per cubic metre

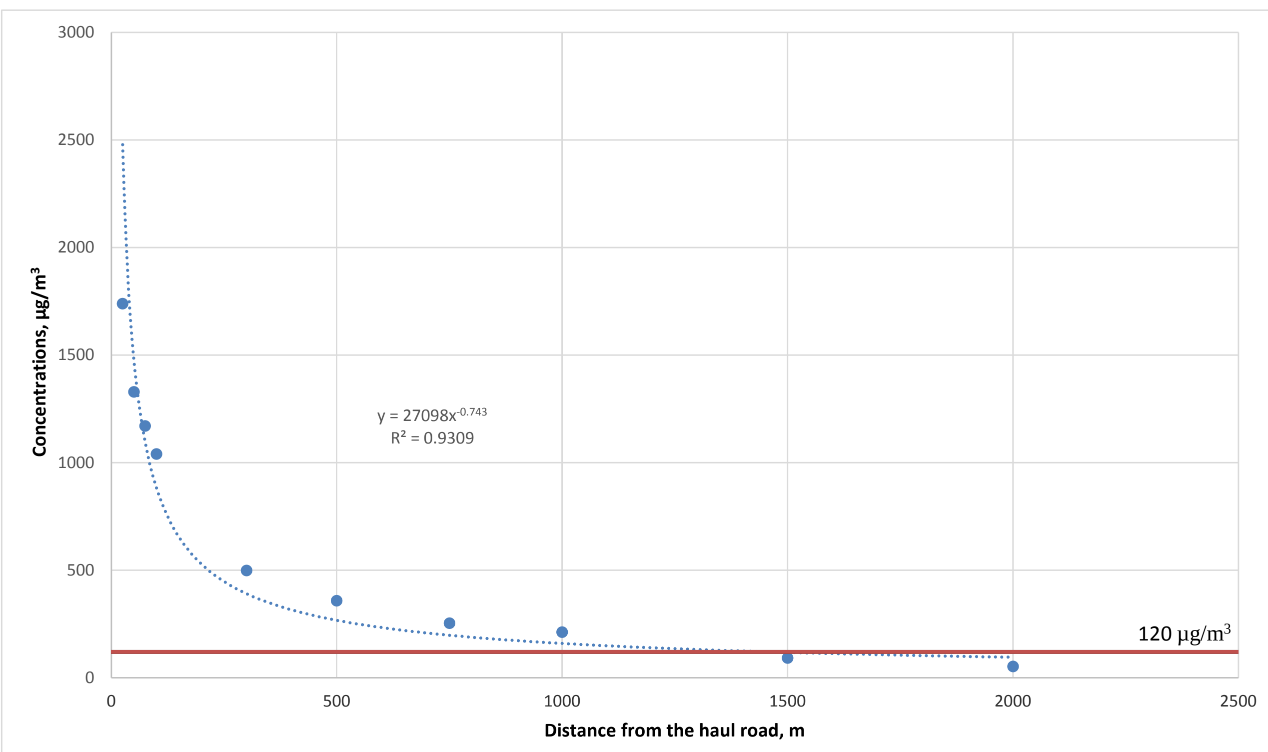

Figure 4-C-19: Maximum Predicted 24-Hour TSP Concentrations with Distance From the Haul Road

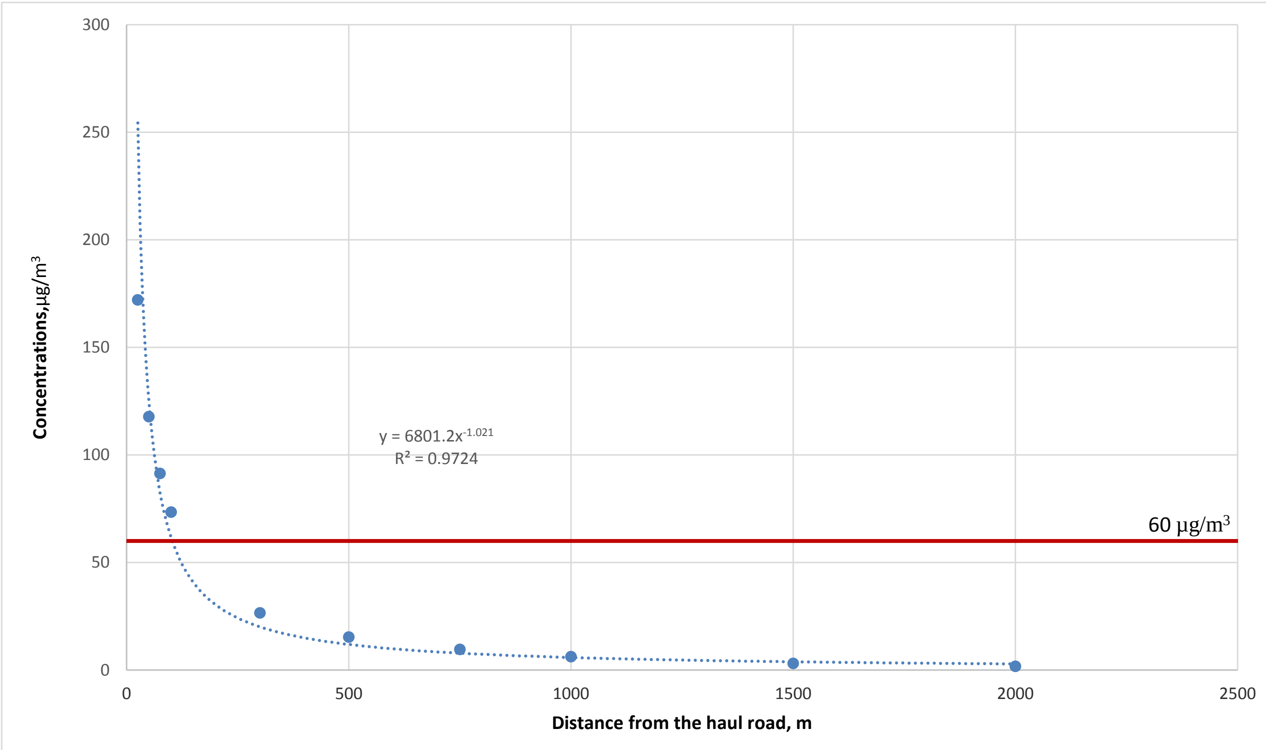

Figure 4-C-20: Maximum Predicted Annual TSP Concentrations with Distance From the Haul Road

There are no dust deposition rate standards for Nunavut Territory. The British Columbia lower and upper dust fall standard for mining is 1.7 milligrams per decimeter squared per day (mg/dm²/day) and 2.9 mg/dm²/day (BC Ministry of Environment 2016). These values correspond to deposition rates of 0.51 mg/cm²/30-days and 0.87 mg/cm²/30-days. The Alberta Environment Department's recreational/residential and industrial/commercial area dustfall guidelines of 0.53 mg/cm²/30-days and 1.58 mg/cm²/30-days are indicated for total dustfall (Alberta Environment 2013). The monthly and annual Ontario dust fall criteria are 0.7 mg/cm²/30-days and 0.46 mg/cm²/30-days, respectively (Ontario Ministry of the Environment 2012). As summarized in Table 4.C-21, the most stringent 30-day and annual dustfall criteria are the 30-day British Columbia deposition rate of 0.51 mg/cm²/30-days and the Ontario annual deposition rate of 0.46 mg/cm²/30-days.

Table 4-C-21: Dust fall criteria (mg/cm²/30-days)

Averaging Time	Alberta Residential and Recreation Areas	BC Lower Level	BC Upper Level	Alberta Commercial and Industrial Areas	Ontario
30 days	0.53	**0.51**	0.87	1.58	0.7
Annual	—	—	—	—	**0.46**

The maximum 24-hour and annual total deposition of TSP was modelled at the same receptors as those used to predict ambient concentrations of TSP with distance from the haul road. At the receptors closest to the haul road (i.e., 25 m), the maximum 24-hour and annual total TSP deposition rates are 0.40 grams per meter squared per day (g/m²/day) and 18.4 grams per metre squared per year (g/m²/year), respectively. The maximum 24-hour and annual total TSP deposition rates can be converted to equivalent deposition rates over a 30-day period, and are equivalent to 1.19 mg/cm²/30-days and 0.15 mg/cm²/30-days, respectively. The conversion of 24-hour deposition rates to 30-day deposition rates is conservative as it assumes that the maximum 24-hour deposition rate occurs every day for the 30-day period.

The dust deposition modelling results are summarized in Table 4-C-22 and illustrated in Figures 4-C-21, and 4-C-22. The maximum predicted dust deposition rates are predicted to be below the 24-hour BC total dustfall standard within 300 m of the haul road. Maximum predicted annual dust deposition rates at 25 m from the haul road are predicted to be less than the Ontario annual dust fall standard.

Note that 24-hour particulate matter concentrations and dustfall rates presented in this section correspond to the maximum predicted values, not average values. There are also inherent uncertainties in modelling fugitive wind-blown dust generated from un-paved roads. During the November through May "frozen" season, 24-hour particulate matter concentrations and dustfall rates are expected to be approximately 1/10th of the maximum predicted values.

Table 4-C-22: Maximum Predicted TSP Total Deposition with Distance From the Haul Road

Distance (m)	24-hour (g/m²/day)	Monthly (mg/cm²/30-days)	Annual (g/m²/year)	Annual (mg/cm²/30-days)
25	0.40	1.19	18.4	0.15
50	0.26	0.77	11.7	0.10
75	0.22	0.65	8.46	0.07
100	0.19	0.56	6.61	0.05
300	0.09	0.26	2.23	0.02
500	0.06	0.18	1.27	0.01
750	0.05	0.14	0.79	0.01
1000	0.04	0.11	0.51	0.00
1500	0.02	0.07	0.26	0.00
2000	0.02	0.05	0.17	0.00
Dust fall criteria	—	0.51	—	0.46

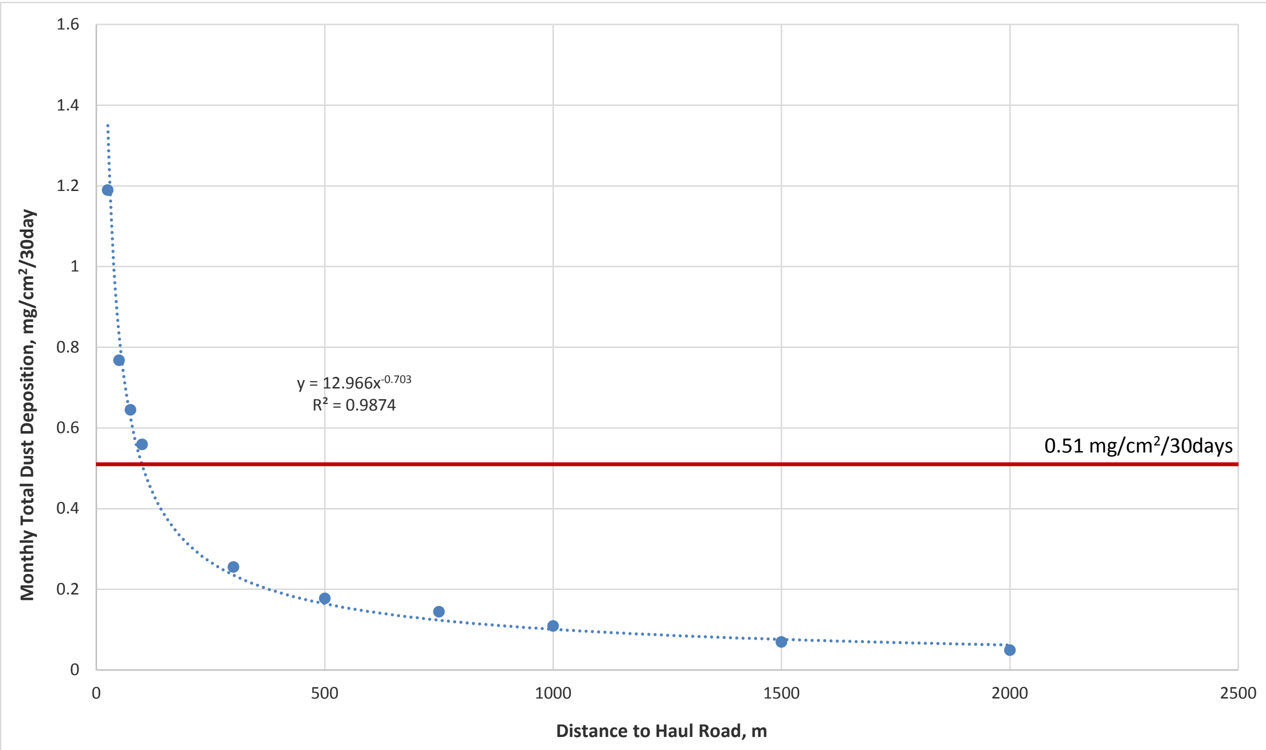

Figure 4-C-21: Maximum Predicted Daily Dust Deposition with Distance From the Haul Road

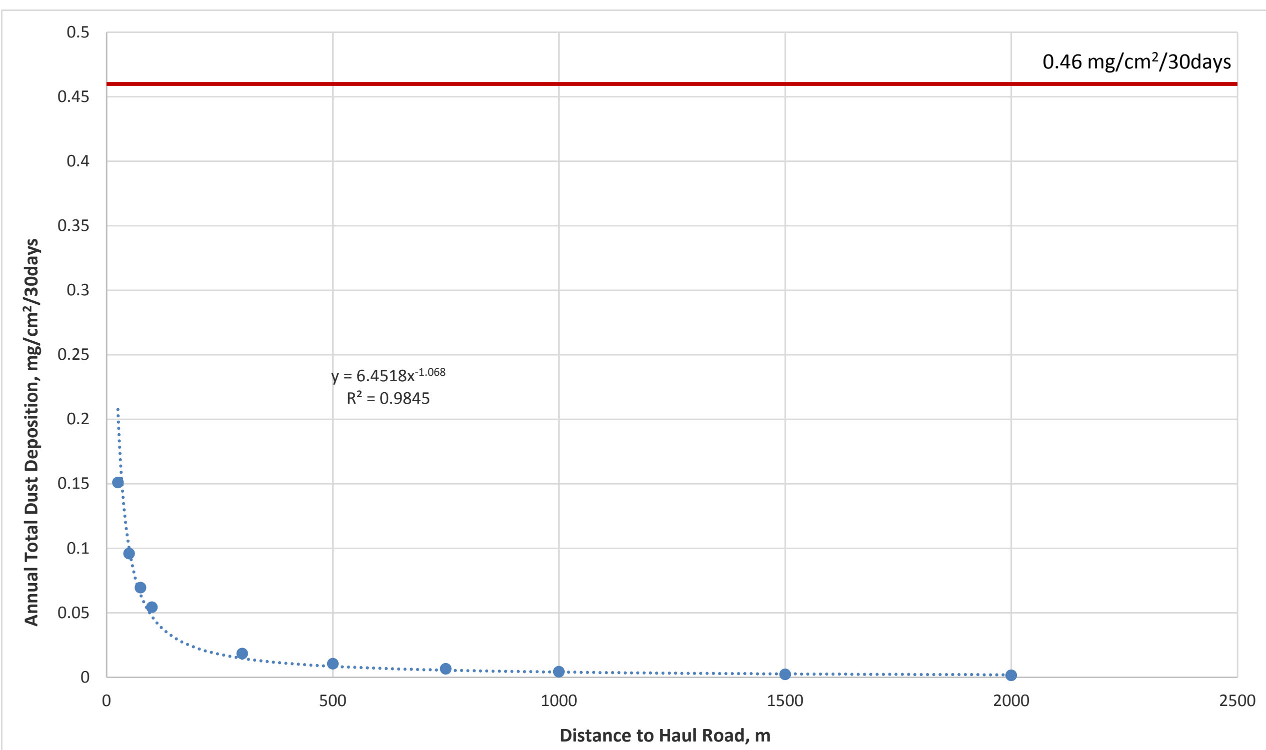

Figure 4-C-22: Maximum Predicted Annual Dust Deposition with Distance From the Haul Road

4.C-8.3 Discussion on Haul Road Dust Mitigation

Elders have expressed concern about the effects of fugitive windblown dust. Daily summertime road watering is proposed as a mitigation measure for the haul roads in the vicinity of the Whale Tail Pit, the ore storage pad and the waste rock storage facility. For conservatism, the assessment assumes no road dust mitigation along the haul road from the Whale Tail Pit to the Meadowbank Mill.

Results of the fugitive wind-blown dust modelling indicate that ambient dust concentrations may exceed ambient air quality criteria at distances of up to 1,000 to 1,500 m from the road on the driest, windiest days. Results of the fugitive wind-blown dust modelling indicate that atmospheric deposition of nuisance dust may exceed monthly recreational/residential guidelines within 300 m of the haul road, but are not expected to exceed monthly industrial/commercial guideline at distances greater than approximately 100 m from the haul road.

The proposed haul road construction material is sand and gravel sourced from regional eskers composed of local country rock materials. No mining waste rock or tailings from the existing Meadowbank Mine are proposed for use as road construction material.

Since there are no residences or other human health receptors within 1,500 m of the haul road, the potential impacts on air quality on the driest windiest days is predicted to be low. Since the road material is sourced from local eskers, and this material does not contain elevated concentrations of deleterious substances (Golder 2014), the potential impacts of dust deposition is predicted to be low.

Potential mitigation options for fugitive dust being generated along the haul road include the following:

1) daily road watering;
2) road watering on a strategic basis, such as:
   a) watering during dry or windy periods;
   b) spot watering at locations where the road tends to generate excessive dust (e.g., due to variation in the composition of the roadbed material used during construction); or
   c) spot watering near sensitive areas, such as near major watercourses.
3) application of a chemical suppressants (e.g., calcium chloride or EK-35).

Daily road watering during the summer months will contribute to additional air emissions from the combustion of fuel used in the watering trucks, be time consuming, and potentially expensive. Other drawbacks to daily road watering include:

1) Large volumes of water will be needed to spray the 62 km haul road twice daily to achieve a predicted 70% reduction in fugitive dust emissions.
2) Extracting road-water from local lakes and streams may have unintended consequences on the local hydrology or aquatic habitat.
3) Evaporation of the water from the road surface will deposit salts found naturally in the road-water and can lead to chemical weathering of the road bed material. This can result in the generation of additional dust-sized salt and mineral particulate in the future.

