# Memo

**To:** Nunavut Impact Review Board
**From:** Agnico Eagle Mines Limited
**Date**: May 23, 2023
**Subject:** Additional Information – Low Frequency Noise Related to Windfarm - Meliadine Extension Proposal

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Agnico Eagle Mines Limited (Agnico Eagle) has prepared a response to a request made from the Sayisi Dene First Nation and Northlands Denesuline First Nation (SDFN/NDFN) and Athabasca Denesuline Né Né Land Corporation (ADNLC) during engagement meetings held on April 12, 2023 in Winnipeg, Manitoba, to develop decay curves for low frequency noise related to wind turbines, including thresholds based on literature.

## 1. Hearing Thresholds for Reindeer

Perra et al. (2022) collected measurements to establish hearing thresholds for reindeer in frequency bands from 30 Hertz (Hz) to 16 kilohertz (kHz). The hearing threshold for each frequency band was established in units of unweighted decibels, which are abbreviated dB peSPL in Perra et al. (2022) and abbreviated dBZ in the environmental acoustics literature. In contrast to A-weighted decibels (dBA), which have been adjusted to account for the frequency sensitivity of the human auditory system, sound levels expressed in unweighted decibels represent the physical magnitude of pressure variations in the air directly, without any weighting or adjustment to account for the sensitivity of the auditory system. As such, the hearing thresholds established by Perra et al. (2022) represent the minimum sound level (i.e., the smallest pressure variations) that can be detected by the auditory system of a reindeer. Results from Perra et al. (2022) are summarized in Table 1.

**Table 1: Hearing Thresholds for Reindeer (Perra et al. 2022)**

| Frequency | Hearing Threshold [dBZ] | |
|---|---|---|
| | Most Sensitive Individual | Least Sensitive Individual |
| 30 Hz | 30 | 60 |
| 60 Hz | 40 | 60 |
| 125 Hz | 50 | 60 |
| 500 Hz | 40 | 70 |
| 1 kHz | 35 | 45 |
| 3 kHz | 20 | 30 |
| 3.8 kHz | 38 | 78 |
| 4 kHz | 30 | 60 |
| 8 kHz | 30 | 50 |
| 16 kHz | 25 | 50 |

It is important to note that testing to establish hearing thresholds such as by Perra et al. (2022) is completed under laboratory conditions in the absence of background noise. When background noise is present it may mask sounds at similar frequencies but with lower sound pressure level, making it more challenging to detect a particular sound source in the presence of background noise than would be case in a quiet laboratory environment. Background noise for the Meliadine Extension will include natural sounds occurring in the area (e.g., wind, birds, wave action on lakes), as well as anthropogenic noise from the existing Meliadine Mine and other human sources (e.g., cabins, all-terrain vehicles, boats).

## 2. Measured Sound Levels – Existing and Pre-Development Conditions

Computer noise modelling and assessment for the Meliadine Extension were conducted in accordance with the ISO 9613-2 technical standard (ISO 1996), which requires consideration of the following nine octave bands: 31.5 Hz, 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz.

In response to concerns about potential low frequency noise effects to caribou, the following analysis is focused on the lowest frequencies for which data on reindeer hearing thresholds are available. In particular, sound levels measured and modelled in the 31.5 Hz octave band will be compared to reindeer hearing thresholds at 30 Hz, and sound levels measured and modelled in the 63 Hz octave band will be compared to reindeer hearing thresholds at 60 Hz. The slight mismatch in frequencies (i.e., 31.5 Hz vs. 30 Hz and 63 Hz vs. 60 Hz), which results from Perra et al. (2022) establishing hearing thresholds in frequency bands that are inconsistent with the ISO frequency bands used in environmental acoustics, is not expected to be material to the analysis that follows.

