TRANSMITTAL

DATE 20 November 2020 20351262-810-TM-Rev0

TO Michel Groleau
Agnico Eagle Mines Limited

CC Jamie Quesnel

FROM Jen Range **EMAIL jrange@golder.com**

MELIADINE MINE RESPONSE TO NIRB-IR-016, GEOTECHNICAL HAZARDS NIRB-IR-016 WATERLINE PERMAFROST IMPACTS

Michel,

Please find enclosed technical memorandum *Meliadine Mine Response to NIRB-IR-016, Geotechnical Hazards NIRB-IR-016 Waterline Permafrost Impacts*. The technical memorandum has been prepared and reviewed by our sub-consultant Golder Associates Inc.

Please contact the undersigned if you require any clarifications.

Sincerely,

GOLDER ASSOCIATES LTD.

Jen Range
Project Manager

Lasha Young
Associate

JR/LY/jr

https://golderassociates.sharepoint.com/sites/132380/project files/5 technical work/01_information_requests/03_ir commitments/2310_terrainpermafrost/20351262-810-coverletter.docx

TECHNICAL MEMORANDUM

DATE 20 November 2020 20351262-810-TM-Rev0

TO Jen Range and Lasha Young
Golder Associates Ltd.

CC

FROM Mark Musial, Andrew Garrigus, and Eric Cannon **EMAIL mmusial@golder.com**

MELIADINE MINE RESPONSE TO NIRB-IR-016, GEOTECHNICAL HAZARDS NIRB-IR-016 WATERLINE PERMAFROST IMPACTS

The NIRB identified the following issue related to geotechnical hazards and their impact on the planned water pipeline in Information Request #NIRB-IR-016.

- **Issue/Concern**: *The IS Addendum states that the occurrence of geotechnical hazards to the project proposal related to climate change is low. The NIRB notes that the scope of activities include the burial of up to 90 percent of the waterlines. No discussion is provided on potential impacts to the waterline from the environment from natural weathering processes (e.g., will the waterline be subject to freeze/thaw, frost heave, subsidence, etc.).*
- **Request**: *Provide a discussion on the impacts of potential hazards to the waterline that could contribute to the long-term performance of the materials.*

1.0 CONDITIONS ALONG ALIGNMENT

Terrain and geohazards along the alignment are described in *Volume 6.0 Terrestrial Environment and Impact Assessment, Final Environmental Impact Statement (FEIS) – Meliadine Gold Project, Nunavut* (Agnico Eagle 2014). Permafrost terrain types and conditions (e.g., ground ice and active layer processes) along the waterline alignment are summarized in *Table 6.3-A, Terrain Unit Descriptions and Interpretations,* with additional description and mapping presented in Appendices B-D (Agnico Eagle 2014). This mapping covers about 25 km from the mine site toward Rankin Inlet. Approximately 8 km from Rankin Inlet to the end of the mapping crosses areas where 20%-40% of the terrain may contain ground ice based on inspection of recent imagery. However, the relative content of ground ice and hazard in these areas is expected to be similar to the mapping.

There are 10 different terrain types present along the alignment. In addition, the waterlines will pass above or around a few shallow lakes/streams and cross three bridges. Typical active layer processes were expected to include frost heave, frost creep, thaw settlement, frost jacking, frost sorting, and frost wedging. Approximately 24% of the alignment (6.2 km) are in terrain types 2E, 3D, 4D, 5D, 5E, and 12C, which are rated as having a potentially high to very high hazard for thaw or freeze inducted displacement. The distribution of these higher hazard areas is shown in Figure 1. However, the bulk of these areas (5.1 km) are in two terrain types, 5E and 5F, which consist of blankets and/or veneers of marine washed, gravelly to lesser sandy till, or marine sands and/or gravels overlying till.

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Figure 1: Risk of Thaw or Subsidence along Pipeline Route (Red is rated as High to Very High (H to VH) as discussed in text)

Approximately 0.4% of the waterline (96 m) crosses areas mapped as lakes (i.e., small streams and/or standing water). Most of these are dry in more recent imagery, but new areas of ponded water are present. These new areas commonly develop adjacent to roads in permafrost terrain and represent areas where ice-rich soils are thawing or the surface drainage has been interrupted by the road embankment. The waterline will either go above or around areas with the potential for water (i.e., small streams and/or standing water).