4) Leaching and runoff from the road during rain events or the spring thaw has the potential to increase total suspended solids and total dissolved solids loadings to the terrestrial and aquatic ecosystems along the haul road.

The application of chemical suppressants may also cause unintended environmental impacts to local terrestrial and aquatic habitats. Chemical suppressants include both inorganic salts and organic hydrocarbons derived from natural or synthetic products.

Inorganic chemical dust suppressants such as the salt calcium chloride ($CaCl_2$) are not found locally at the surface near the Project. Reapplication of $CaCl_2$ is required approximately annually to replace material that is blown away with the road dust, and because $CaCl_2$ can be leached from the road surface by precipitation and during the spring melt. The $CaCl_2$ that leaches from the road surface can reach aquatic habitats where it could affect water quality, including alkalinity and total dissolved solids concentrations.

Man-made organic chemical dust suppressants are also an option for dust mitigation (e.g., EK-35). The chemical dust suppressant EK-35 is manufactured from a synthetic iso-alkane (a branched hydrocarbon) and tall oil pitch and rosin. The materials safety data sheet for EK-35 indicates that it has no human health effects due to inhalation, skin contact or ingestion, but may become irritating to the eyes with prolonged contact. The potential for eco-toxicity and food chain concentration (i.e., bioaccumulation) is considered low. However, there are no known studies on the long-term effects of the use of this synthetic product, or its potential impacts on Arctic ecosystems specifically. This option is not recommended and is likely cost prohibitive.

The proposed mitigation along the haul road includes strategic watering of fugitive dust hot spots along the haul road (as identified by haul truck drivers etc.), and haul road watering during periods of prolonged drought and/or high winds. This will enable the use of inexpensive locally abundant water, while minimizing water quantities withdrawn from local lakes and streams.

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APPENDIX 4-D

Noise Baseline Report

December 2015

AGNICO EAGLE MINES: MEADOWBANK DIVISION - WHALE TAIL PIT PROJECT

Noise Baseline Report

Submitted to:
Agnico Eagle Mines Limited
Ryan Vanengen
Environment Superintendent

REPORT

Report Number: Doc 031-1524321.1500 Ver 0

Distribution:

1 copy: Agnico Eagle Mines Limited
1 copy: Golder Associates Ltd.

Golder Associates

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TABLES

FIGURES

APPENDICES

1.0 INTRODUCTION

Agnico Eagle Mines Limited: Meadowbank Division (Agnico Eagle) is proposing to develop Whale Tail Pit, a satellite deposit on the Amaruq property, in continuation of mine operations and milling of the Meadowbank Mine. The Amaruq Exploration property is a 408 square kilometre (km^2) site located on Inuit Owned Land approximately 150 kilometres (km) north of the hamlet of Baker Lake and approximately 50 km northwest of the Meadowbank Mine in the Kivalliq region of Nunavut (Figure 1-1). The property was acquired by Agnico Eagle in April 2013 subject to a mineral exploration agreement with Nunavut Tunngavik Incorporated.

The Meadowbank Mine is an approved mining operation and Agnico Eagle is looking to extend the life of the mine by constructing and operating Whale Tail Pit (referred to in this document as the Project), which is located on the Amaruq Exploration property. As an amendment to the existing operations at the Meadowbank Mine, it is subject to an environmental review established by Article 12, Part 5 of the *Nunavut Land Claims Agreement* (NLCA). Baseline data have been collected in support of the Environmental Review to document existing conditions and to provide the foundation for a qualitative and quantitative assessment of project operations and the extension of the mine development, to be evaluated in the Environmental Impact Statement (EIS) for the Project.

This report presents the results of a baseline noise monitoring survey completed by Golder Associates Ltd. (Golder) for the area associated with the Project.

1.1 Background

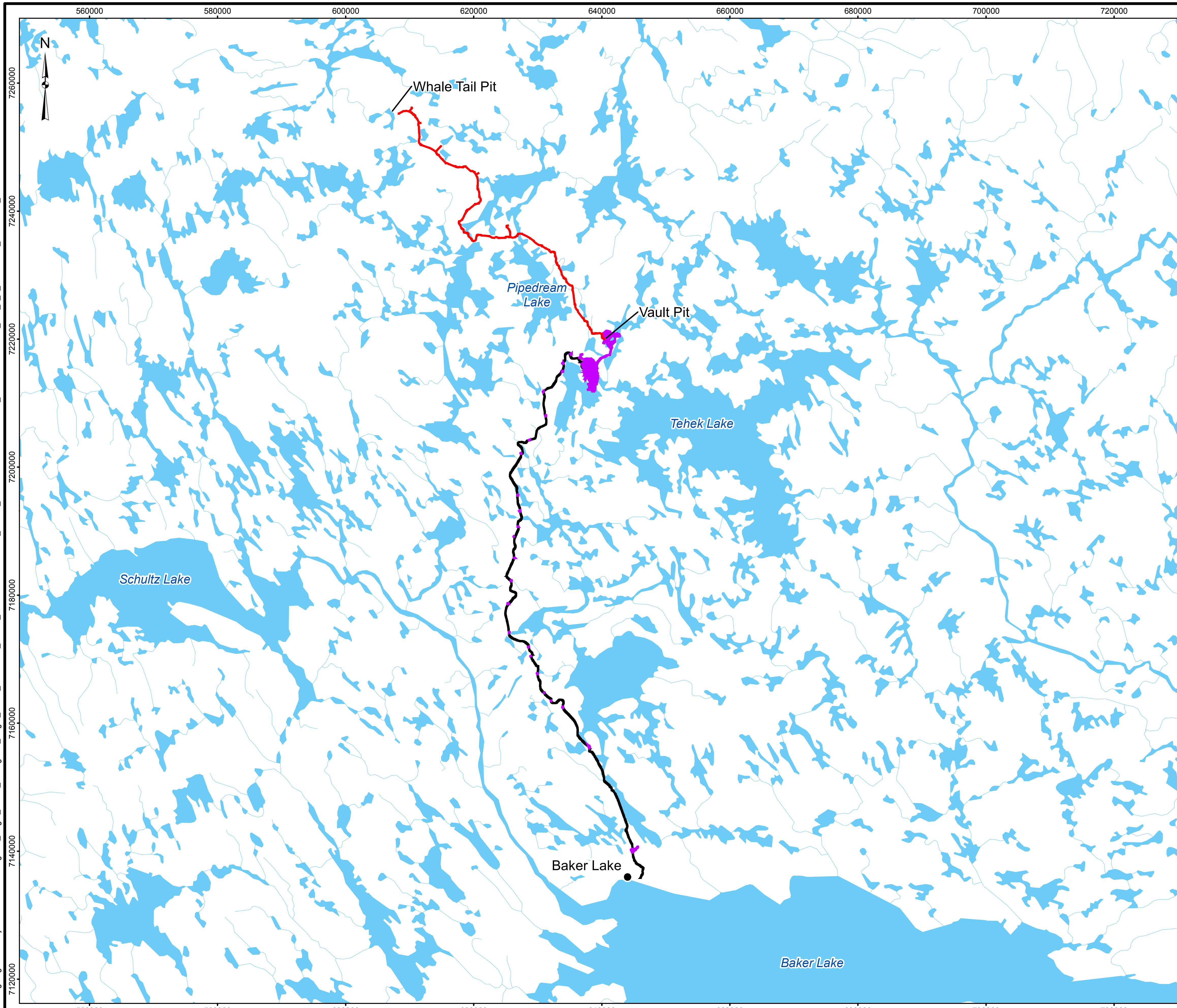
Since 2009, Agnico Eagle has conducted annual noise surveys at five representative locations surrounding the Meadowbank Mine site in support of their Noise Monitoring and Abatement Plan (Agnico Eagle 2009, 2013). The most recent noise monitoring report for Meadowbank Mine completed in 2014 (Agnico Eagle 2014) summarized the noise monitoring survey data from these locations. The locations for the 2009 through 2014 surveys were chosen to characterize the baseline noise levels are within several kilometres of the Meadowbank Mine. Therefore, the monitoring results for these locations are not considered applicable as background noise levels for the current noise survey for the Project (i.e., the future Whale Tail Pit and Haul Road). As a result, an additional baseline noise monitoring survey was completed in 2015.

1.2 Objective

The 2015 noise monitoring survey was completed to obtain information regarding baseline noise levels in the area surrounding the proposed Project. The objectives of the baseline noise survey were:

- to establish the baseline noise levels in the area adjacent to the Project; and
- to collect data that will be used in the noise related section of the EIS for the Project.

The following sections present the results of the baseline noise monitoring conducted at four monitoring sites from August 7 to August 10, 2015.



LEGEND

- COMMUNITY
- PROPOSED HAUL ROAD
- ALL WEATHER ROAD
- MEADOWBANK INFRASTRUCTURE
- WATERCOURSE
- WATERBODY

REFERENCE

1. HAUL ROAD OBTAINED FROM AGNICO EAGLE MINES LIMITED. 2015-10-14 FROM 6103-117-230-200_R0.dwg
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.
3. INSET MAP DATA OBTAINED FROM ESRI

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

12 0 12
KILOMETRES

PROJECT

AGNICO EAGLE

AGNICO EAGLE MINES LIMITED:
MEADOWBANK DIVISION
WHALE TAIL PIT PROJECT

TITLE

PROJECT LOCATION

Golder Associates

PROJECT		1524321	FILE No.	
DESIGN	JR	24 Sept. 2015	SCALE AS SHOWN	REV. A
GIS	CD	13 Nov. 2015		
CHECK	JR	16 Dec. 2015	**FIGURE 1-1**	
REVIEW	DRW	16 Dec. 2015		

\\golder.gds\gal\burnaby\CAD-GIS\Client\Agnico_Eagle_Mines_Ltd\Agnico_Eagle_Mines_Ltd\Whale_Tail\99_PROJECTS\1524321_EIS\02_PRODUCTION\BASELINE_REPORT\1524321_FIG_1_1_GENERAL_PROJECT_LOCATION.mxd

2.0 METHODS

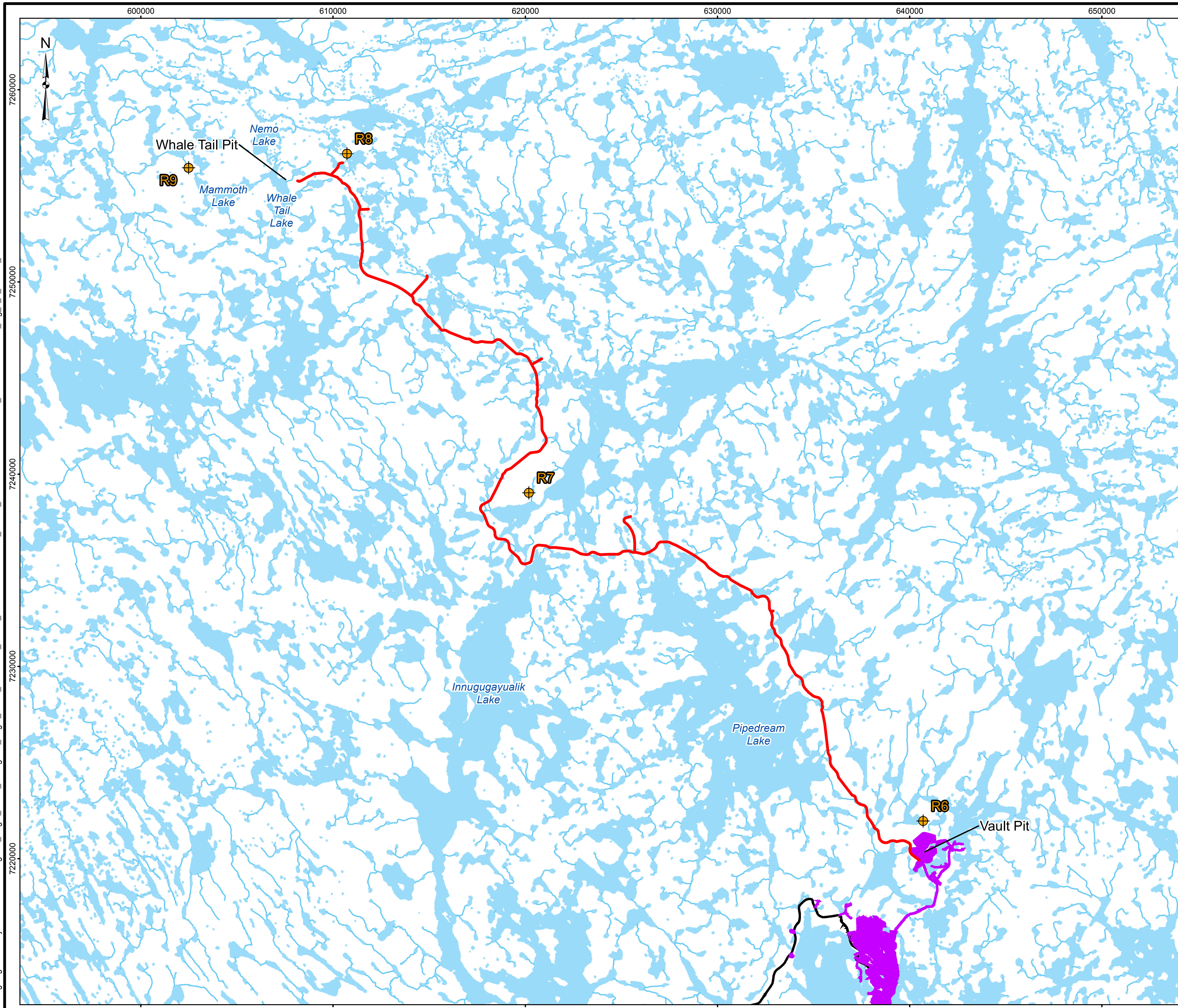
The territory of Nunavut does not have noise specific regulations or guidance that could be applicable to noise baseline measurements. Environment Canada recommends management tools for noise associated with metal mines activities in the document “Environmental Code of Practice for Metal Mines” (Environment Canada 2009), however, there is no specific guidance for baseline noise monitoring in Nunavut in this document. To characterize baseline noise levels existing in the area of the Project, Alberta Energy Regulator (AER) Directive 038 *Noise Control* (EUB 2007) was adopted and followed during the baseline noise program and data analysis. Directive 038 is frequently used to aid assessment of noise effects from mining developments located in the Canadian North (e.g., De Beers 2010 and Dominion Diamond 2014). In addition, the Environmental Impact Review Board (EIRB) (EIRB 2011) explicitly references the AER Directive 038 as the guidance for noise impact assessments in the Inuvialuit Settlement Region of Canada’s western Arctic.

2.1 Baseline Noise Monitoring Sites

Directive 038 specifies that noise impact should be assessed at the most impacted residences (including seasonally or permanently occupied dwellings) located within 1.5 km from the project boundary. The proposed Whale Tail Pit will be located at the same location as the existing exploration site on the Amaruq property, and the proposed Haul Road will be built by expanding the exploration access road from the Meadowbank Mine to the Amaruq exploration site. The Project is located in a highly remote area; there are no residences or cabins near Whale Tail Pit as the site is approximately 150 km north of the nearest community of Baker Lake. Therefore, the noise monitoring locations were chosen based on the locations of the existing exploration site and exploration access road. In the absence of residences located within 1.5 km from the exploration site and access road, the following four unoccupied locations were chosen at the distance of about 1.5 km from the proposed Project to be representative of the baseline noise conditions in the area. The baseline noise monitoring program for the Project is the continuation of the annual noise surveys for Meadowbank Mine site (Agnico Eagle 2009, 2013, 2014), which were conducted at five representative locations (R1 – R5) surrounding the Meadowbank Mine site in support of their Noise Monitoring and Abatement Plan. So the four monitoring locations chosen for the baseline noise monitoring for the Project were numbered as R6, R7, R8, and R9:

- R6 is located along the southern portion of the proposed Haul Road and north of Vault Pit, at about 1.5 km from the proposed Haul Road and approximately 1.5 km from the centre of Vault Pit;
- R7 is located between the proposed Whale Tail Pit and Vault Pit, at approximately 1.5 km from the proposed Haul Road; and
- R8 and R9 are located about 1.5 km northwest and northeast of the existing exploration site, respectively.

The locations of monitoring sites are presented in Table 2-1. Figure 2-1 shows the noise monitoring locations, as well as the proposed Haul Road, Whale Tail Pit, and Vault Pit. In the future, the monitoring locations (R6 – R9) identified and evaluated for baseline purposes for the Project may be relocated depending on operational requirements.



LEGEND

- NOISE MONITORING SITE
- PROPOSED HAUL ROAD
- ALL WEATHER ROAD
- WATERCOURSE
- WATERBODY
- MEADOWBANK INFRASTRUCTURE

REFERENCE

1. HAUL ROAD OBTAINED FROM AGNICO EAGLE MINES LIMITED. 2015-10-14 FROM 6103-117-230-200_R0.dwg
2. WATERCOURSE AND WATERBODY DATA OBTAINED FROM CANVEC © DEPARTMENT OF NATURAL RESOURCES CANADA. ALL RIGHTS RESERVED.