The most recent noise monitoring program at Meliadine was completed in July 2022. During this monitoring program, measurements were collected at four points of reception surrounding the mine: NPOR06a, NPOR08, NPOR14a, and NPOR17a (Agnico Eagle 2023). The most relevant point of reception for the present analysis of potential low frequency noise effects from the proposed wind turbines is NPOR06a, which is located north of the mine site, close to the future location of the wind turbines. Please note that NPOR06a is a surrogate for the cabin identified as NPOR06 in the noise modelling for the Meliadine Extension (Golder 2021) and the FEIS (Agnico Eagle 2014). A surrogate monitoring location was used to reduce the potential for interaction with community members during the COVID-19 pandemic. The surrogate monitoring location (NPOR06a) is located closer to mining activities and equipment than the cabin (NPOR06), so measured noise levels are expected to be greater than those predicted via computer modelling.

Table 2 presents sound levels measured at NPOR06a during the July 2022 monitoring program. Measured sound levels are presented for the 31.5 Hz and 63 Hz octave bands in dBZ units. Sound levels presented in Table 2 include the contribution from sources associated with mining activities (e.g., heavy equipment), as well as natural sources (e.g., wind, birds, insects).

**Table 2: Sound Levels Measured at NPOR06a in July 2022**

| Measurement Period | Measured Sound Level [dBZ] | |
|---|---|---|
| | 31.5 Hz Octave Band | 63 Hz Octave Band |
| July 17 to 20, 2022 | 53.5 | 52.2 |
| July 25 to 28, 2022 | 63.7 | 56.0 |
| *Average – both periods* | *61.1* | *54.5* |

There are no measurements of pre-development sound levels available for the area surrounding the Meliadine Mine. However, pre-development sound levels were measured in August 2015 in remote areas surrounding the future location of the Whale Tail Mine (Golder 2015). Agnico Eagle respectfully submits that these measurements are also generally representative of pre-development sound levels in the Meliadine area (i.e., sound levels associated with the natural background).

Table 3 presents pre-development sound levels measured at the Whale Tail site in August 2015. Measured sound levels in the 31.5 Hz and 63 Hz octave bands are presented in dBZ units. Sound levels presented in Table 3 represent the contribution from natural sources (e.g., wind, birds, insects) and do not include the contribution from mining equipment or other industrial sources.

**Table 3: Natural Background Sound Levels Measured at Whale Tail Site in August 2015**

| Measurement Location[(a)] | Measured Sound Level [dBZ] | |
|---|---|---|
| | 31.5 Hz Octave Band | 63 Hz Octave Band |
| R2 | 47.8 | 39.4 |
| R4 | 50.0 | 38.4 |
| *Average – both locations* | *49.0* | *38.9* |

[(a)] Please see Whale Tail baseline report (Golder 2015) for detailed information on the measurement locations.

## 3. Predicted Sound Levels for Meliadine Wind Turbines

A computer noise model, based on the ISO 9613-2 technical standard (ISO 1996), was used to predict sound levels expected from maximum/full-power operation of one of the Enercon E-115 EP3 wind turbines being proposed for the Meliadine Extension. Wind turbine sound levels were predicted as a function of propagation distance (i.e., distance from the base of the wind turbine tower). Sound levels were predicted for both the 31.5 Hz and 63 Hz octave bands. Predicted wind turbine sound levels were compared to the reindeer hearing thresholds from Perra et al. (2022) to determine the maximum distances at which a caribou could be expected to detect sound from the turbine under ideal laboratory conditions. Predicted wind turbine sound levels were also compared to natural background sound levels (see Table 3) to determine the distance at which turbine sound levels are expected to decay to natural background levels.

The 31.5 Hz sound level from a single wind turbine drops below the hearing threshold for the least sensitive reindeer within approximately 300 metres (m) of the turbine, the sound level from a single wind turbine does not fall below the hearing threshold for the most sensitive reindeer until approximately 11 kilometres (km) from the turbine. In other words, under ideal laboratory conditions (i.e., in the absence of background noise), the most sensitive individuals may be able to detect 31.5 Hz sound from a single turbine out to 11 km. However, because of masking from background noise, the actual detection range is likely to be much smaller. The wind turbine sound level drops below the natural background level approximately 1 km from the turbine. In other words, at propagation distances greater than 1 km, the 31.5 Hz sound level from the wind turbine is expected to be no greater than the background sound level associated with wind, birds, and other natural sources.