2.0 WATERLINE IMPACTS

The waterline will be built in one of seven typical configurations shown in Figure 2. In these configurations the waterline will be subjected to freezing temperatures when it is empty in the winter and seasonal movements as the ground refreezes after summer operations. The line will only be operational for a few months during summer, and it will be empty the rest of the year. During summer operations the water will be slightly saline and have a temperature of approximately 4ºC. Some additional thawing should be anticipated in permafrost near the waterlines, but the potential thaw and associated settlement will be mitigated to some degree by the fill placed below the waterlines, as indicated in Figure 2. Natural thawing associated with climate change is expected to be much greater that any thawing associated with waterline operations, potentially increasing by 2 to 4 m during the life of mine operations (Volume 6, Section 6.3.4.4).

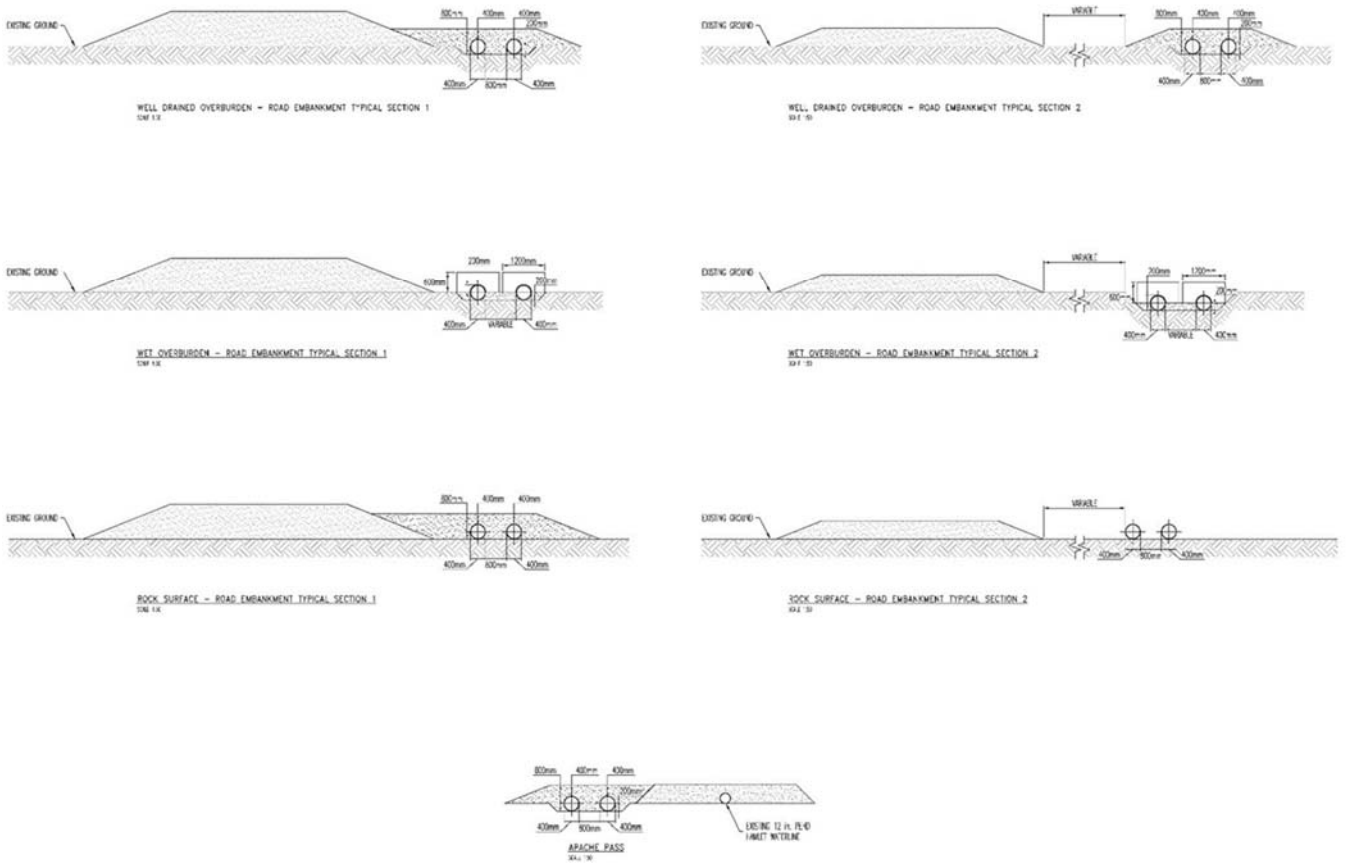

Figure 2: Typical Waterline Configurations

Waterlines and other linear infrastructure are most at risk from geohazards where differential movement occurs such as where the waterline changes from below ground to aboveground modes. These movements could be due to freezing and thawing process or mass wasting. The terrain analysis discussed in Section 1 indicates relatively low potential for differential movement related to geohazards to occur during the relatively short summer season when the waterline is operations. This assessment is also supported by experience at the site. For example, the mine operator has indicated that there has been little or no change in the grade of the All-Weather Access Road over 7 years of operations, which suggests that even in the high risk areas ground conditions are relatively insensitive to thawing and that significant thermokarst that could lead to unsupported segments and over-stressing of the waterline has not developed along the All-Weather Access Road or Bypass Road (Long 2020, pers. comm.). In addition, the mine has operated a 4 km pipeline discharge to Meliadine Lake that is similar to those planned (16 inch diameter HDPE pipe) over the last 3 years with no signs of degradation to the tundra nor signs of distress to the pipe itself.