DATUM: NAD 83 CSRS PROJECTION: UTM ZONE 14

4 0 4
KILOMETRES

PROJECT
AGNICO EAGLE
AGNICO EAGLE MINES LIMITED: MEADOWBANK DIVISION WHALE TAIL PIT PROJECT

TITLE
LOCATION OF BASELINE NOISE MONITORING SITES

Golder Associates

PROJECT		1524321	FILE No.	
DESIGN	AF	1 OCT. 2015	SCALE AS SHOWN	REV. A
GIS	CD	1 OCT. 2015		
CHECK	JR	16 DEC. 2015	FIGURE 2-1	
REVIEW	AF	16 DEC. 2015		

\\golder.gds\gal\burnaby\CAD-GIS\Client\Agnico_Eagle_Mines_Ltd\Agnico_Eagle_Mines_Ltd\Whale_Tail\99_PROJECTS\1524321_EIS\02_PRODUCTION\BASELINE_REPORT\1524321_Fig_2_1_NOISE_MONITORING.mxd

Table 2-1: Location of Noise Monitoring Sites

Noise Monitoring Site	Monitoring Site Description	Universal Transverse Mercator Location (Zone 14, NAD 83)	
		Easting [m]	Northing [m]
R6	Unoccupied site located 1.5 km from proposed Haul Road and approximately 1.5 km from the centre of the Vault Pit	640708	7221964
R7	Unoccupied site located 1.5 km from the proposed Haul Road	620194	7239038
R8	Unoccupied site located 1.5 km northeast from the proposed Whale Tail Pit	610725	7256677
R9	Unoccupied site located 1.5 km northwest from the proposed Whale Tail Pit	602488	7255946

m = metres; km = kilometres; NAD = North American Datum.

2.2 Noise Monitoring Methodology

The methodology of the baseline noise monitoring program was in accordance with Directive 038 (EUB 2007). The noise monitoring was conducted for approximately 72 hours, which allows for the collection of noise data sufficient to characterize the local daytime and nighttime variability of noise levels.

At each monitoring location, a Model 2250 Brüel and Kjær Type I integrating sound level meter (SLM) was used to collect noise measurements and to record audible sound for the entire duration of the monitoring program.

Data parameters recorded during the baseline monitoring survey included:

- equivalent energy noise level over a one-minute time period ($L_{eq,1min}$) in A-weighted decibels (dBA); and
- 1/3 octave band L_{eq} values over a one-minute time period in unweighted decibels (dB).

Due to site-specific weather conditions characterized by strong winds, extra windscreens were determined to be warranted for the microphones to minimize the unwanted effects of wind-induced noise on the monitoring data. In addition to standard environmental microphone screens (i.e., UA 1404 and UA 1679), each monitoring kit was equipped with a secondary windscreen, Brüel and Kjær model NH-2512, designed and developed specifically for noise measurements at high wind speeds in order to minimize wind-induced microphone noise.

Each SLM used during the survey was calibrated with a Brüel and Kjær Type 4231 calibrator immediately before and after each monitoring period to ensure the sound meter's variance was within 1 dB. The calibration data were logged by the meter, and calibration results were recorded in the field notes. The recordings of calibration signals are documented in Appendix A.

Directive 038 requires noise data be collected under appropriate weather conditions including the absence of steady precipitation, snow, water, or ice ground cover, as well as under meteorological conditions acceptable for noise measurement, which includes restrictions on maximum wind speed (EUB 2007). The survey was conducted during the summer and therefore the ground surface was not covered by either snow or ice. During the survey, weather data were collected using Nielsen-Kellerman Kestrel 4500 pocket weather meters deployed near the noise monitoring sites. The weather meters were set to record wind speed, wind direction, temperature, and relative humidity data every five minutes. The weather data (wind speed, wind direction, temperature, and humidity) are presented in Appendix B. Data from the weather meters were used to screen the collected noise data based on the weather condition requirements outlined in Directive 038. In addition, direct observations in the field and field notes taken by the survey team, including information regarding precipitation, cloud cover, wind direction, and audible noise sources, were used in the data analysis.

2.2.1 Data Analysis Methodology

Data recorded at each of the four monitoring sites were downloaded to a computer for analysis with the Brüel and Kjær 7820 Evaluator software program.

Following the guidance of Directive 038, a maximum wind speed of 15 kilometres per hour (km/h) (4.17 metres per second [m/s]) was used as the acceptable limit for the data analysis. Data collected when wind speed was less than 15 km/h was considered valid, while data collected when wind speed was greater than 15 km/h was not. The 15 km/h limit allowed for the removal of periods of high wind resulting in potential increased noise levels due to wind effects. The 15 km/h wind speed limit is set by Directive 038 and is not affected by the presence or absence of the wind screens.

Subsequently, based on Directive 038, any noise data containing recordings of anomalous or abnormal noise sources not representative of the existing noise levels were also removed as invalid. Since the Project is located in a remote area surrounded by the tundra and not exposed to heavy human development (i.e., industry), there were no specific anthropogenic noise sources identified except the activities in the existing Vault Pit and the existing exploration site, which were continuously operating during the noise survey and were considered to be normal noise sources for the Project area. During the analysis of the data, specific abnormal noise events were identified mainly by listening to the sound recordings. Other indicators used to identify sources of noise were field observations. Abnormal noise sources identified and subsequently removed included the following:

- technician activities;
- wildlife in the proximity of microphone;
- helicopter flyovers in the proximity of the microphone; and
- wind-induced microphone noise.

While all one-minute data samples recorded when wind speeds exceeded the Directive 038 wind speed limit (i.e., 15 km/h) were automatically removed during the first step of data analysis, one-minute data samples recorded at wind speeds below the Directive 038 limit were also manually removed when wind-generated noise was clearly audible (e.g., as the result of a short but intense gust).

Hourly noise levels ($L_{eq,1hr}$) were calculated for each hour of monitoring based on the valid one-minute data. The valid one-minute data were used to calculate daytime equivalent energy noise levels ($L_{eq,day}$) and nighttime equivalent energy noise levels ($L_{eq,night}$) for each location. Daytime is defined as the time period between 7:00 a.m. to 10:00 p.m., and nighttime as the time period between 10:00 p.m. to 7:00 a.m., in accordance with Directive 038 (EUB 2007). A noise monitoring survey is considered to be acceptable under Directive 038 if there are a minimum of 180 valid minutes during the daytime period and 180 valid minutes during the nighttime period.

3.0 RESULTS

This section presents the results obtained during baseline noise monitoring at receptor sites associated with the Project, as well as a description of baseline noise conditions within the Project area.

3.1 Monitoring Site R6

Monitoring site R6 was located approximately 1.5 km east from the proposed Haul Road and approximately 1.5 km from the centre of the Vault Pit. At the time of the survey, the terrain was relatively flat and covered by vegetation typical of tundra (i.e., low vegetation). In addition, the ground surface near the receptor was covered by scattered rocks. The waste rock storage area of the Vault Pit is located approximately 750 m south from the monitoring site.

The noise levels at monitoring site R6 were influenced by operations at Vault Pit, as well as noise generated by wind. Invalid noise events removed from the monitored data included technician activities, periods of high speed wind, and helicopter flyovers in the proximity of the microphone. The sound monitoring equipment deployed at R6 is shown in Photo 3-1.

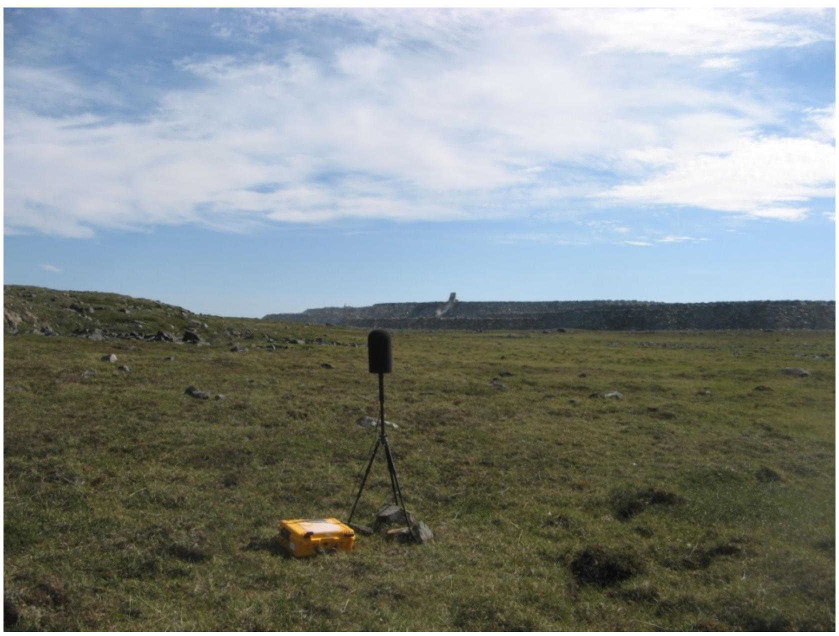


Photo 3-1: Sound Level Meter Deployed at Monitoring Site R6 (Vault Pit waste rock storage area can be seen in the background)

The individual $L_{eq,1min}$ recorded at monitoring site R6 are shown graphically in Figure 3-1. The invalid samples removed from the calculation of $L_{eq,day}$ and $L_{eq,night}$ are indicated. The weather data collected during the survey (wind speed, wind direction, temperature, and humidity) are presented in Appendix B.

Filtered hourly noise levels ($L_{eq,1hr}$) and daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) at R6 are presented in Appendix C, Table C-1. As discussed in Section 2.2.1, the $L_{eq,1hr}$ values were obtained by energy averaging the valid $L_{eq,1min}$ data. Daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) are summarized in

Table 3-1. There are more than 180 valid minutes during both the daytime and nighttime periods; therefore, the monitoring at R6 is considered acceptable according to Directive 038 criteria.

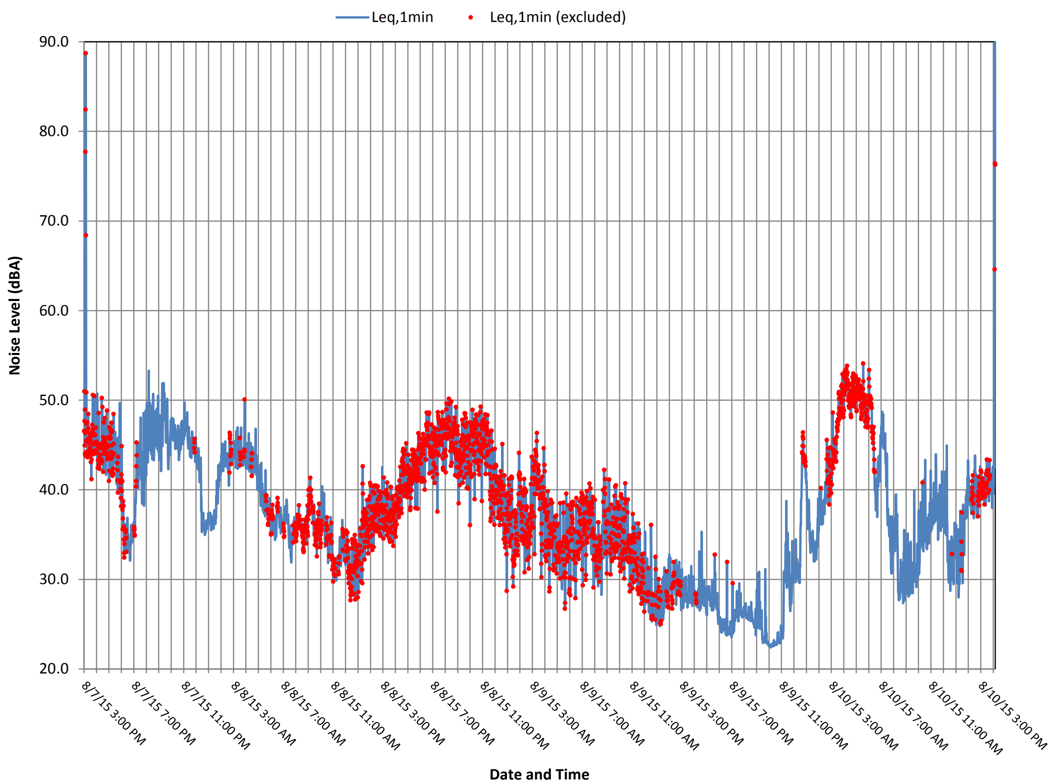


Figure 3-1: One-minute Noise Data Recorded at Monitoring Site R6

Table 3-1: Daytime and Nighttime Noise Levels at Monitoring Site R6

Period	L_{eq} [dBA]	Number of Valid Minutes
Daytime (7:00 a.m. to 10:00 p.m.)	39	1,462
Nighttime (10:00 p.m. to 7:00 a.m.)	41	814

3.2 Monitoring Site R7

Monitoring site R7 was located approximately 1.5 km east from the proposed Haul Road. The SLM was deployed at an elevated area gently sloping towards a nearby lake. The ground surface around the monitoring site at the time of the survey was covered by vegetation typical of tundra (i.e., low vegetation). In addition, the ground surface was covered with scattered rocks. The noise level at R7 was influenced by noise generated by wind and waves on the nearby lake, sporadic presence of wildlife (e.g., birds), and sporadic helicopter flyovers. Invalid noise events removed from the monitored data included technician activities, periods of extensive wind, insects and birds nearby the microphone, and helicopter flyovers in the proximity of the microphone. The sound monitoring equipment deployed at monitoring site R7 is shown in Photo 3-2.

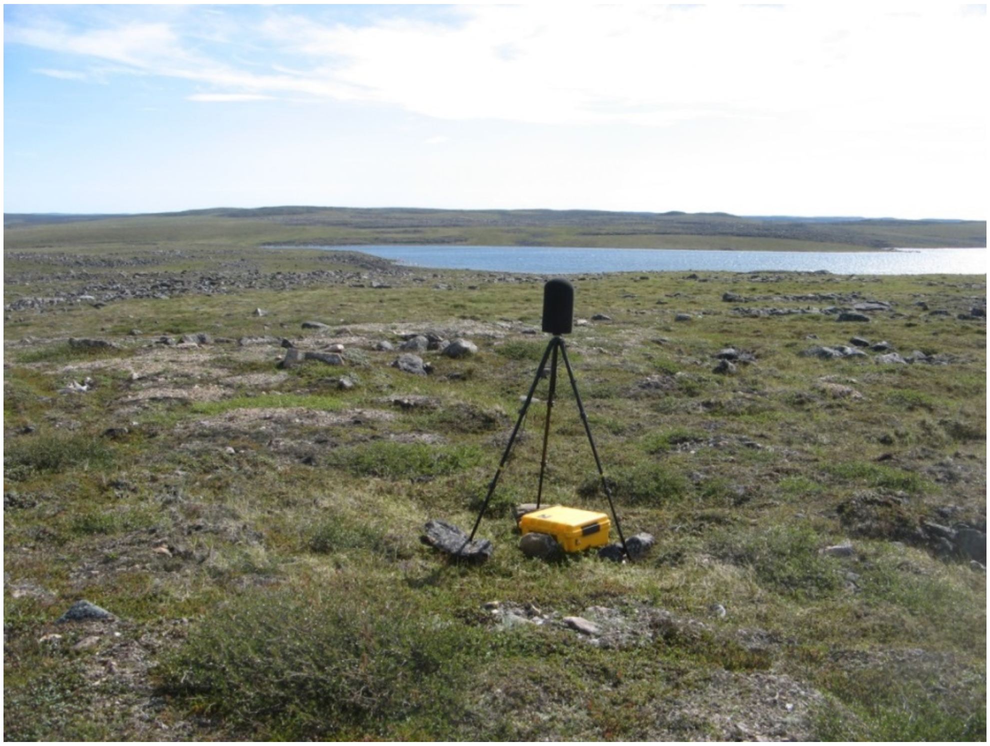


Photo 3-2: Sound Level Meter Deployed at Monitoring Site R7

The individual $L_{eq,1min}$ recorded at R7 are shown graphically in Figure 3-2. The invalid samples removed from the calculation of $L_{eq,day}$ and $L_{eq,night}$ are indicated. The weather data collected during the survey (wind speed, wind direction, temperature, and humidity) are presented in Appendix B.

Filtered hourly noise levels ($L_{eq,1hr}$) and daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) at R7 are presented in Appendix C, Table C-2. As discussed in Section 2.2.1, the $L_{eq,1hr}$ values were obtained by energy averaging the valid $L_{eq,1min}$ data. Daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) are summarized in Table 3-2. There are more than 180 valid minutes during both the daytime and nighttime periods; therefore, the monitoring at R7 is considered acceptable according to Directive 038 criteria.

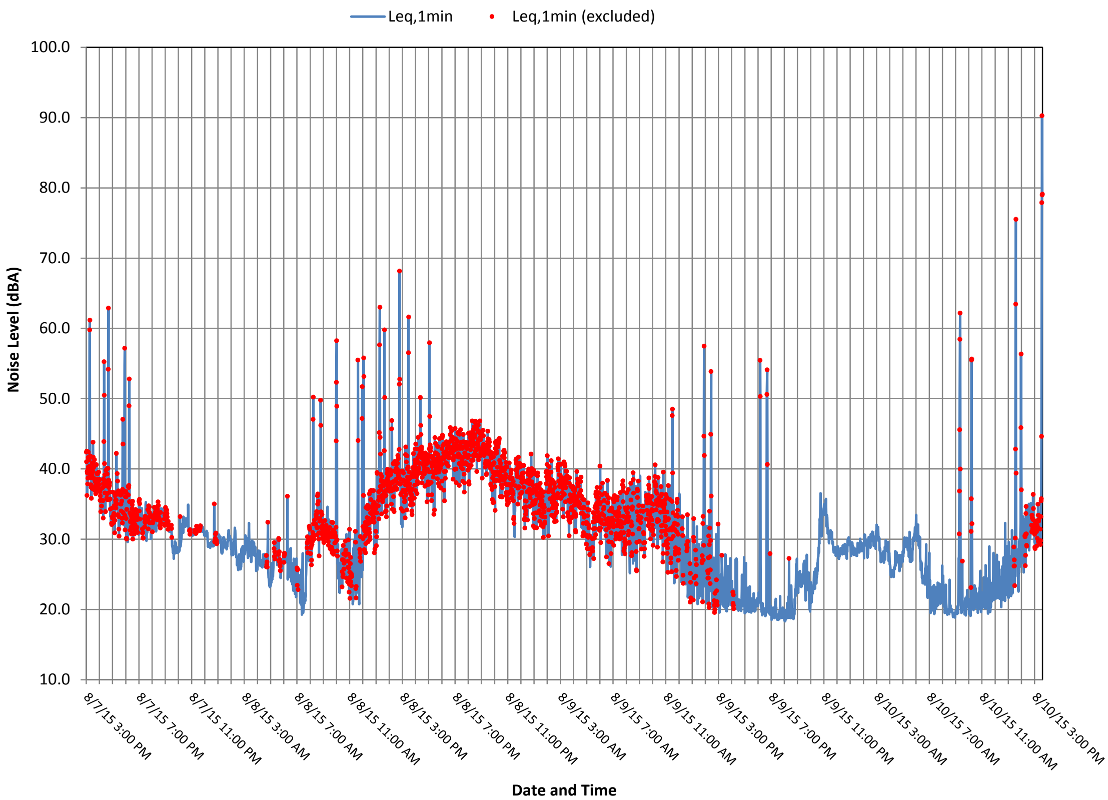


Figure 3-2: One-minute Noise Data Recorded at Monitoring Site R7

Table 3-2: Daytime and Nighttime Noise Levels at Monitoring Site R7

Period	L_{eq} [dBA]	Number of Valid Minutes
Daytime (7:00 a.m. to 10:00 p.m.)	29	1,295
Nighttime (10:00 p.m. to 7:00 a.m.)	29	1,065

3.3 Monitoring Site R8

Monitoring site R8 was located on an elevated plateau approximately 1.5 km northeast from the proposed Whale Tail Pit site. At the time of the survey, the ground surface was covered by vegetation typical of tundra (i.e., low vegetation) and covered by scattered rocks. The noise levels at R8 were influenced by noise generated by wind, operations at the proposed Whale Tail Pit site, and helicopter traffic associated with exploration activities. Invalid noise events removed from the monitored data included technician activities, periods of extensive wind, and helicopter flyovers in the proximity of the microphone. Exploration activities (including several exploration drill rigs) at the proposed satellite deposit were continuously operating during the survey. However, the influence of these potential noise sources was identified not to be dominant at R8 through listening to the sound recordings. The sound monitoring equipment deployed at R8 is shown in Photo 3-3.