The 63 Hz sound level from a single wind turbine drops below the hearing threshold for the least sensitive reindeer within approximately 250 m of the turbine, the wind turbine sound level does not fall below the hearing threshold for the most sensitive reindeer until approximately 2.5 km from the turbine. In other words,

under ideal laboratory conditions (i.e., in the absence of background noise), the most sensitive individuals may be able to detect 63 Hz sound from a single turbine out to 2.5 km.

When considering the potential for low frequency noise effects from the proposed wind turbines, it is also helpful to consider the wind turbine sound levels in the context of sound levels associated with other sources/activities associated with Meliadine Extension operations. Figure 1 and Figure 2 present predicted Meliadine Extension sound levels in the 31.5 Hz octave band. Figure 1 presents sound levels for core mining activities (i.e., omitting the wind turbines) and Figure 2 presents sound levels for core mining activities plus the wind turbines. Figure 3 and Figure 4 present predicted Meliadine Extension sound levels in the 63 Hz octave band. Figure 3 presents sound levels for core mining activities (i.e., omitting the wind turbines) and Figure 4 presents sound levels for core mining activities plus the wind turbines.

While addition of the wind turbines increases predicted sound levels in the low frequency octave bands (especially in the northern part of the study area), Figures 1 and 3 show there is also low frequency sound associated with core mining operations, which is supported by measurement data from Table 2. In other words, addition of the proposed wind turbines will increase low frequency sound levels but will not fundamentally change the character of the acoustic environment relative to existing conditions, which already include low frequency sound from mining operations and from natural sources.

It should be noted that sound level contours presented in Figures 1 through 4 reflect default downwind propagation conditions set out in the ISO 9613-2 technical standard (ISO 1996). In other words, the modelling assumes that each location in the study area is downwind from every noise source 100% of the time. Since downwind conditions tend to enhance sound propagation, the contours presented in Figures 1 through 4 are inherently conservative (i.e., tending to overestimate sound levels from the Meliadine Extension).

Data collected at Meliadine between June 2016 and September 2022 indicates that prevailing winds come from the northwest (see Figure 5). As such, sound propagation will be enhanced in situations where receptors are southeast of a source (i.e., downwind conditions) and diminished in situations where receptors are northwest of a source (i.e., upwind conditions). The proposed wind turbines will be located at the northwest end of the Meliadine site such that areas with enhanced downwind propagation of sound from the turbines (i.e., areas to the southeast of the turbines) will be located within the footprint of the mine. This spatial arrangement reduces the potential for wind turbine noise effects to caribou since caribou are unlikely to be present within the footprint of the mine.

## 4. Conclusion

Based on the preceding analysis, caribou are unlikely to detect low frequency noise from wind turbines at distances greater than 1 km (for the 31.5 Hz octave band) and 2.5 km (for the 63 Hz octave band).

