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Via Email

Richard Dwyer
Licensing Administrator
Nunavut Water Board
P.O. Box 119
Gjoa Haven, NU X0E 1J0

Subject: **Water License #2AM-MEA0815, Agnico-Eagle Mines Ltd., Meadowbank Gold Project, Submission of *Bay-Goose Dike and South Camp Dike Designs, Meadowbank Gold Project, Nunavut* (Golder Associates, Feb. 2/09)**

Dear Richard,

Please be advised that Indian and Northern Affairs Canada has completed a review of the above referenced dike design report submitted by Agnico-Eagle Mines Ltd. to the Nunavut Water Board for approval.

A Technical Review Memorandum (attached) is provided for the Board's consideration.

Should you have any questions regarding this submission, feel free to contact me at 867-975-4555 or David.Abernethy@inac-ainc.gc.ca.

Regards,

David W. Abernethy
Regional Coordinator

Cc. Kevin Buck, Water Resources Division Manager
Michael Nadler, Director of Operations - Acting

Technical Review Memorandum

Date: Mar. 27/09

To: Richard Dwyer, Nunavut Water Board

From: David Abernethy, Indian and Northern Affairs Canada

Re: Technical Review, *Bay-Goose Dike and South Camp Dike Designs, Meadowbank Gold Project, Nunavut* (Golder Associates, Feb. 2/09)

1. Description

On Feb. 9/09 the Nunavut Water Board (NWB or Board) acknowledged receipt of the above referenced Golder Associates (Golder) dike design report that was submitted by Agnico-Eagle Mines Ltd. (AEM) for approval as required by Part D, Item #2 of Water License #2AM-MEA0815. The NWB subsequently placed this report on their public registry and made it available for review on Mar. 2/08, requesting written representations from interested parties by Apr. 2/09.

The following reports were included in this technical review:

- Meadowbank Dike Review Board. *Report No. 2.* Feb. 10/09;
- Meadowbank Dike Review Board. *Trip Report – Dr. Andrew M. Robertson – October 31, 2008*. Nov. 4/09; and,
- Meadowbank Dike Review Board. *Report No. 1*. Sept. 29/08.

2. Results of Review

The following comments / recommendations are provided to the Board for consideration in the approval of the proposed dike design report. Where appropriate, similar comments that were made by the Meadowbank Dike Review Board (MDRB) in either their Sept. 29/08 Report No. 1 (MDRB #1) or Feb. 10/09 Report No. 2 (MDRB #2) are indicated.

1. The revised alignment is an improvement over the original as it generally puts the dike in shallower water and therefore should make construction of the cut-off easier (see also MDRB#1, Section 5.0);

2. A comprehensive site investigation certainly needs to be carried out. It is understood that the site investigation was expected to start this month. The following should be considered during this site investigation:

    a. Target some boreholes in the fault zone;

    b. A significant number of the boreholes should be inclined and cores in the bedrock should be oriented to allow the preferential fracture direction to be determined. This information will help determine whether the proposed vertical grouting approach is appropriate or if angled grout holes would be more effective (see also MDRB#1, Section 3.9.1);

    c. A drilling procedure that allows the amount of cobbles and boulders in the till to be quantified. A large diameter sonic drilling program was successful in quantifying the cobble and boulder content in the similar till materials found on the lakebed at the Diavik mine (see also MDRB#2, Section 5.0); and,

    d. Drilling or probing techniques that will define the thickness of the lacustrine sediment and its variation in the footprint of the dike should be employed (see also MDRB#1, Section 3.3 and 5.0).

3. It is unclear why the Bay-Goose dike was given a High dam classification but the South Camp Dike was given a Significant dam classification (CDA 2007, Table 2-1). A failure of either dike floods the same area, and hence, the same number of people will potentially be at risk. The High classification is based on loss of life of 10 people or fewer. We would anticipate that more than 10 people would be in the pits at any one time, so a classification of **Very High** is felt to be more appropriate for both dikes;

4. Relevant ground temperature data is lacking; therefore, the permafrost distribution along the dikes (in particular at the abutments) is not well understood. There are 23 ground temperature cables at site, but permafrost temperatures and distribution provided in this design report are based on the CALM site at Baker Lake for some reason. There is a comment that the active layer is typically deeper near the shoreline, which seems odd. Extensive ground temperature instrumentation at other mines in similar climatic and soil/rock conditions have indicated that frozen ground is typically found offshore into water depths of up to 1 to 1.5 m (the water depth where the ice freezes to the bottom during the winter). The active layer immediately onshore (at the water's edge) is generally roughly the same as is found further inland unless there is exposed bedrock. The boundary between frozen and unfrozen ground found offshore at the 1.0 m to 1.5 m water depth is typically near vertical;