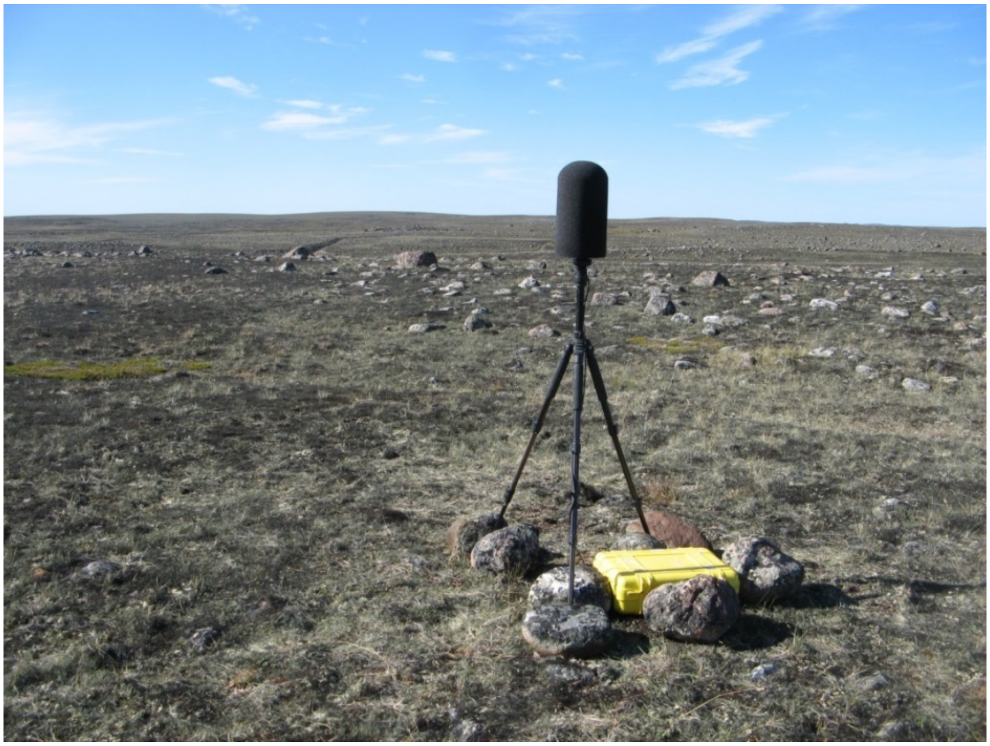


Photo 3-3: Sound Level Meter Deployed at Monitoring Site R8

The individual $L_{eq,1min}$ recorded at R8 are shown graphically in Figure 3-3. The invalid samples removed from the calculation of $L_{eq,day}$ and $L_{eq,night}$ are indicated. The weather data collected during the survey (wind speed, wind direction, temperature, and humidity) are presented in Appendix B.

Filtered hourly noise levels ($L_{eq,1hr}$) and daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) at R8 are presented in Appendix C, Table C-3. As discussed in Section 2.2.1, the $L_{eq,1hr}$ values were obtained by energy averaging the valid $L_{eq,1min}$ data. Daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) are summarized in Table 3-3. There are more than 180 valid minutes during both the daytime and nighttime periods; therefore, the monitoring at R8 is considered acceptable according to Directive 038 criteria.

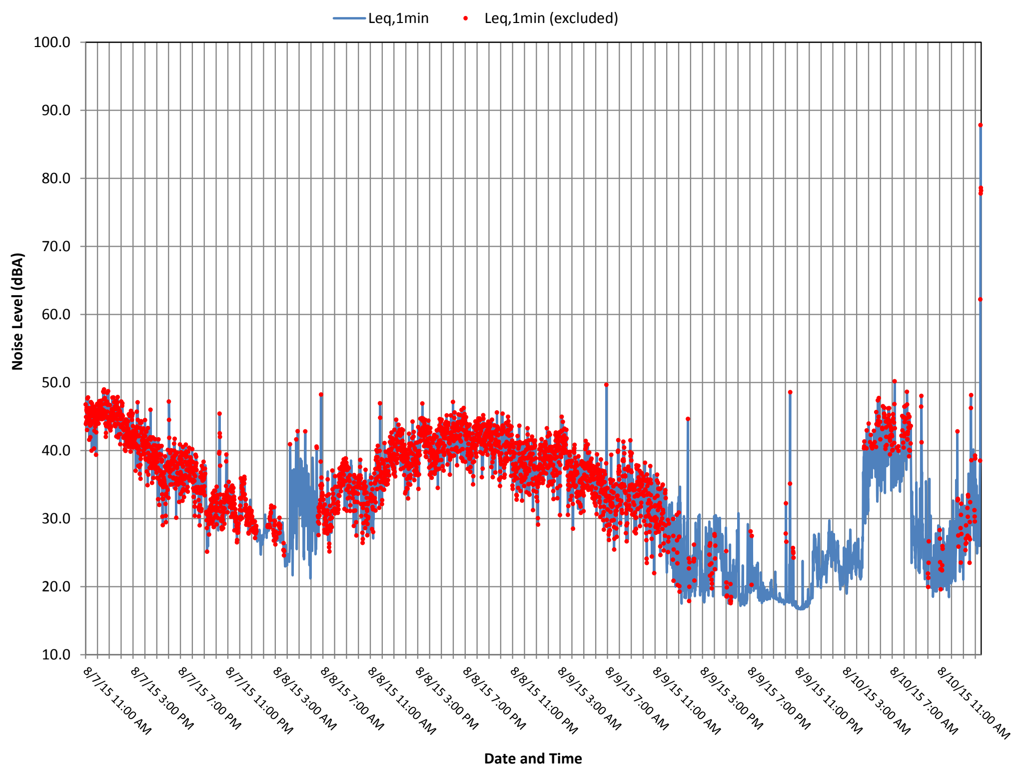


Figure 3-3: One-minute Noise Data Recorded at Monitoring Site R8

Table 3-3: Daytime and Nighttime Noise Levels at Monitoring Site R8

Period	L_{eq} [dBA]	Number of Valid Minutes
Daytime (7:00 a.m. to 10:00 p.m.)	30	1,006
Nighttime (10:00 p.m. to 7:00 a.m.)	31	761

3.4 Monitoring Site R9

Monitoring site R9 was located approximately 1.5 km northwest from the proposed Whale Tail Pit. At the time of the survey, the ground surface was covered by vegetation typical of tundra (i.e., low vegetation) and covered by scattered rocks. The noise levels at R9 were influenced by noise generated by wind, operations at the exploration camp, and helicopter traffic associated with exploration activities. Invalid noise events removed from the monitored data included technician activities, periods of high wind speeds, and helicopter flyovers in the proximity of the microphone. Exploration activities (including several exploration drill rigs) at the proposed Whale Tail Pit satellite deposit were continuously operating during the survey. However, the influence of these potential noise sources was identified not to be dominant at R9 through listening to the sound recordings. The sound monitoring equipment deployed at R9 is shown in Photo 3-4.

Photo 3-4: Sound Level Meter Deployed at Monitoring Site R9

The individual $L_{eq,1min}$ recorded at R9 are shown graphically in Figure 3-4. The invalid samples removed from the calculation of $L_{eq,day}$ and $L_{eq,night}$ are indicated. The weather data collected during the survey (wind speed, wind direction, temperature, and humidity) are presented in Appendix B.

Filtered hourly noise levels ($L_{eq,1hr}$) and daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) at R9 are presented in Appendix C, Table C-4. As discussed in Section 2.2.1, the $L_{eq,1hr}$ values were obtained by energy averaging the valid $L_{eq,1min}$ data. Daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) are summarized in Table 3-4. There are more than 180 valid minutes during both the daytime and nighttime periods; therefore, the monitoring at R9 is considered acceptable according to Directive 038 criteria.

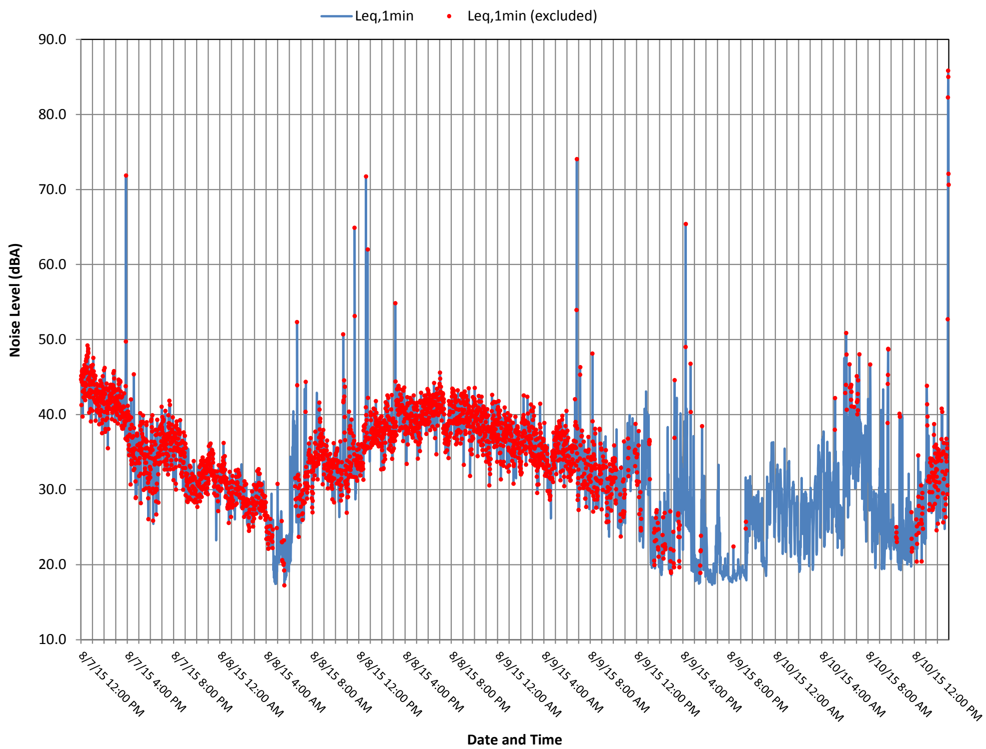


Figure 3-4: One-minute Noise Data Recorded at Monitoring Site R9

Table 3-4: Daytime and Nighttime Noise Levels at Monitoring Site R9

Period	L_{eq} [dBA]	Number of Valid Minutes
Daytime (7:00 a.m. to 10:00 p.m.)	31	1,089
Nighttime (10:00 p.m. to 7:00 a.m.)	31	747

4.0 SUMMARY

Four monitoring locations were chosen to characterize the baseline noise levels for the exploration site and access road of the Project. In future the monitoring locations identified and evaluated for baseline purposes for the Project may be relocated depending on operational requirements.

The results indicate that the baseline noise levels in the area of the proposed Project, except for the area adjacent to Vault Pit operations (i.e., R6), are primarily influenced by noise generated by natural noise sources, such as wind.

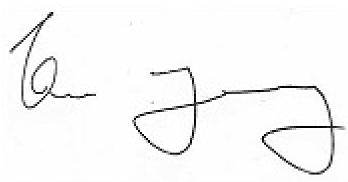
Table 4-1 summarizes the daytime and nighttime noise levels at the monitoring sites for the Project. The baseline noise levels established as result of the noise monitoring program are considered representative of the baseline noise conditions in the area associated with the Project. The results presented in Table 4-1 indicate that the noise levels measured at noise monitoring sites varied between 29 dBA and 39 dBA for daytime, and between 29 dBA and 41 dB for nighttime, respectively.

Table 4-1: Daytime and Nighttime Noise Levels at Project Monitoring Sites

Noise Monitoring Site	$L_{eq,day}$ [dBA]	$L_{eq,\ night}$ [dBA]
R6	39	41
R7	29	29
R8	30	31
R9	31	31

Report Signature Page

GOLDER ASSOCIATES LTD.



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Senior Acoustic Engineer

ZY/VY/AF/DF/jr

https://capws.golder.com/sites/p1524321amaruqwhaletailbaselineandeis/baseline/p1500 noise/noise reporting/doc 031-1524321 whale tail baseline noise report ver a.docx

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APPENDIX A

Calibration Results

This Appendix presents the calibration results for the sound level meters used at the monitoring sites for the Project baseline noise measurements. The Brüel and Kjær Type 4231 calibrator emits a 1,000 Hz tone at a sound pressure level of 94 dB. For a calibration to be valid, the sound level meter must read 94 ± 1 dB.

At each monitoring site, one initial calibration before recording and one final calibration after recording were made for the sound level meter. The results of the calibration process at each monitoring station are presented graphically below with the measured sound pressure level during calibration shown as a blue line (the red lines shown in the figures are cursors and are an artifact of figure generation via screen capture from the data analysis software).

1.0 CALIBRATION RECORD

1.1 Monitoring Site R6

Each of the sound level meter initial and final calibration measurements was at 94 ± 1 dB, as indicated on Figure A-1 and Figure A-2, respectively, at noise monitoring site R6.