## 5. References

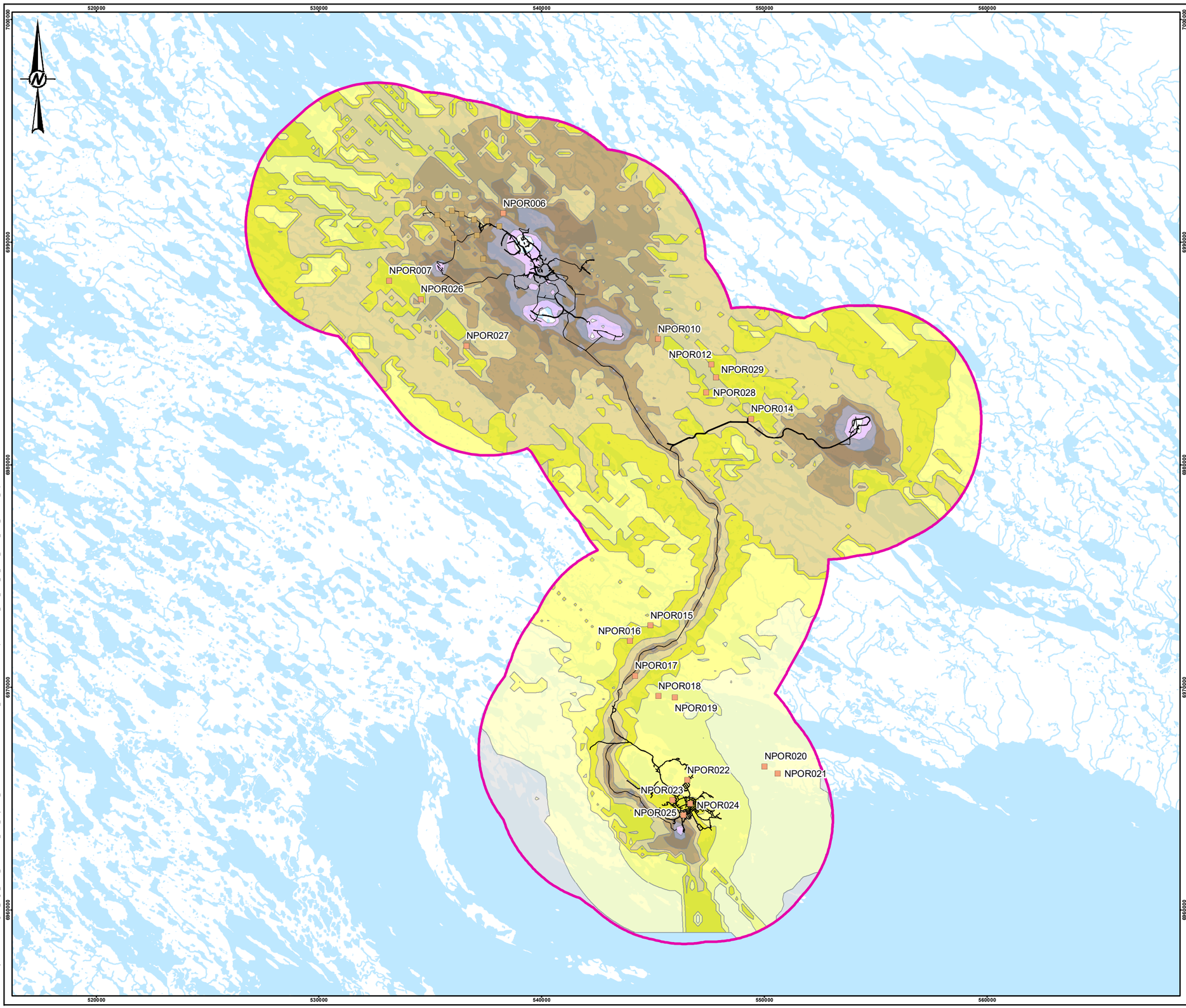
Agnico Eagle (Agnico Eagle Mines Limited). 2023. Meliadine Gold Mine 2022 Noise Monitoring Report. In Accordance with NIRB Project Certificate No. 006. March 2023.

Golder (Golder Associates Ltd.). 2015. Amaruq Whale Tail and Amaruq Haul Road Baseline Noise Report.

Golder. 2021. Meliadine Extension Noise Modelling.

ISO (International Organization for Standardization). 1996. ISO 9613-2 Acoustics – Attenuation of sound during propagation outdoors – Part 2: General method of calculation.

Perra M, Brickman T, Scheifele P, Barcalow, S. 2022. Exploring auditory thresholds for Reindeer, *Rangifer tarandus*. Journal of Veterinary Behaviour. 52:37-44.