5. It will be difficult or impossible to grout in frozen soil or rock because the voids or fractures will be filled with ice. Therefore, the abutments and offshore in areas with water depths up to 1.0 m to 1.5 m cannot be effectively grouted. If seepage happens through the unfrozen soils/rock found immediately offshore of the near vertical frozen/unfrozen boundary noted in point 4 above, the boundary will potentially degrade, moving it towards the abutment into the previously frozen rock or soils. It is for this reason that active/passive thermal siphons were installed near the abutments of the dikes at the Diavik mine. Accordingly, the permafrost conditions at the abutments should be better defined and understood with respect to the current and future thermal and seepage regimes. This should include an evaluation of how seepage through the grouted zone could affect the frozen/unfrozen boundary and what measures may be required to control seepage and mitigate thaw;

6. There is potential for frozen ground at depth (a closed talik) in shallow water areas, like the South Camp dike area. Again, the frozen soil/rock will not be able to be grouted, and the originally frozen, impermeable soil/rock could thaw if seepage occurs in the unfrozen overlying materials. This could lead to increased seepage with time;

7. There is considerable potential for the lacustrine sediment found above the till on the lakebed to be mobilized into the water column during dike construction. It is stated that a sediment control curtain will be used to control release into the environment. A specification and design for the sediment control system should be included in the design and specification documents (see also MDRB#1, Section 3.3). The documents should include a performance specification for evaluating the effectiveness of the system;

8. The thickness of the lacustrine sediment along the dike alignment is not well understood. If it is very thick, it will settle and could put significant down drag forces on the wall (see also MDRB#1, Section 5.0);

9. Cobbles and boulders in the till have not been characterized and the till gradations presented in the report are on scalped (cobbles removed) samples. The bidding contractor(s) could potentially be misled by this. It is strongly recommended that the till gradations indicate that they have been determined on materials with the over-sized material removed. Considerable amounts of till have been excavated on site, and it would be appropriate to use this experience to define typical percentages of oversize material that can be expected in the lakebed tills. It will likely be the cobbles and boulders in the till that determine how deep the cut-off wall can be excavated into the lakebed tills (see also MDRB#1, Sections 3.5 and 3.8). Therefore, the contractor should be well aware of the amount of cobbles and boulders in the till in order to bid appropriately and

eventually to have the correct equipment available at site to handle these materials;

10. There is no design for the seepage collection system, perhaps because it is noted to be the owner's responsibility. The design and specification should include designs and specifications for the seepage collection system. Consideration should be given in this design with respect to how it will function during the winter;

11. The design report does not address the procedure to be employed for dewatering the area inside of the dike. Depending on the procedure used and the weather conditions during pumping, it is expected that between 50% and 60% of the water may be discharged directly to the environment (see also MDRB#1, Section 3.11). It is unclear where and how the remainder of the water will be handled. The design and specifications should indicate how this water will be handled unless this is specified in another document;

12. There is a question in our minds regarding whether the site investigation will be complete and design finalized in time for contractor bids, contractor selection, and subsequent equipment mobilization. It will be very difficult for the contractors to bid accurately and mobilize the appropriate equipment fleet until the design is finalized and quantities are available. This raises questions with respect to what might be done if the contractor does not have the correct equipment available to undertake the work (see also MDRB#1, Section 6.0); and,

13. The design of and specifications for the instrumentation is not at all detailed. The instruments should adequately record conditions in the dike and allow appropriate warning of any undesirable or potentially unsafe conditions; it is therefore important that the instrumentation is properly installed and monitored. The reviewers recommend that additional detail be included in the drawings and specifications for the instrumentation system.

3. Specific Issues

The following highlights comments with specific sections of the report, drawings, or specifications.

A. Design Report

1. *Section 3.3 – Freeboard* notes a 1.0 m freeboard, which is seems appropriate. However, no provision (overbuild) seems to exist in the

design to account for settlements that could reduce the freeboard with time;

2. *Section 4.1 – Shallow Depth Design* indicates that dynamic compaction will be carried out to densify the backfill. The specifications do not indicate the procedures, criteria, etc., for dynamic compaction; and,

3. *Section 4.2 – Medium Depth Design* identifies that thermal siphons could be considered if additional treatment of the foundation tills is required. This technique might indeed be suitable; however, the need for a minimum one full winter of freezing must be considered in the construction timeline (see also MDRB#1, Section 5.0).