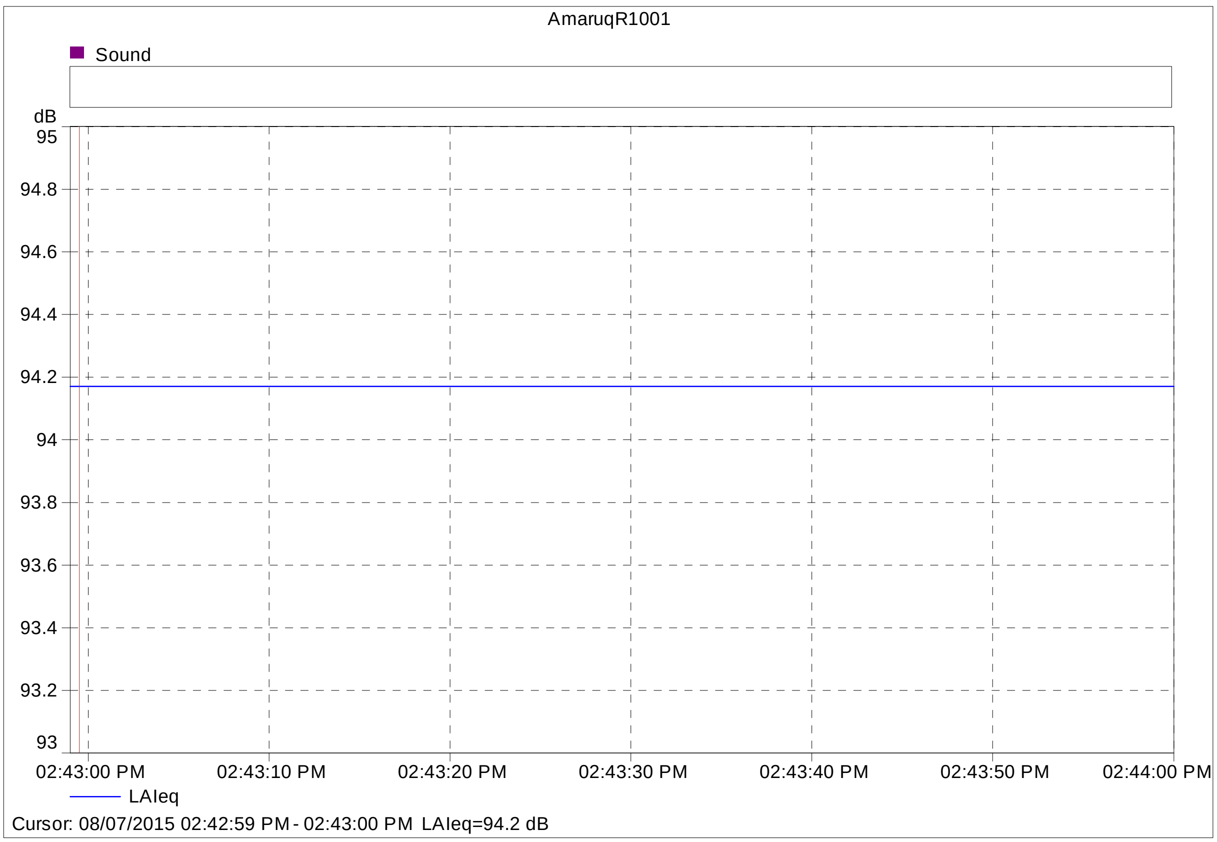

Figure A-1 Monitoring Site R6: Initial Calibration

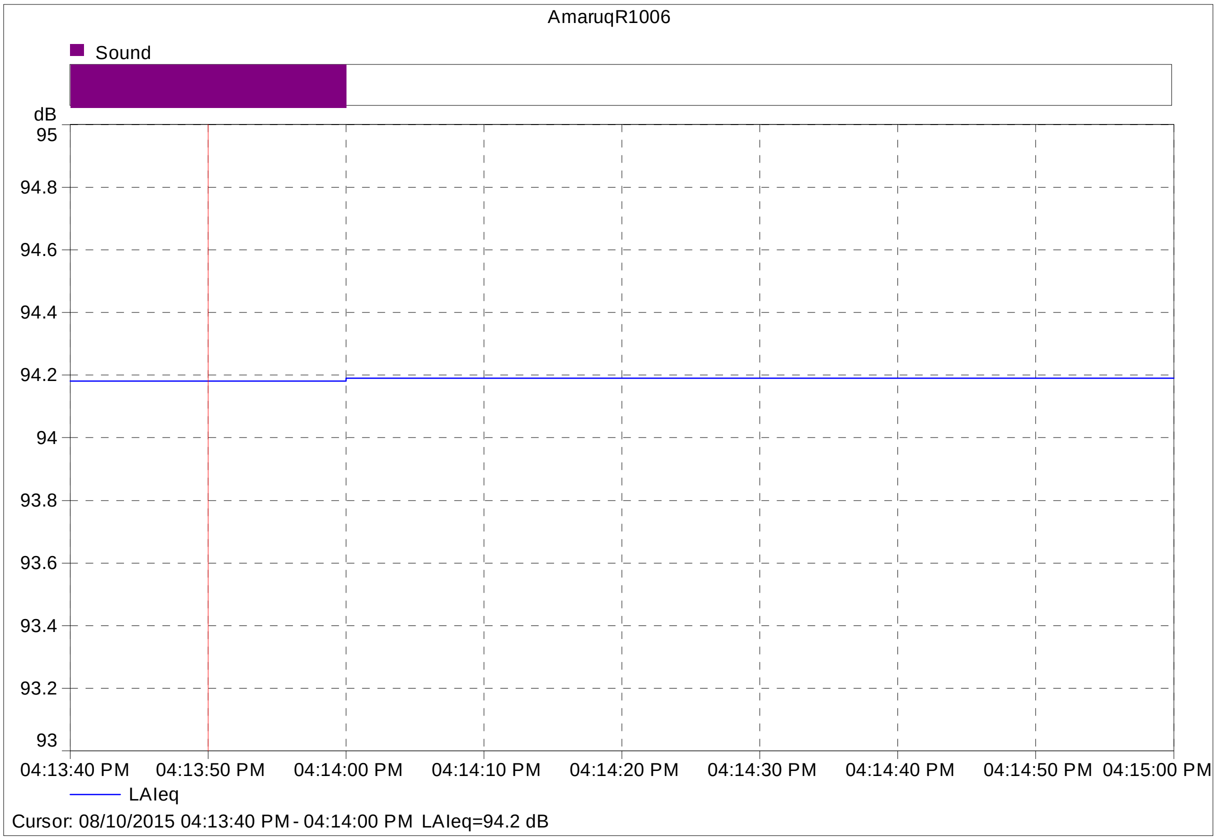

Figure A-2 Monitoring Site R6: Final Calibration

1.2 Monitoring Site R7

Each of the sound level meter initial and final calibration measurements was at 94 ± 1 dB, as indicated on Figure A-3 and Figure A-4, respectively, at noise monitoring site R7.

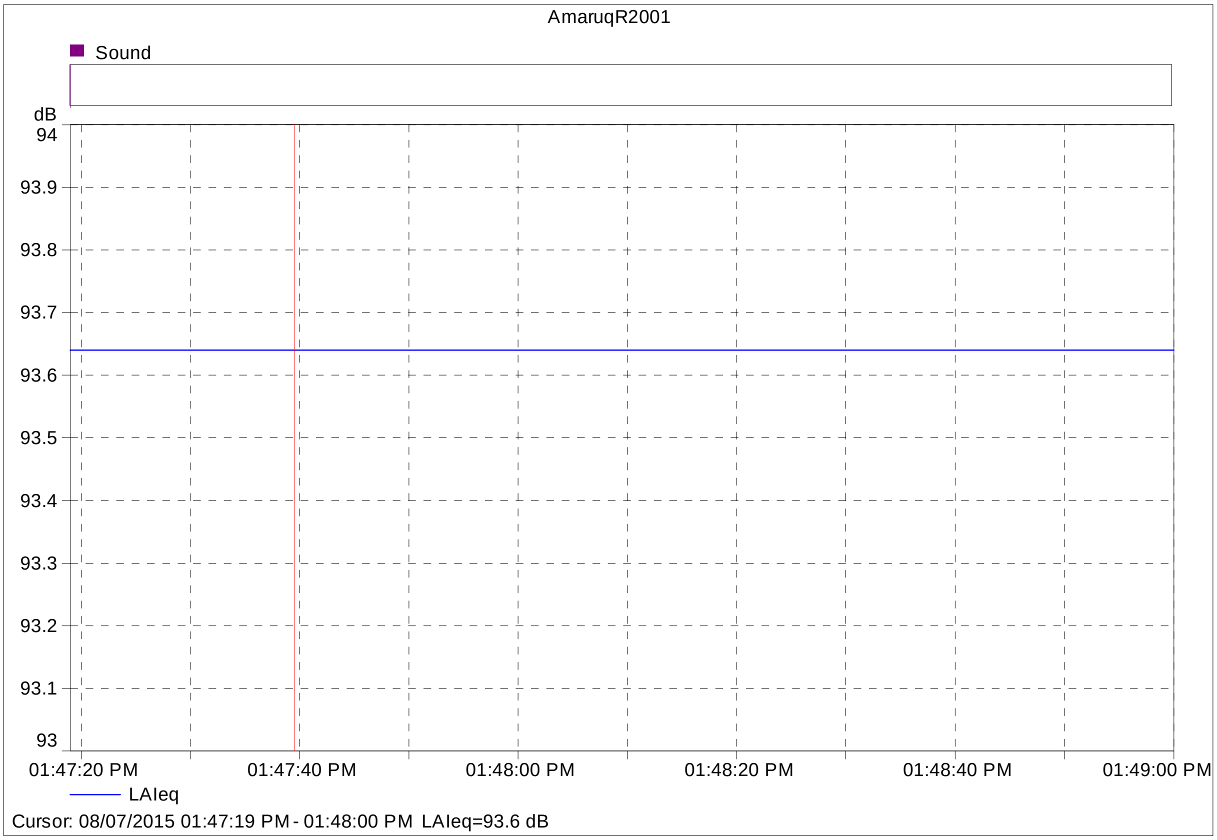

Figure A-3 Monitoring Site R7: Initial Calibration

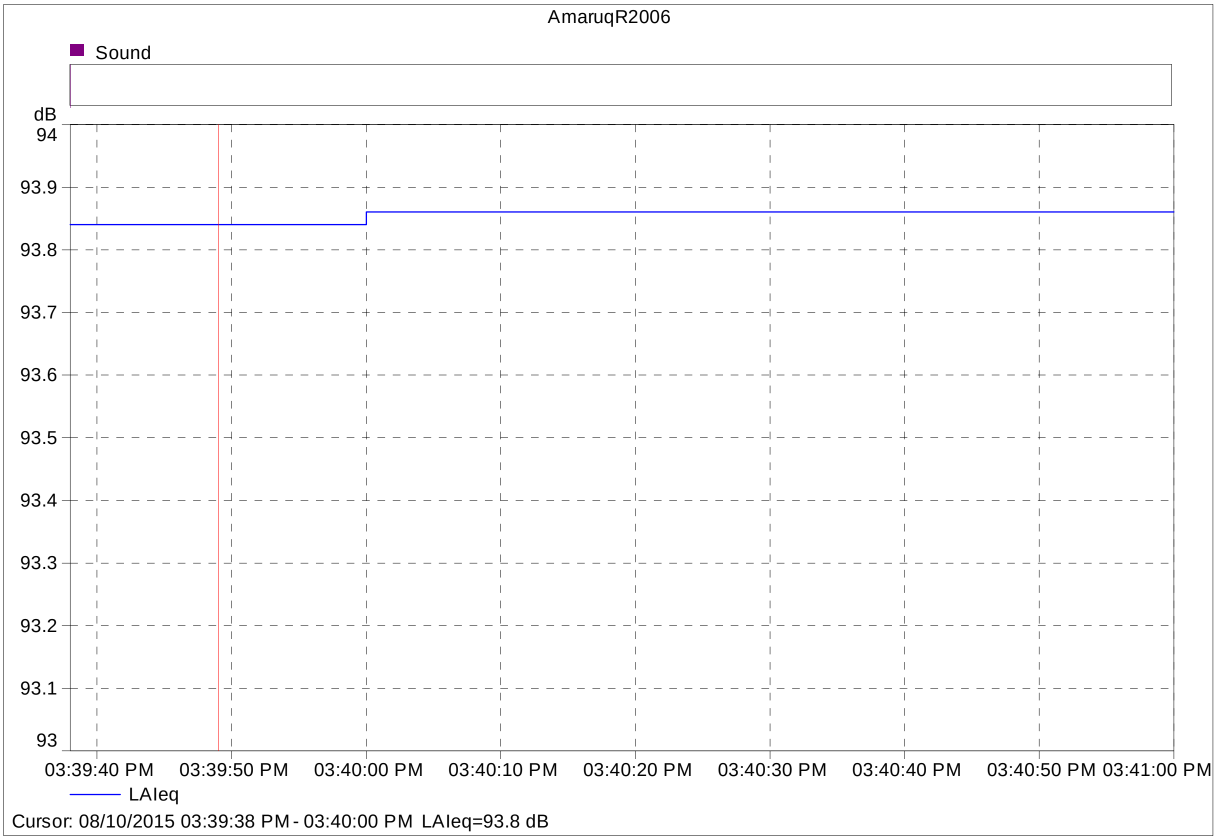

Figure A-4 Monitoring Site R7: Final Calibration

1.3 Monitoring Site R8

Each of the sound level meter initial and final calibration measurements was at 94 ± 1 dB, as indicated on Figure A-5 and Figure A-6, respectively, at noise monitoring site R8.

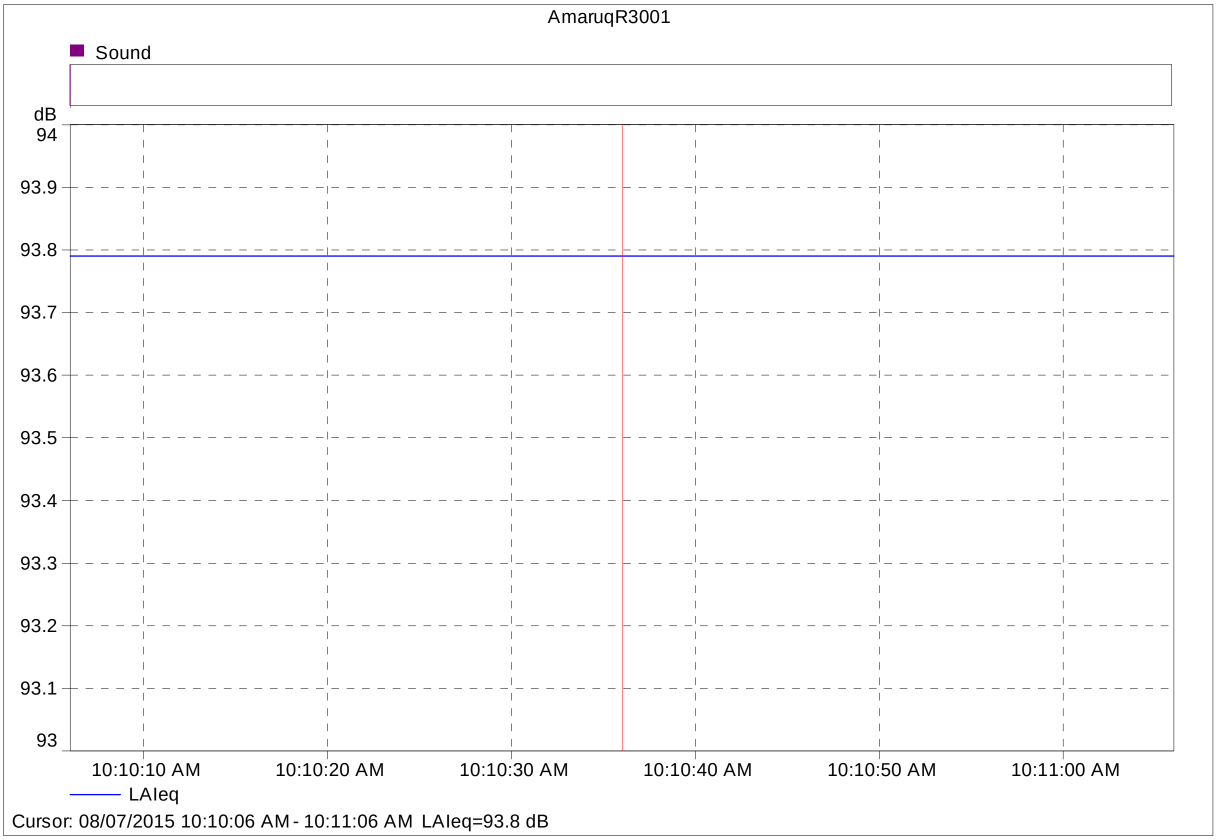

Figure A-5 Monitoring Site R8: Initial Calibration

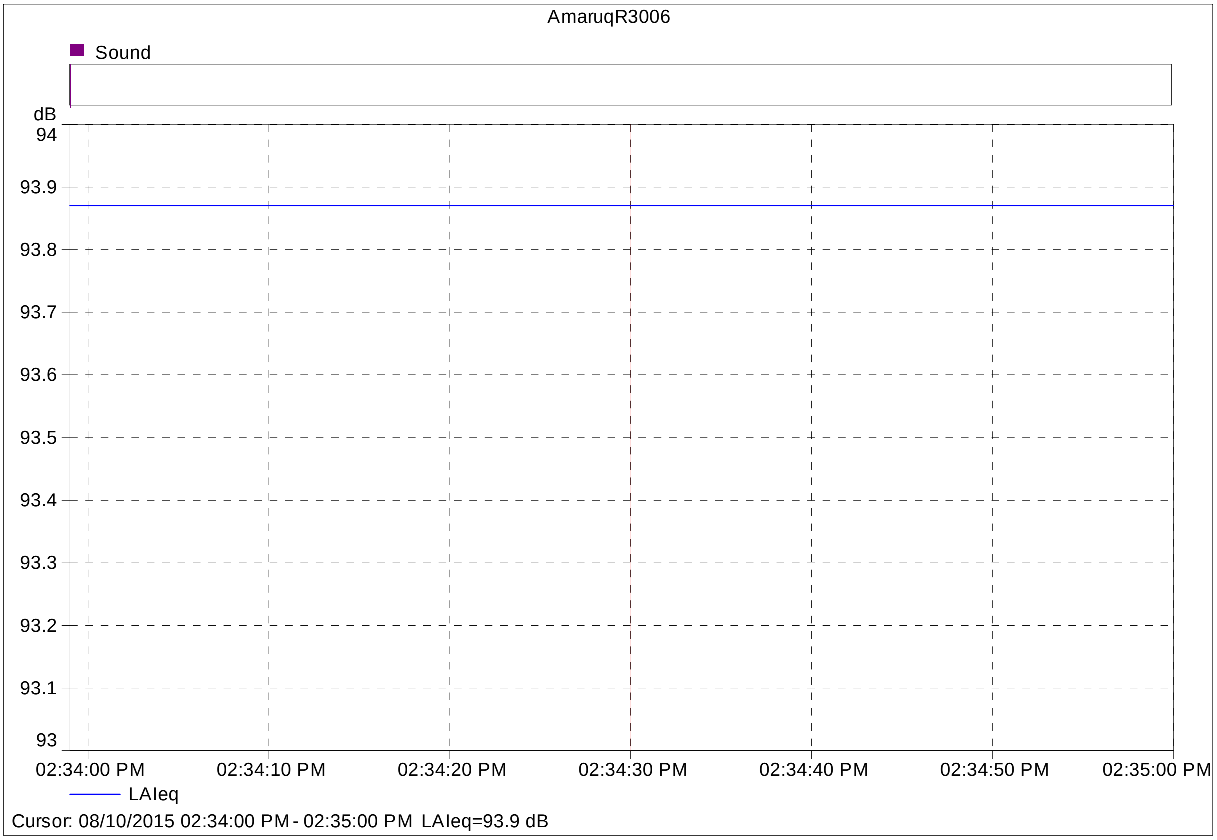

Figure A-6 Monitoring Site R8: Final Calibration

1.4 Monitoring Site R9

Each of the sound level meter initial and final calibration measurements was at 94 ± 1 dB, as indicated on Figure A-7 and Figure A-8, respectively, at noise monitoring site R9.