**LEGEND**

- ON-SITE WIND TURBINES
- NOISE RECEPTOR
- NOISE STUDY AREA
- WATERBODY
- WATERCOURSE
- ROAD

**PREDICTED PROJECT NOISE LEVEL [dBZ]**

- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70

0 4,000 8,000

1:170,000 METRES

**REFERENCE(S)**

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED AND NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 15

CLIENT

AGNICO EAGLE MINES LIMITED

**AGNICO EAGLE**

PROJECT

MELIADINE GOLD PROJECT
NUNAVUT

TITLE

**PREDICTED NOISE LEVELS FROM CORE MELIADINE EXTENSION – 31.5 Hz OCTAVE BAND**

CONSULTANT

wsp

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|---|---|
| YYYY-MM-DD | 2023-05-12 |
| DESIGNED | VY |
| PREPARED | LH |
| REVIEWED | VY |
| APPROVED | DC |

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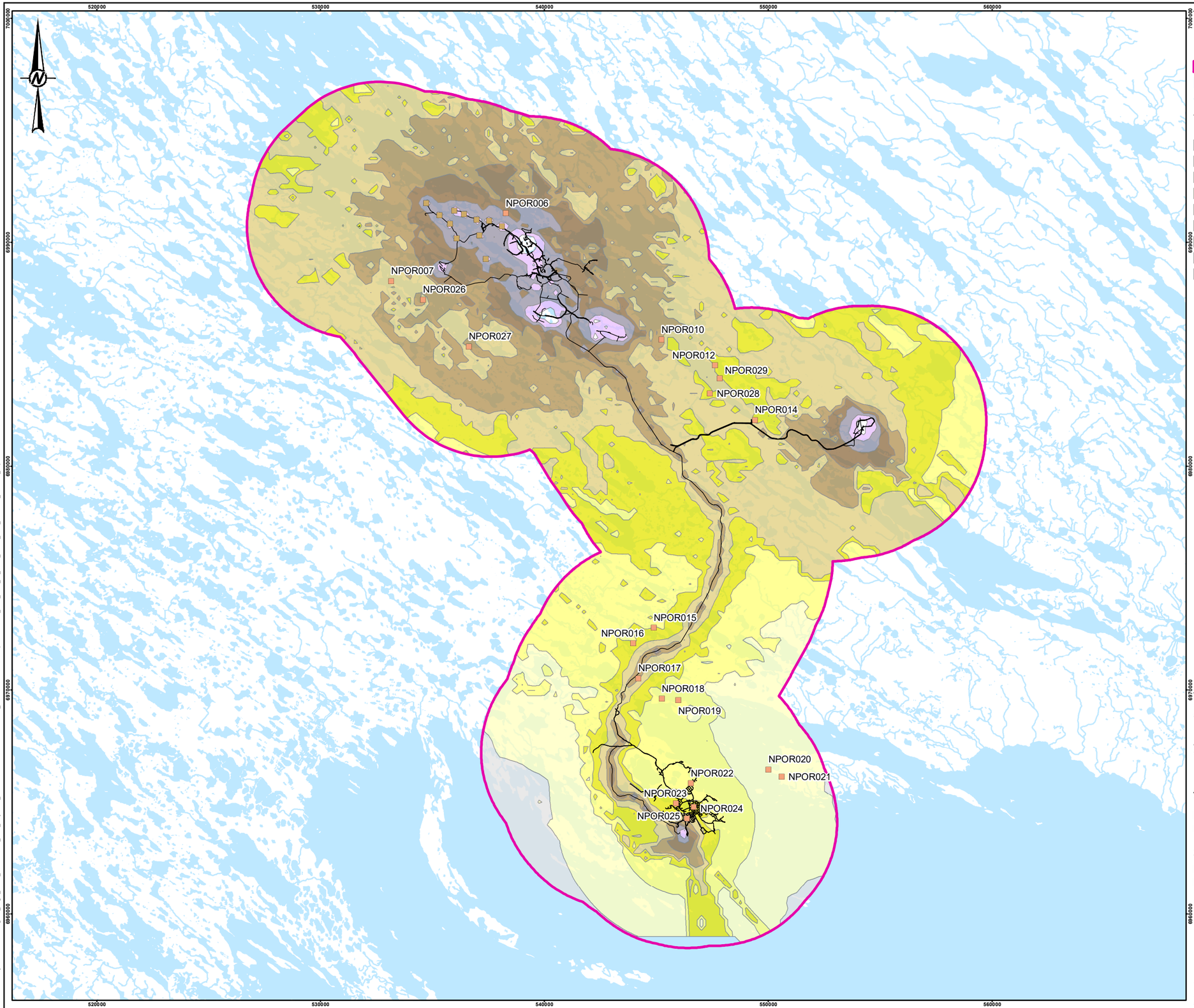