The waterlines will only be operated in the summer and subject to monitoring for leaks. If leaks were to occur, water discharge will cause erosion or localized degradation of the permafrost in areas where the slightly saline water can pond, as well as causing vegetation damage and potentially impacting fish habitat (i.e., over bridge crossings). The worst-case spill of saline water identified in the Failure Modes and Effects Analysis (FMEA) is 5,000 m^3. This water is expected to spread to a maximum area of 10 acres at an average of 10 cm deep. Surface water or interstitial

water in thawed overburden would dilute the salinity and it would be further diluted as it melts ground ice it contacts. If water remains ponded, surface conditions will be changed and there will be a longer term degradation of permafrost conditions. However, potential impacts to the waterline caused by the spill will depend on the ice content of the soil in the spill area. As indicated above, the available data suggests that the impacts are likely to be minor.

3.0 SUMMARY

Most of the waterline length will be in areas where there is low to moderate risk of thaw or freezing induced displacements occurring and where the waterlines will move with seasonal changes in the ground from frozen to thawed or where the waterlines are in lakes and become encased in ice during the winter. The approximately 6.2 km segments crossing terrain with higher hazard of freezing or thawing induced displacements will have higher potential for differential movement, but evidence from performance of the existing All-Weather Access Road indicates that significant thermokarst features that could lead to unsupported and more highly stressed sections of pipe are unlikely to develop. In addition, performance of an existing 16-inch diameter HDPE pipe with discharge to Meliadine Lake has reportedly performed well over 3 seasons of operations.

4.0 CLOSURE

Please do not hesitate to contact the undersigned with any questions.

Andrew Garrigus, PE (AK)
Senior Geotechnical Engineer

Mark R. Musial, PE (AK)
Principal, Senior Geotechnical-Permafrost Engineer

MRM

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References

Agnico Eagle. 2014. Final Environmental Impact Statement (FEIS) - Meliadine Gold Project, Nunavut from: ftp://ftp.nirb.ca/02-REVIEWS/ACTIVE%20REVIEWS/11MN034-Agnico Eagle%20MELIADINE/2-REVIEW/09-FINAL%20EIS/FEIS.

Long M. 2020. Construction Superintendent, Agnico Eagle Mines Limited. All-weather Access Road grade during operations. FMEA workshop with Agnico Eagle and Subject Matter Experts. 4 November 2020.