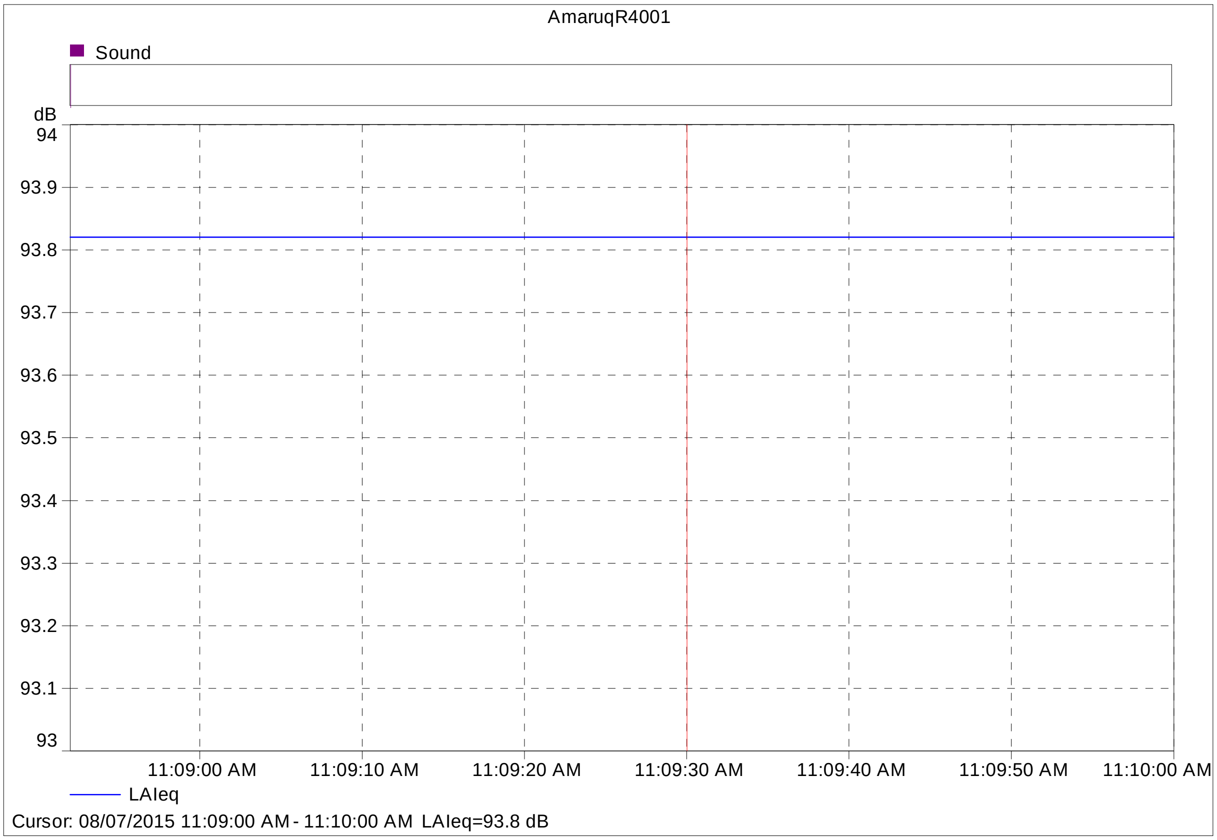

Figure A-7 Monitoring Site R9: Initial Calibration

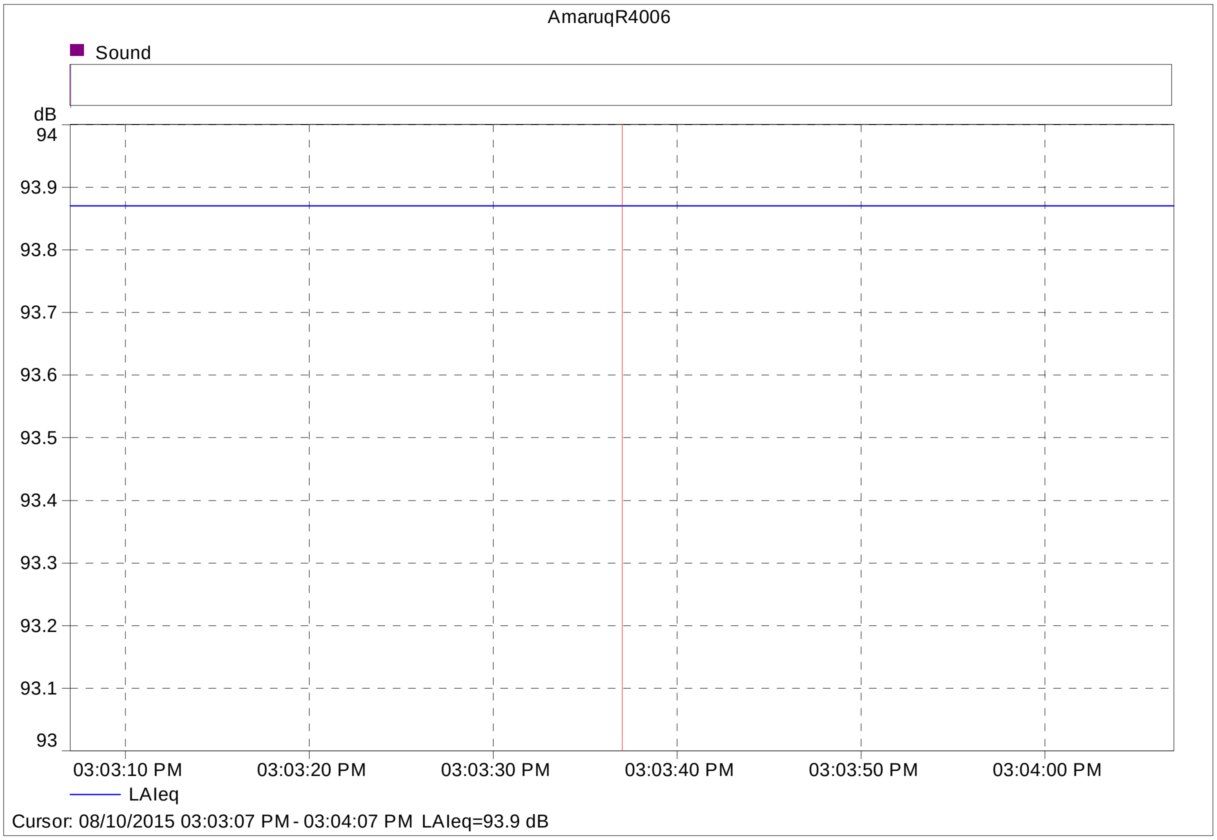

Figure A-8 Monitoring Site R9: Final Calibration

APPENDIX B

Weather Data

Appendix B provides information regarding weather conditions observed at each monitoring site during the noise baseline measurements for the Project.

1.0 WEATHER DATA

1.1 Monitoring Site R6

Figure B-1 shows the wind speed and wind direction recorded at monitoring site R6. The acceptable limit of wind speed (15 km/h) for the data analysis based on Directive 038 is shown in Figure B-1 as well.

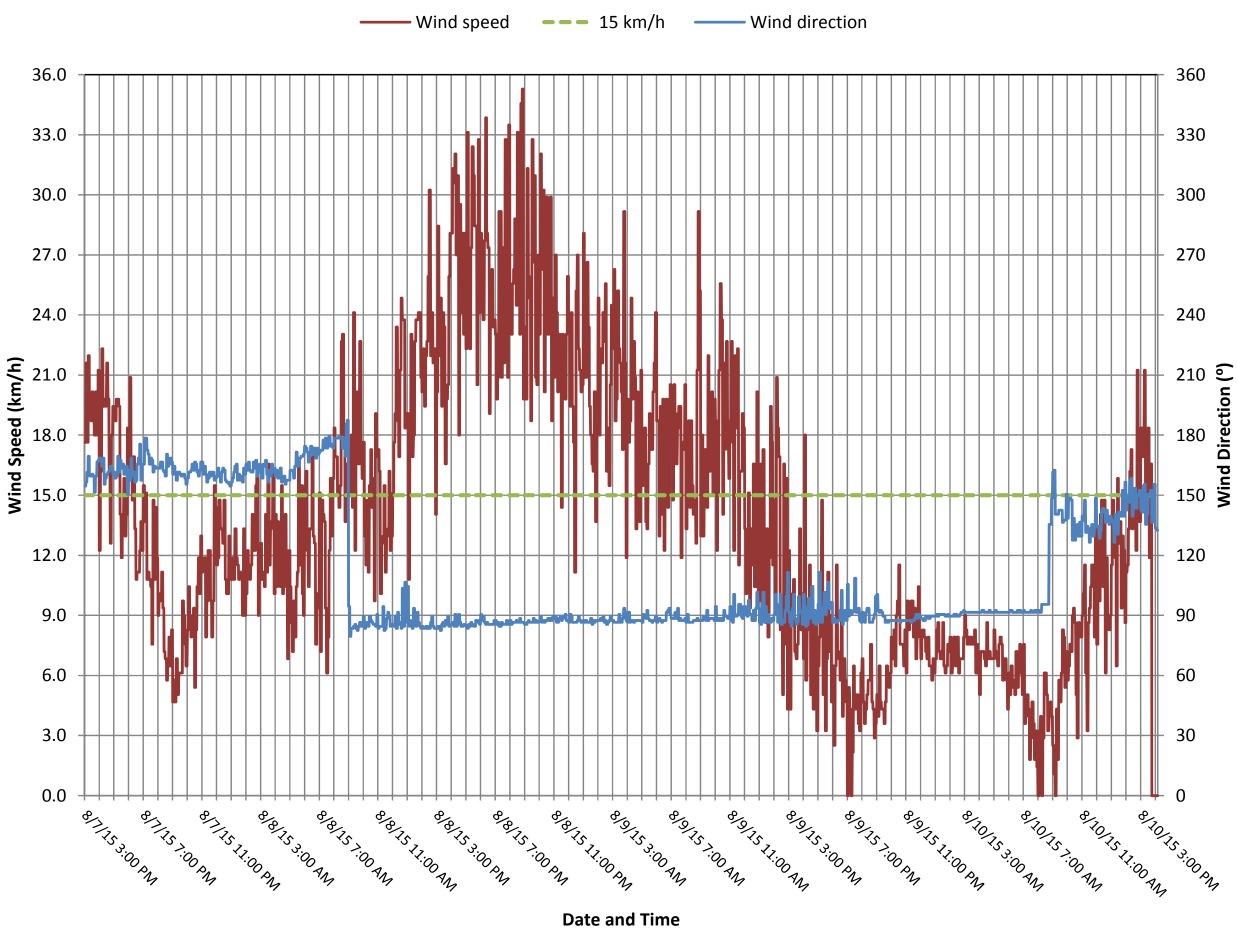

Figure B-1 Wind Speed and Direction Recorded at Monitoring Site R6

Figure B-2 shows the temperature and humidity measured at R6.

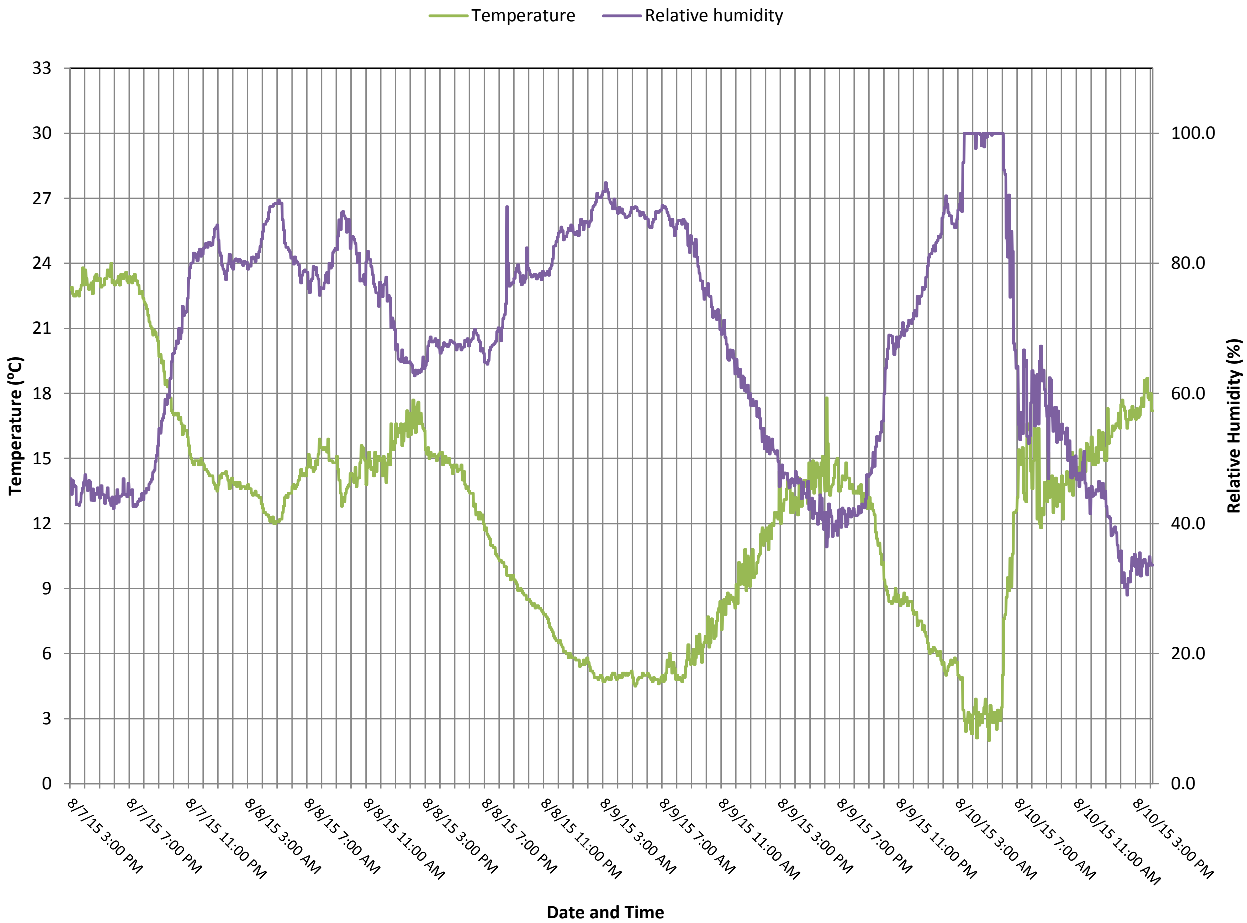

Figure B-2 Temperature and Humidity Measured at Monitoring Site R6

1.2 Monitoring Site R7

Figure B-3 shows the wind speed and wind direction recorded at monitoring site R7. The acceptable limit of wind speed (15 km/h) for the data analysis based on Directive 038 is shown in Figure B-3 as well.

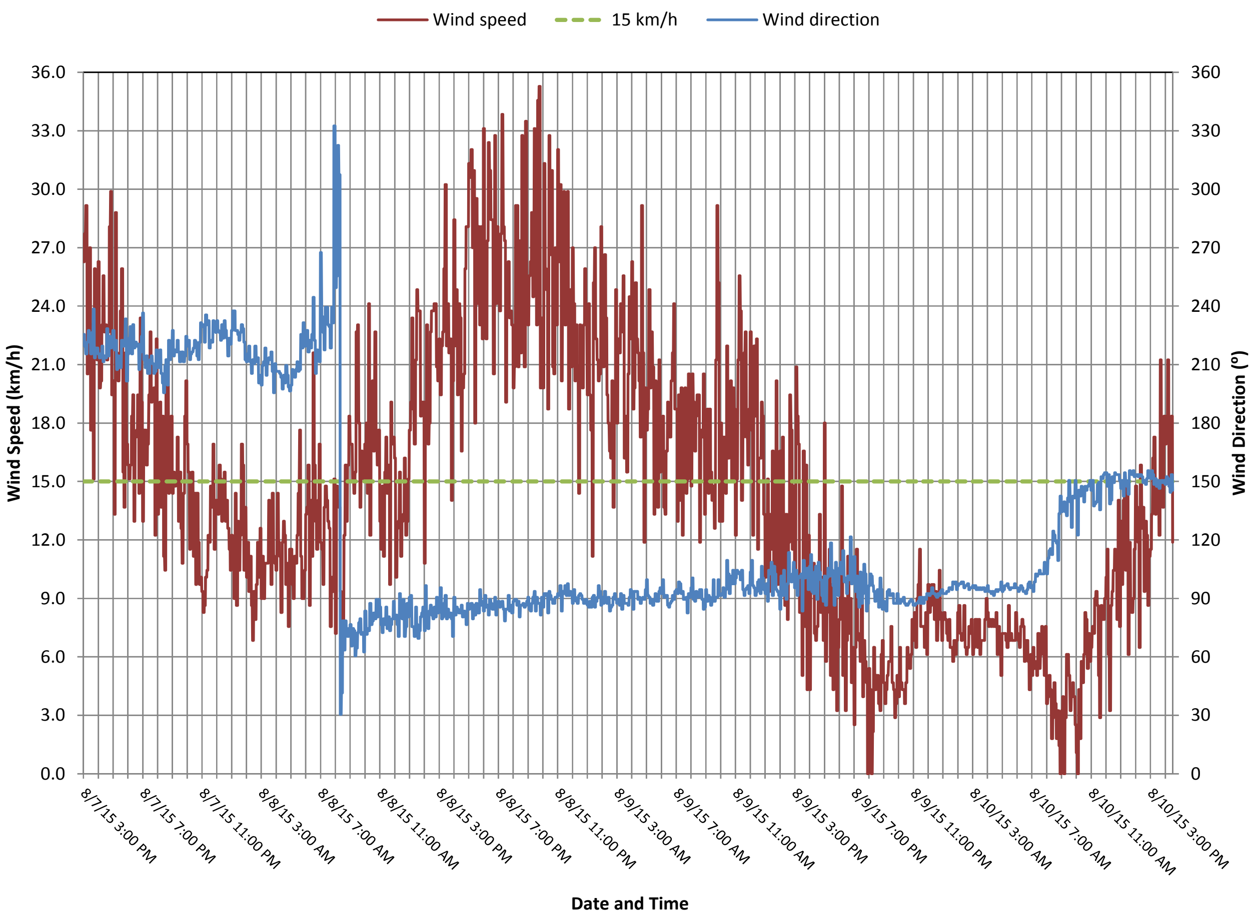

Figure B-3 Wind Speed and Direction Recorded at Monitoring Site R7

Figure B-4 shows the temperature and humidity measured at R7.