**LEGEND**

- ON-SITE WIND TURBINES
- NOISE RECEPTOR
- NOISE STUDY AREA
- WATERBODY
- WATERCOURSE
- ROAD

**PREDICTED PROJECT NOISE LEVEL [dBZ]**

- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70

0 4,000 8,000

1:170,000 METRES

**REFERENCE(S)**

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED AND NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 15

CLIENT

AGNICO EAGLE MINES LIMITED

**AGNICO EAGLE**

PROJECT

MELIADINE GOLD PROJECT
NUNAVUT

TITLE

**PREDICTED NOISE LEVELS FROM CORE MELIADINE EXTENSION PLUS WIND TURBINES – 31.5 Hz OCTAVE BAND**

CONSULTANT

wsp

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| YYYY-MM-DD | 2023-05-12 |
| DESIGNED | VY |
| PREPARED | LH |
| REVIEWED | VY |
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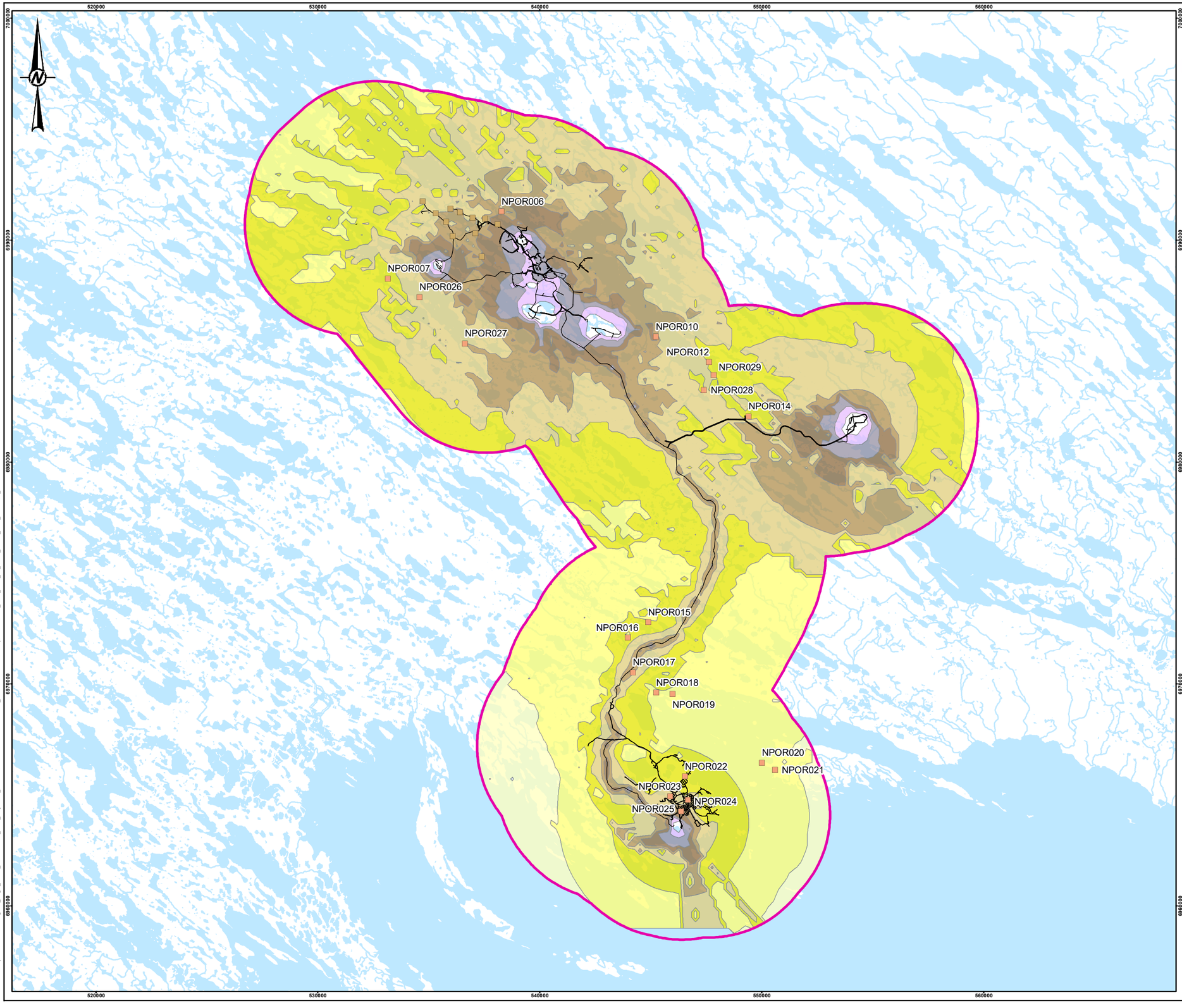