   Seepage evaluations have been carried for the dike, with a range of hydraulic conductivities for the lakebed soils and these have indicated seepage volumes of between 85 and 1500 m^3/day for a 300 m long section. It is expected that the final design will use the results from the latest site investigations and experience with the construction of the East Dike to determine an expected range of inflows for the entire length of the dike. Foundation conditions and the effectiveness of the grouting will be highly variable and therefore it will be difficult to predict inflows accurately. However, it is recommended that a parametric seepage analysis be carried out to estimate the range of expected inflows to be able to design the seepage collection system appropriately (see also MDRB#1, Section 3.8).

B. Drawings

1. *Drawing 4200-06* – The 0.75H:1V slope on the Core Backfill seems optimistic particularly when it is specified that the core backfill must precede placement of the Coarse Filter “wings” (Specification S5.9.4, page 47);

2. *Drawing 4200-11* – This drawing does not show the piezometer installation locations. Additionally, the details for wiring the instruments into the proposed data acquisition “cabins” noted in the specifications are not shown;

3. *Drawing 4200-12* - It appears that the typical section shows the wrong chainages: 30+235 should be 31+235 and 31+760 should be 30+760, if they are shown correctly on Drawing 4200-11;

4. *Drawing 4200-13* – Typical thermistor section does not show an installation detail for how the cables are to be installed (e.g., in a casing);

5. *Drawing 4200-18* – The section generally shows a 2 m depth of lakebed soils. It is known that the soils will be of variable thickness; however, the depths from the existing boreholes indicate a simple average thickness of 3.2 m. Data will be available from the upcoming/ongoing site investigation, but the known information indicates that perhaps something greater than 2.0 m depth should have been considered; and,

6. *Drawing 4200-19* – The section indicates that all grouting will be carried out in vertical holes. As noted in the Section 2.0, it is questioned whether vertical grout holes are the most appropriate orientation.

C. Specifications

1. *Section S1.2.3, Table 1-2* – All but one of the specifications are ASTM standards. It is suggested that CSA standards should be used for many of the required tests since this is a project in Canada and will probably use Canadian contractors;

2. *Section S1.4, Table 1-3 – Scope of Work* – It is indicated that dewatering is to be carried out by the owner. It is recommended that the specifications include a section for dewatering;

3. *Section S3 – Turbidity Barrier* – This section indicates that specifications for the barrier (material, dimensions, etc.) will be provided under separate cover. The reviewers strongly recommend that the specifications for the turbidity barrier be included in this document (see also MDRB#1, Section 3.3);

4. *Section S5.9.5 – Fill Compaction* – It is indicated that procedures for densification of the Core Backfill will be trialed. Some methods may require specialized equipment, and unless it is planned for in advance, this equipment may not be available at site. It is suggested that the designers should indicate the expected methods to be employed (trialed) so the contractor has the appropriate equipment available;

5. *Section S6.3.5 – SB Backfill* – This section indicates that the slump of the SB Backfill shall be between 50 mm and 150 mm. Section S5.4.5 indicates that the till for this backfill can have particles up to 152.4 mm size. It is questioned how the slump of a material with very large aggregate could be measured. If it cannot be measured, is there an alternate test specification that is more appropriate for this material or is this till appropriate for making the SB Backfill? The QC and QA requirements (Table 9-2) also indicate that the permeability of this material will be measured. The reviewers question the feasibility of testing the permeability of a material with very large aggregate;

6. *Section S6.3.6 – CB Backfill* – Note that CB Backfill will cure in the dike at temperatures that will probably be considerably colder than in the laboratory. In this case, strength gain in situ will probably be less rapid than in the laboratory, and the ultimate strength may also be substantially less. It is therefore questioned whether the desired 172 kPa strength is truly required. If it is, it may be more appropriate to specify strength for specimens cured at a temperature that more realistically reflects the in situ curing temperature for the CB Backfill or, conversely, a higher required strength for samples cured under laboratory conditions;

7. *Section S8.2.3 &.6 – Cabins and Accessories* – There is no specification or details on the drawings for the cabins, supports and accessories that are supposed to be supplied by the contractor; and,

8. *Section S8.3.7 – Data Acquisition and Processing Equipment* – There is no specification for the data acquisition systems to be installed.

4. Conclusion

Indian and Northern Affairs Canada is of the opinion that AEM should implement these comments / recommendations into the Bay-Goose and South Camp dike designs.