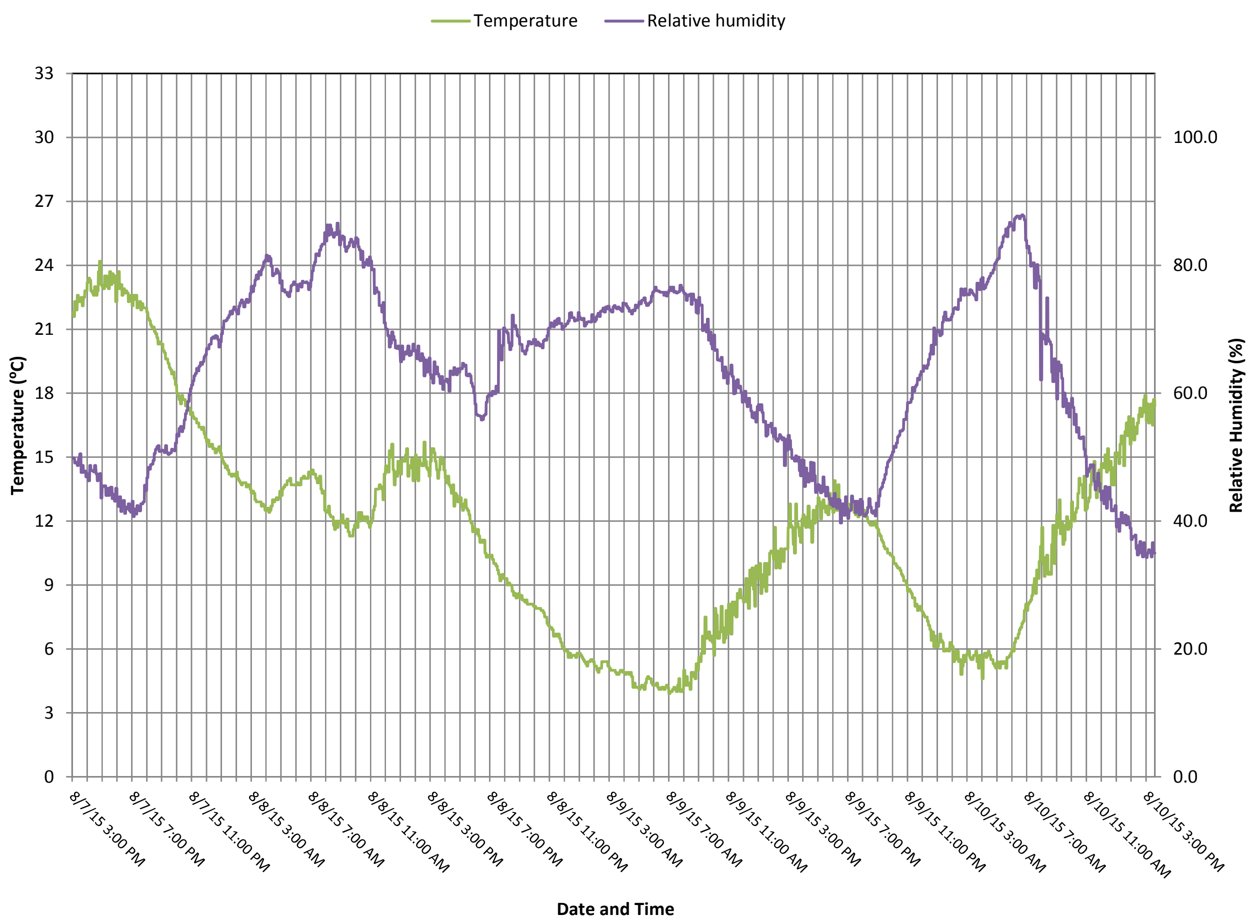

Figure B-4 Temperature and Humidity Measured at Monitoring Site R7

1.3 Monitoring Site R8

Figure B-5 shows the wind speed and wind direction recorded at monitoring site R8. The acceptable limit of wind speed (15 km/h) for the data analysis based on Directive 038 is shown in Figure B-5 as well.

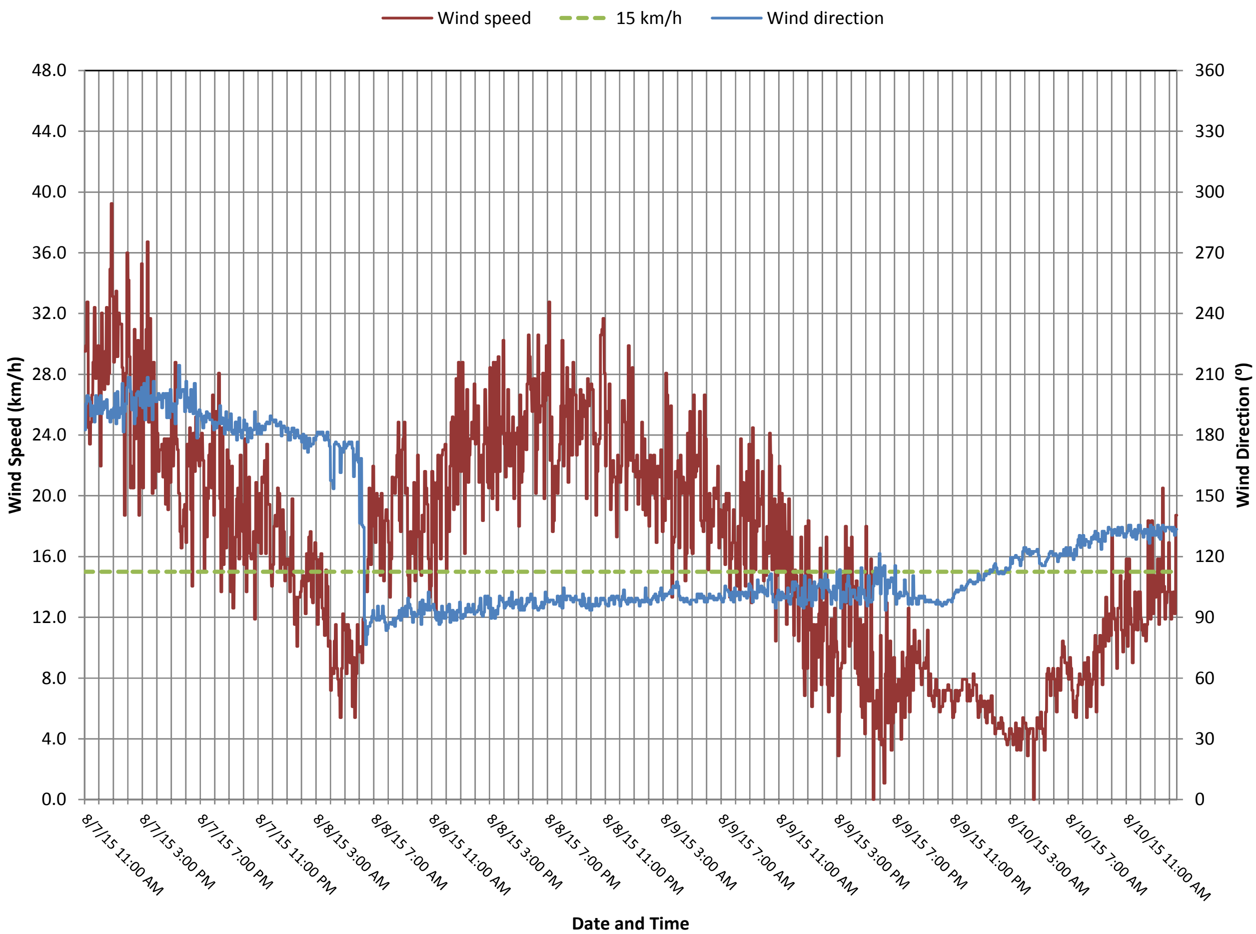

Figure B-5 Wind Speed and Direction Recorded at Monitoring Site R8

Figure B-6 shows the temperature and humidity measured at R8.

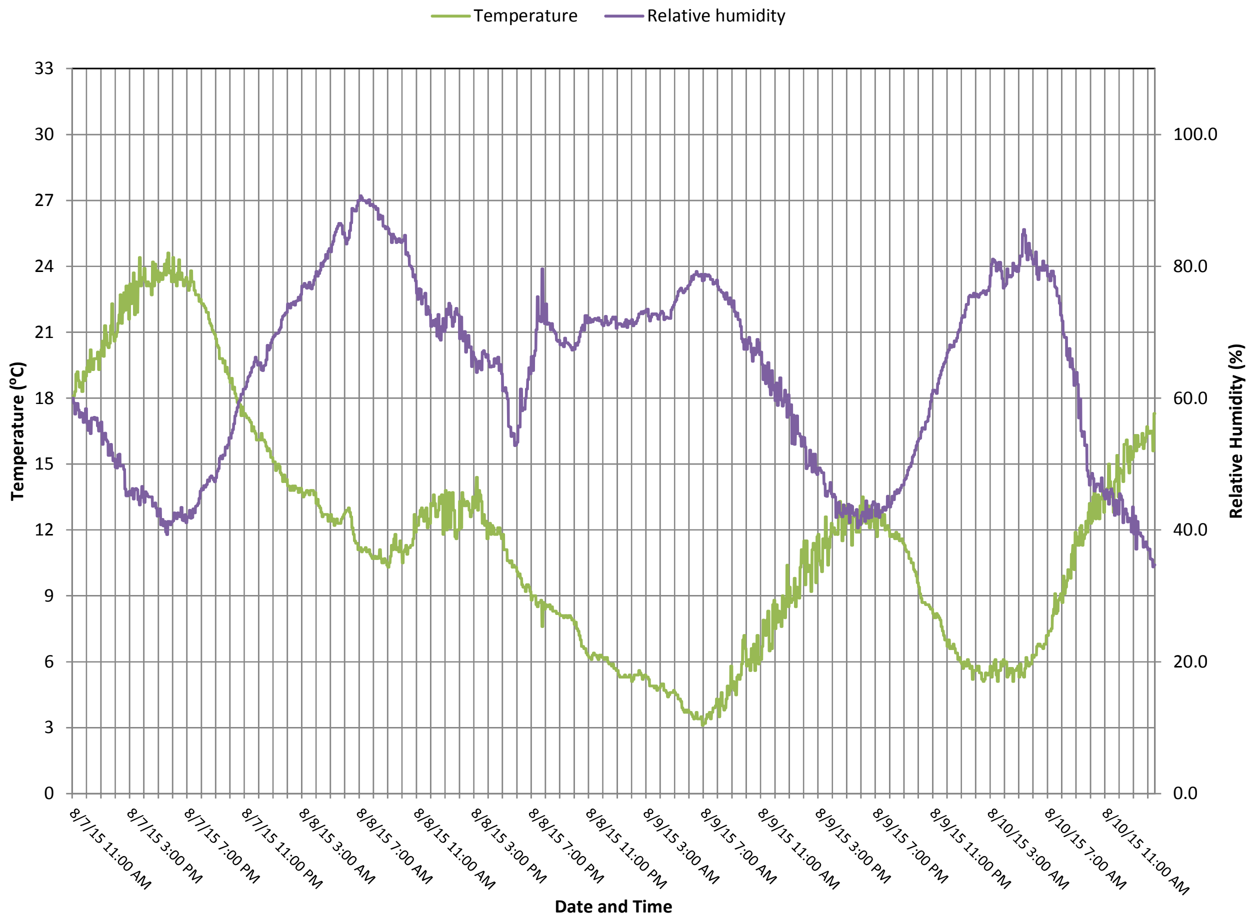

Figure B-6 Temperature and Humidity Measured at Monitoring Site R8

1.4 Monitoring Location R9

Figure B-7 shows the wind speed and wind direction recorded at monitoring site R9. The acceptable limit of wind speed (15 km/h) for the data analysis based on Directive 038 is shown in Figure B-7 as well.

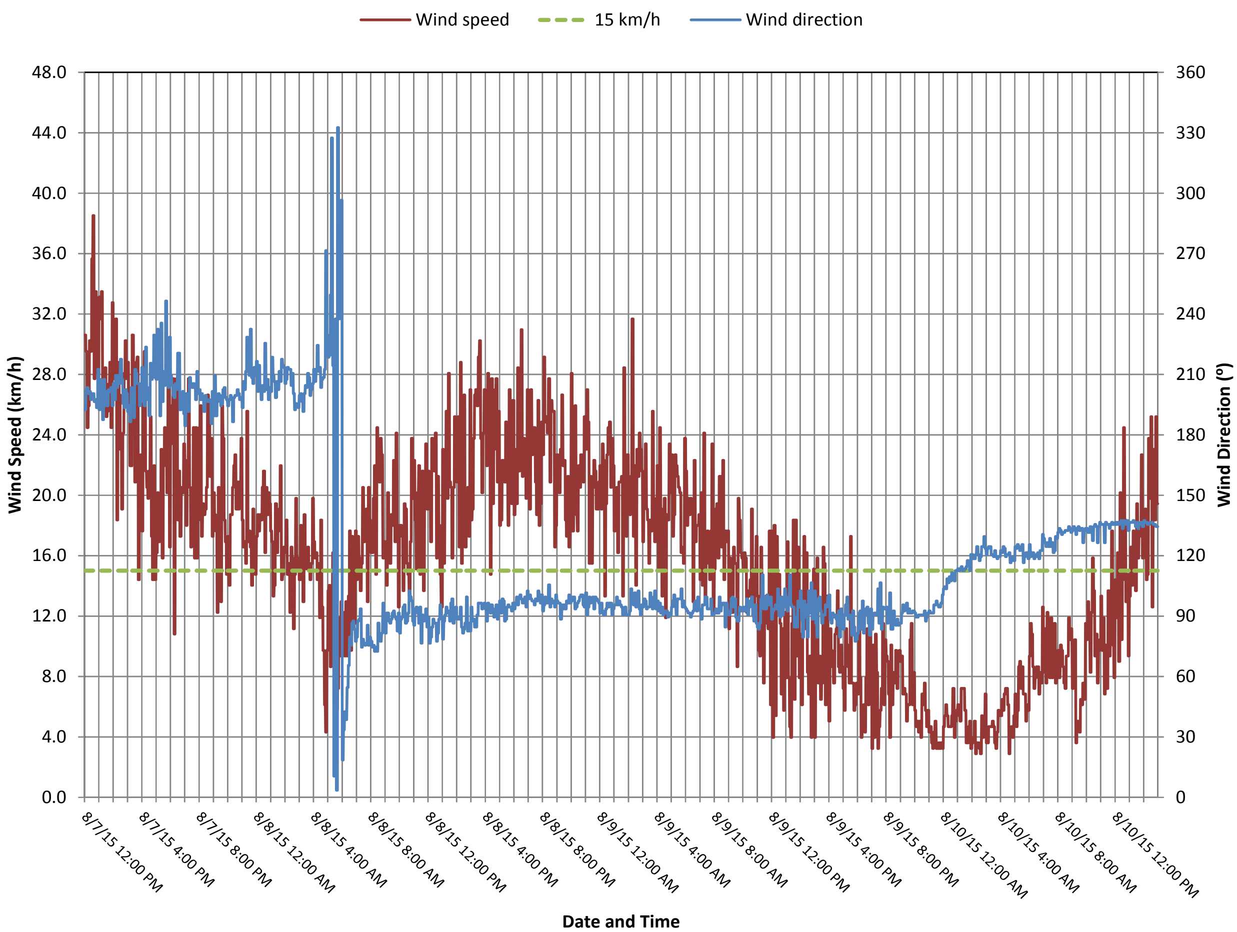

Figure B-7 Wind Speed and Direction Recorded at Monitoring Site R9

Figure B-8 shows the temperature and humidity measured at R9.

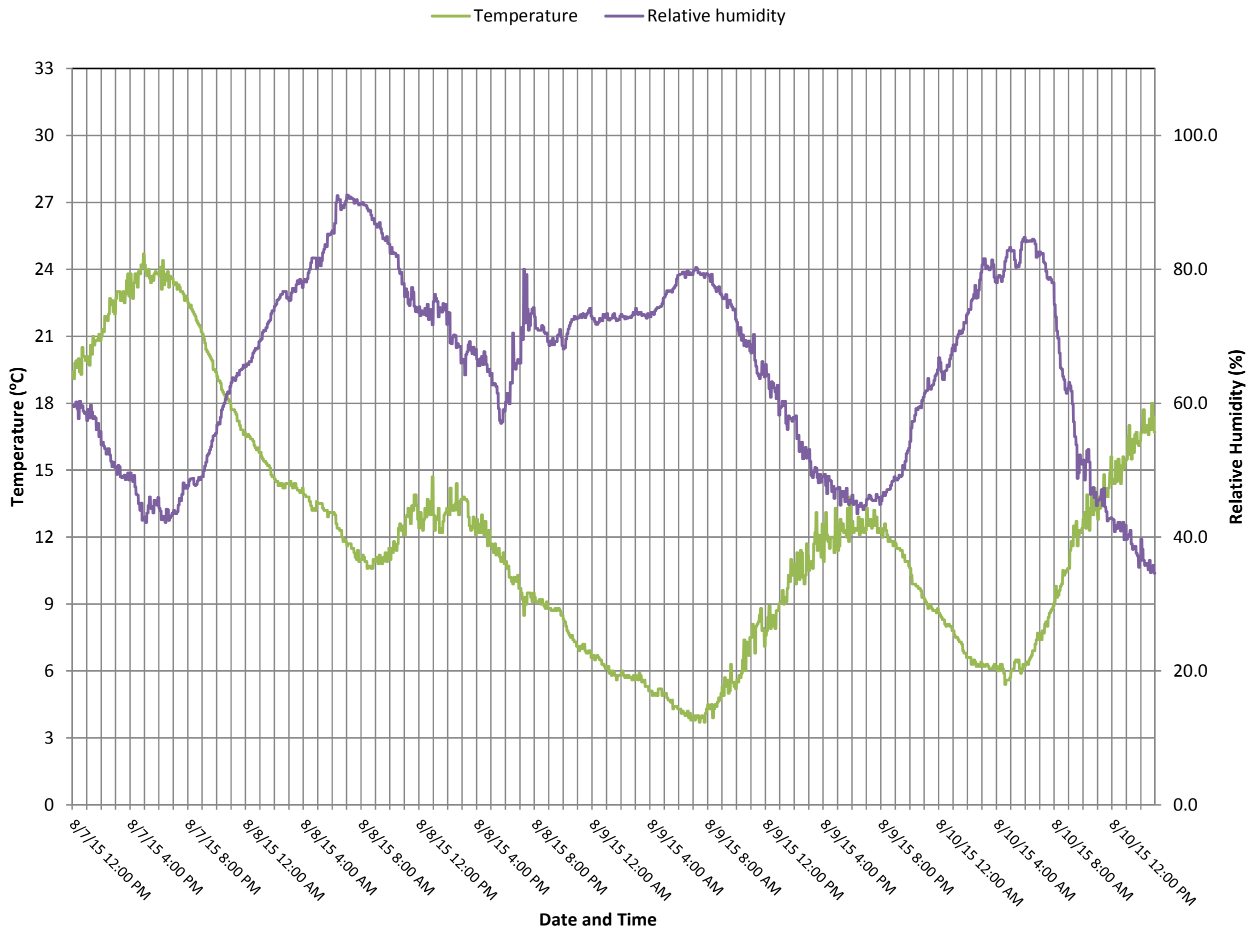

Figure B-8 Temperature and Humidity Measured at Monitoring Site R9

APPENDIX C

Noise Data

Filtered hourly noise levels ($L_{eq,1hr}$) and daytime and nighttime noise levels ($L_{eq,day}$ and $L_{eq,night}$) at R6, R7, R8, and R9 are presented in Tables C-1, C-2, C-3, and C-4, respectively. A count of the one-minute noise data recorded, including a breakdown for the daytime and nighttime periods are also presented.