**LEGEND**

- ON-SITE WIND TURBINES
- NOISE RECEPTOR
- NOISE STUDY AREA
- WATERBODY
- WATERCOURSE
- ROAD

**PREDICTED PROJECT NOISE LEVEL [dBZ]**

- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70

0 4,000 8,000

1:170,000 METRES

**REFERENCE(S)**

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED AND NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 15

CLIENT

AGNICO EAGLE MINES LIMITED

AGNICO EAGLE

PROJECT

MELIADINE GOLD PROJECT
NUNAVUT

TITLE

**PREDICTED NOISE LEVELS FROM CORE MELIADINE EXTENSION – 63 Hz OCTAVE BAND**

CONSULTANT

wsp

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| YYYY-MM-DD | 2023-05-12 |
| DESIGNED | VY |
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NPOR024
NPOR025

**LEGEND**

- ON-SITE WIND TURBINES
- NOISE RECEPTOR
- NOISE STUDY AREA
- WATERBODY
- WATERCOURSE
- ROAD

**PREDICTED PROJECT NOISE LEVEL [dBZ]**

- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60
- 60 - 65
- 65 - 70

0 4,000 8,000

1:170,000 METRES

**REFERENCE(S)**

1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED AND NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 15

CLIENT

AGNICO EAGLE MINES LIMITED

**AGNICO EAGLE**

PROJECT

MELIADINE GOLD PROJECT
NUNAVUT

TITLE

**PREDICTED NOISE LEVELS FROM CORE MELIADINE EXTENSION PLUS WIND TURBINES – 63 Hz OCTAVE BAND**

CONSULTANT

wsp

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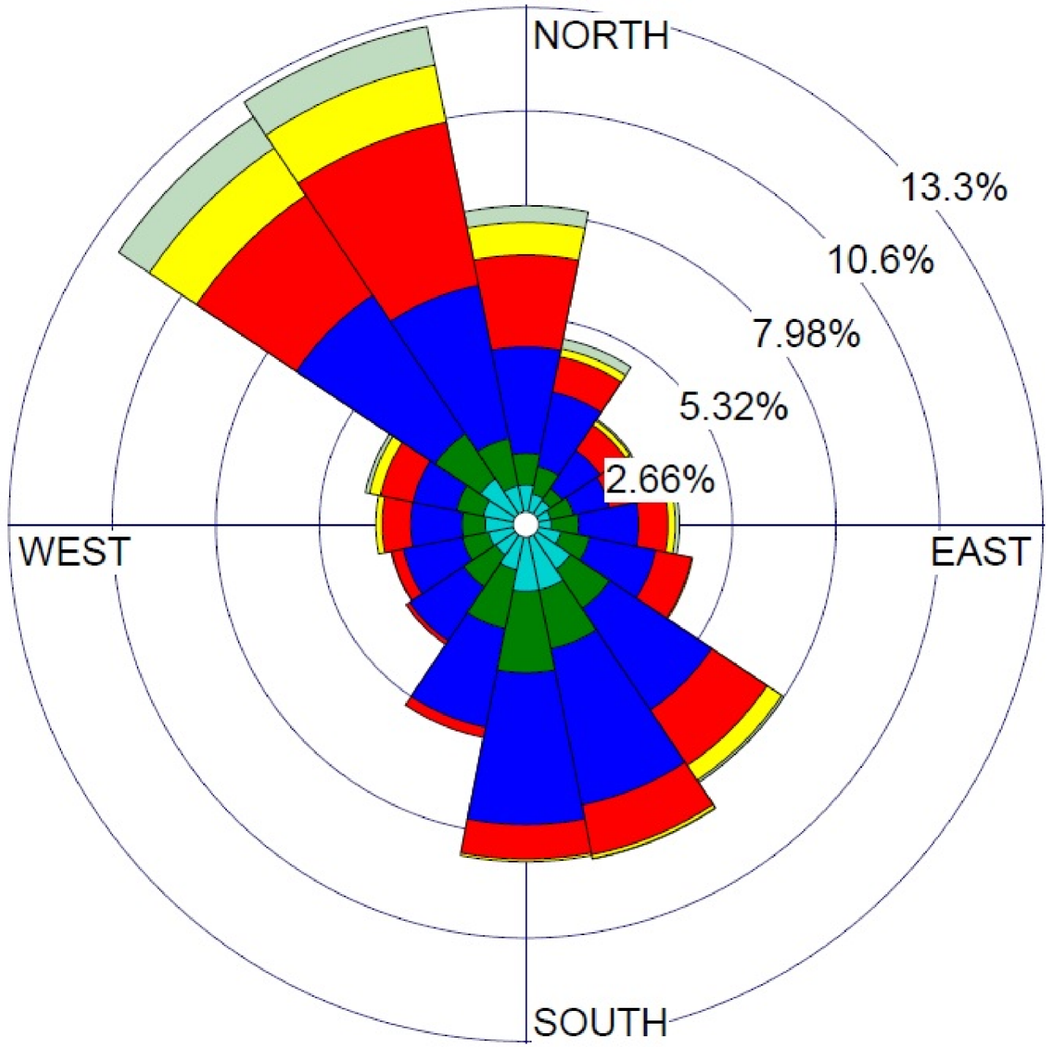


WIND SPEED
(m/s)

- >= 11.10
- 8.80 - 11.10
- 5.70 - 8.80
- 3.60 - 5.70
- 2.10 - 3.60
- 0.50 - 2.10

Calms: 0.31%

**REFERENCE(S)**
1. BASE DATA OBTAINED FROM AGNICO EAGLE MINES LIMITED AND NATURAL RESOURCES CANADA.
DATUM: NAD 83 PROJECTION: UTM ZONE 15

CLIENT
AGNICO EAGLE MINES LIMITED
AGNICO EAGLE

PROJECT
MELIADINE GOLD PROJECT
NUNAVUT

TITLE
**WIND ROSE – MELIADINE WIND DATA FROM JUNE 2016 TO SEPTEMBER 2022**

CONSULTANT
wsp

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| YYYY-MM-DD | 2023-05-12 |
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