Table C-1: Filtered Hourly Noise Levels at Monitoring Site R6

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
08/07/2015	3:00 p.m.	No Valid Data	0
08/07/2015	4:00 p.m.	46	10
08/07/2015	5:00 p.m.	45	25
08/07/2015	6:00 p.m.	35	40
08/07/2015	7:00 p.m.	43	50
08/07/2015	8:00 p.m.	47	60
08/07/2015	9:00 p.m.	47	60
08/07/2015	10:00 p.m.	46	60
08/07/2015	11:00 p.m.	46	55
08/08/2015	12:00 a.m.	40	60
08/08/2015	1:00 a.m.	39	60
08/08/2015	2:00 a.m.	43	50
08/08/2015	3:00 a.m.	44	50
08/08/2015	4:00 a.m.	43	55
08/08/2015	5:00 a.m.	39	50
08/08/2015	6:00 a.m.	36	45
08/08/2015	7:00 a.m.	36	45
08/08/2015	8:00 a.m.	36	10
08/08/2015	9:00 a.m.	38	10
08/08/2015	10:00 a.m.	37	30
08/08/2015	11:00 a.m.	33	40
08/08/2015	12:00 p.m.	No Valid Data	0
08/08/2015	1:00 p.m.	33	5
08/08/2015	2:00 p.m.	40	5
08/08/2015	3:00 p.m.	No Valid Data	0
08/08/2015	4:00 p.m.	No Valid Data	0
08/08/2015	5:00 p.m.	No Valid Data	0
08/08/2015	6:00 p.m.	No Valid Data	0
08/08/2015	7:00 p.m.	No Valid Data	0
08/08/2015	8:00 p.m.	No Valid Data	0
08/08/2015	9:00 p.m.	No Valid Data	0
08/08/2015	10:00 p.m.	No Valid Data	0
08/08/2015	11:00 p.m.	45	5
08/09/2015	12:00 a.m.	41	5
08/09/2015	1:00 a.m.	36	2
08/09/2015	2:00 a.m.	No Valid Data	0

Table C-1: Filtered Hourly Noise Levels at Monitoring Site R6 (continued)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
08/09/2015	3:00 a.m.	No Valid Data	0
08/09/2015	4:00 a.m.	35	9
08/09/2015	5:00 a.m.	32	10
08/09/2015	6:00 a.m.	33	8
08/09/2015	7:00 a.m.	34	5
08/09/2015	8:00 a.m.	34	20
08/09/2015	9:00 a.m.	35	15
08/09/2015	10:00 a.m.	34	7
08/09/2015	11:00 a.m.	34	10
08/09/2015	12:00 p.m.	29	44
08/09/2015	1:00 p.m.	28	40
08/09/2015	2:00 p.m.	30	35
08/09/2015	3:00 p.m.	29	60
08/09/2015	4:00 p.m.	28	55
08/09/2015	5:00 p.m.	28	59
08/09/2015	6:00 p.m.	25	59
08/09/2015	7:00 p.m.	26	59
08/09/2015	8:00 p.m.	26	60
08/09/2015	9:00 p.m.	25	60
08/09/2015	10:00 p.m.	23	60
08/09/2015	11:00 p.m.	31	60
08/10/2015	12:00 a.m.	36	43
08/10/2015	1:00 a.m.	36	60
08/10/2015	2:00 a.m.	38	36
08/10/2015	3:00 a.m.	No Valid Data	0
08/10/2015	4:00 a.m.	No Valid Data	0
08/10/2015	5:00 a.m.	No Valid Data	0
08/10/2015	6:00 a.m.	42	31
08/10/2015	7:00 a.m.	43	60
08/10/2015	8:00 a.m.	33	60
08/10/2015	9:00 a.m.	32	60
08/10/2015	10:00 a.m.	37	59
08/10/2015	11:00 a.m.	38	60
08/10/2015	12:00 p.m.	35	59
08/10/2015	1:00 p.m.	37	55
08/10/2015	2:00 p.m.	40	40
08/10/2015	3:00 p.m.	41	25
08/10/2015	4:00 p.m.	42	6
$L_{eq,day}$ [dBA]	**7 a.m. to 10 p.m.**	**39**	**1,462**
$L_{eq,night}$ [dBA]	**10 p.m. to 7 a.m.**	**41**	**814**

Table C-2: Filtered Hourly Noise Levels at Monitoring Site R7

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
08/07/2015	3:00 p.m.	No Valid Data	0
08/07/2015	4:00 p.m.	35	10
08/07/2015	5:00 p.m.	45	10
08/07/2015	6:00 p.m.	33	10
08/07/2015	7:00 p.m.	32	35
08/07/2015	8:00 p.m.	33	30
08/07/2015	9:00 p.m.	30	40
08/07/2015	10:00 p.m.	32	54
08/07/2015	11:00 p.m.	31	45
08/08/2015	12:00 a.m.	30	49
08/08/2015	1:00 a.m.	30	60
08/08/2015	2:00 a.m.	28	60
08/08/2015	3:00 a.m.	29	60
08/08/2015	4:00 a.m.	27	54
08/08/2015	5:00 a.m.	27	45
08/08/2015	6:00 a.m.	26	54
08/08/2015	7:00 a.m.	24	45
08/08/2015	8:00 a.m.	33	8
08/08/2015	9:00 a.m.	32	10
08/08/2015	10:00 a.m.	27	30
08/08/2015	11:00 a.m.	29	36
08/08/2015	12:00 p.m.	No Valid Data	0
08/08/2015	1:00 p.m.	33	4
08/08/2015	2:00 p.m.	35	5
08/08/2015	3:00 p.m.	No Valid Data	0
08/08/2015	4:00 p.m.	No Valid Data	0
08/08/2015	5:00 p.m.	No Valid Data	0
08/08/2015	6:00 p.m.	No Valid Data	0
08/08/2015	7:00 p.m.	No Valid Data	0
08/08/2015	8:00 p.m.	No Valid Data	0
08/08/2015	9:00 p.m.	No Valid Data	0
08/08/2015	10:00 p.m.	No Valid Data	0
08/08/2015	11:00 p.m.	34	5
08/09/2015	12:00 a.m.	No Valid Data	0
08/09/2015	1:00 a.m.	32	4
08/09/2015	2:00 a.m.	No Valid Data	0
08/09/2015	3:00 a.m.	No Valid Data	0
08/09/2015	4:00 a.m.	33	9
08/09/2015	5:00 a.m.	29	10
08/09/2015	6:00 a.m.	33	16

Table C-2: Filtered Hourly Noise Levels at Monitoring Site R7 (continued)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
08/09/2015	7:00 a.m.	33	6
08/09/2015	8:00 a.m.	33	21
08/09/2015	9:00 a.m.	35	15
08/09/2015	10:00 a.m.	35	9
08/09/2015	11:00 a.m.	33	10
08/09/2015	12:00 p.m.	29	45
08/09/2015	1:00 p.m.	26	39
08/09/2015	2:00 p.m.	26	31
08/09/2015	3:00 p.m.	23	59
08/09/2015	4:00 p.m.	22	55
08/09/2015	5:00 p.m.	21	60
08/09/2015	6:00 p.m.	22	54
08/09/2015	7:00 p.m.	19	60
08/09/2015	8:00 p.m.	21	59
08/09/2015	9:00 p.m.	24	60
08/09/2015	10:00 p.m.	30	60
08/09/2015	11:00 p.m.	31	60
08/10/2015	12:00 a.m.	29	60
08/10/2015	1:00 a.m.	29	60
08/10/2015	2:00 a.m.	30	60
08/10/2015	3:00 a.m.	29	60
08/10/2015	4:00 a.m.	27	60
08/10/2015	5:00 a.m.	29	60
08/10/2015	6:00 a.m.	28	60
08/10/2015	7:00 a.m.	22	60
08/10/2015	8:00 a.m.	20	60
08/10/2015	9:00 a.m.	21	53
08/10/2015	10:00 a.m.	21	54
08/10/2015	11:00 a.m.	23	60
08/10/2015	12:00 p.m.	25	60
08/10/2015	1:00 p.m.	27	47
08/10/2015	2:00 p.m.	32	40
08/10/2015	3:00 p.m.	31	5
$L_{eq,day}$ [dBA]	**7:00 a.m. to 10:00 p.m.**	**29**	**1,295**
$L_{eq,night}$ [dBA]	**10:00 p.m. to 7:00 a.m.**	**29**	**1,065**

Table C-3: Filtered Hourly Noise Levels at Monitoring Site R8

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
8/07/2015	11:00 a.m.	No Valid Data	0
08/07/2015	12:00 p.m.	No Valid Data	0
08/07/2015	1:00 p.m.	No Valid Data	0
08/07/2015	2:00 p.m.	No Valid Data	0
08/07/2015	3:00 p.m.	No Valid Data	0
08/07/2015	4:00 p.m.	No Valid Data	0
08/07/2015	5:00 p.m.	No Valid Data	0
08/07/2015	6:00 p.m.	35	1
08/07/2015	7:00 p.m.	No Valid Data	0
08/07/2015	8:00 p.m.	36	5
08/07/2015	9:00 p.m.	34	10
08/07/2015	10:00 p.m.	32	10
08/07/2015	11:00 p.m.	30	5
08/08/2015	12:00 a.m.	31	5
08/08/2015	1:00 a.m.	27	40
08/08/2015	2:00 a.m.	29	35
08/08/2015	3:00 a.m.	27	40
08/08/2015	4:00 a.m.	33	57
08/08/2015	5:00 a.m.	34	59
08/08/2015	6:00 a.m.	33	33
08/08/2015	7:00 a.m.	31	10
08/08/2015	8:00 a.m.	32	5
08/08/2015	9:00 a.m.	35	15
08/08/2015	10:00 a.m.	33	15
08/08/2015	11:00 a.m.	34	5
08/08/2015	12:00 p.m.	No Valid Data	0
08/08/2015	1:00 p.m.	No Valid Data	0
08/08/2015	2:00 p.m.	No Valid Data	0
08/08/2015	3:00 p.m.	No Valid Data	0
08/08/2015	4:00 p.m.	No Valid Data	0
08/08/2015	5:00 p.m.	No Valid Data	0
08/08/2015	6:00 p.m.	No Valid Data	0
08/08/2015	7:00 p.m.	No Valid Data	0
08/08/2015	8:00 p.m.	No Valid Data	0
08/08/2015	9:00 p.m.	No Valid Data	0
08/08/2015	10:00 p.m.	No Valid Data	0
08/08/2015	11:00 p.m.	No Valid Data	0
08/09/2015	12:00 a.m.	No Valid Data	0
08/09/2015	1:00 a.m.	No Valid Data	0
08/09/2015	2:00 a.m.	No Valid Data	0

Table C-3: Filtered Hourly Noise Levels at Monitoring Site R8 (continued)

Date	Start Hour	$L_{eq,\,1hr}$ [dBA]	Number of Valid Minutes
08/09/2015	3:00 a.m.	No Valid Data	0
08/09/2015	4:00 a.m.	32	4
08/09/2015	5:00 a.m.	No Valid Data	0
08/09/2015	6:00 a.m.	No Valid Data	0
08/09/2015	7:00 a.m.	32	5
08/09/2015	8:00 a.m.	31	9
08/09/2015	9:00 a.m.	34	10
08/09/2015	10:00 a.m.	32	14
08/09/2015	11:00 a.m.	30	15
08/09/2015	12:00 p.m.	28	45
08/09/2015	1:00 p.m.	27	49
08/09/2015	2:00 p.m.	25	55
08/09/2015	3:00 p.m.	24	50
08/09/2015	4:00 p.m.	27	55
08/09/2015	5:00 p.m.	22	50
08/09/2015	6:00 p.m.	22	60
08/09/2015	7:00 p.m.	21	57
08/09/2015	8:00 p.m.	19	60
08/09/2015	9:00 p.m.	18	60
08/09/2015	10:00 p.m.	19	51
08/09/2015	11:00 p.m.	17	60
08/10/2015	12:00 a.m.	24	60
08/10/2015	1:00 a.m.	25	60
08/10/2015	2:00 a.m.	24	60
08/10/2015	3:00 a.m.	24	60
08/10/2015	4:00 a.m.	32	55
08/10/2015	5:00 a.m.	38	39
08/10/2015	6:00 a.m.	38	28
08/10/2015	7:00 a.m.	38	39
08/10/2015	8:00 a.m.	35	35
08/10/2015	9:00 a.m.	29	57
08/10/2015	10:00 a.m.	25	55
08/10/2015	11:00 a.m.	24	50
08/10/2015	12:00 p.m.	28	49
08/10/2015	1:00 p.m.	33	37
08/10/2015	2:00 p.m.	32	24
$L_{eq,day}$ [dBA]	**7:00 a.m. to 10:00 p.m.**	**30**	**1,006**
$L_{eq,night}$ [dBA]	**10:00 p.m. to 7:00 a.m.**	**31**	**761**

Table C-4: Filtered Hourly Noise Levels at Monitoring Site R9

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
08/07/2015	12:00 p.m.	No Valid Data	0
08/07/2015	1:00 p.m.	No Valid Data	0
08/07/2015	2:00 p.m.	No Valid Data	0
08/07/2015	3:00 p.m.	No Valid Data	0
08/07/2015	4:00 p.m.	35	10
08/07/2015	5:00 p.m.	No Valid Data	0
08/07/2015	6:00 p.m.	34	5
08/07/2015	7:00 p.m.	No Valid Data	0
08/07/2015	8:00 p.m.	No Valid Data	0
08/07/2015	9:00 p.m.	31	15
08/07/2015	10:00 p.m.	31	5
08/07/2015	11:00 p.m.	30	10
08/08/2015	12:00 a.m.	No Valid Data	0
08/08/2015	1:00 a.m.	29	20
08/08/2015	2:00 a.m.	28	20
08/08/2015	3:00 a.m.	29	15
08/08/2015	4:00 a.m.	23	33
08/08/2015	5:00 a.m.	22	50
08/08/2015	6:00 a.m.	33	40
08/08/2015	7:00 a.m.	35	15
08/08/2015	8:00 a.m.	39	5
08/08/2015	9:00 a.m.	34	10
08/08/2015	10:00 a.m.	32	11
08/08/2015	11:00 a.m.	33	10
08/08/2015	12:00 p.m.	37	10
08/08/2015	1:00 p.m.	No Valid Data	0
08/08/2015	2:00 p.m.	No Valid Data	0
08/08/2015	3:00 p.m.	No Valid Data	0
08/08/2015	4:00 p.m.	39	5
08/08/2015	5:00 p.m.	No Valid Data	0
08/08/2015	6:00 p.m.	No Valid Data	0
08/08/2015	7:00 p.m.	No Valid Data	0
08/08/2015	8:00 p.m.	No Valid Data	0
08/08/2015	9:00 p.m.	No Valid Data	0
08/08/2015	10:00 p.m.	No Valid Data	0
08/08/2015	11:00 p.m.	No Valid Data	0
08/09/2015	12:00 a.m.	38	5
08/09/2015	1:00 a.m.	37	5
08/09/2015	2:00 a.m.	36	4
08/09/2015	3:00 a.m.	No Valid Data	0

Table C-4: Filtered Hourly Noise Levels at Monitoring Site R9 (continued)

Date	Start Hour	$L_{eq, 1hr}$ [dBA]	Number of Valid Minutes
08/09/2015	4:00 a.m.	33	10
08/09/2015	5:00 a.m.	No Valid Data	0
08/09/2015	6:00 a.m.	35	5
08/09/2015	7:00 a.m.	33	25
08/09/2015	8:00 a.m.	29	5
08/09/2015	9:00 a.m.	33	20
08/09/2015	10:00 a.m.	30	30
08/09/2015	11:00 a.m.	35	50
08/09/2015	12:00 p.m.	36	45
08/09/2015	1:00 p.m.	28	40
08/09/2015	2:00 p.m.	27	45
08/09/2015	3:00 p.m.	33	43
08/09/2015	4:00 p.m.	32	56
08/09/2015	5:00 p.m.	24	54
08/09/2015	6:00 p.m.	20	60
08/09/2015	7:00 p.m.	22	60
08/09/2015	8:00 p.m.	19	59
08/09/2015	9:00 p.m.	25	58
08/09/2015	10:00 p.m.	26	60
08/09/2015	11:00 p.m.	30	60
08/10/2015	12:00 a.m.	29	60
08/10/2015	1:00 a.m.	29	60
08/10/2015	2:00 a.m.	26	60
08/10/2015	3:00 a.m.	30	60
08/10/2015	4:00 a.m.	32	60
08/10/2015	5:00 a.m.	36	58
08/10/2015	6:00 a.m.	36	47
08/10/2015	7:00 a.m.	35	51
08/10/2015	8:00 a.m.	31	59
08/10/2015	9:00 a.m.	31	55
08/10/2015	10:00 a.m.	30	53
08/10/2015	11:00 a.m.	24	55
08/10/2015	12:00 p.m.	28	40
08/10/2015	1:00 p.m.	33	15
08/10/2015	2:00 p.m.	32	15
$L_{eq,day}$ [dBA]	**7:00 a.m. to 10:00 p.m.**	**31**	**1,089**
$L_{eq,night}$ [dBA]	**10:00 p.m. to 7:00 a.m.**	**31**	**747**

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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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