SNC • LAVALIN

SUSTAINABLE MINE DEVELOPMENT

FINALDESIGN REPORT

AGNICO-EAGLE MEADOWBANK DIVISION

DETAILED ENGINEERING OF VAULT DIKE

Our file:
610548-2020-4GER-0001

JANUARY, 2013

Certified ISO 9001

WE CARE
NOUS VEILLONS

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Québec, January 14, 2013

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Subject: Detailed Engineering of Vault Dike
Our file: 610548-2020-4GER-0001-00

Dear Madame Bélanger,

We are pleased to submit our final report on the detailed engineering of Vault Dike.

Do not hesitate to communicate with the undersigned for any question regarding the content of this report.

Truly yours,

SNC LAVALIN INC.

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JFSTL/YJ/GH/sh

LIST OF REVISIONS

Revision				Revised pages	Remarks
#	Prep.	App.	Date		
PA	JFSTL	YJ	2012/12/13	All	Internal review
PB	JFSTL/YJ	GH	2012/12/14	All	Issue for comments
PC	JFSTL/YJ	GH	2012/12/17		Issue for MDRB comments
00	JFSTL/YJ	GH	2013/01/14		Final report

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1 INTRODUCTION

This document presents the detailed design of Vault Dike at Agnico-Eagle Mines' Meadowbank site. Vault Dike will allow the dewatering of Vault Lake in Spring 2013, and will limit water infiltration from Wally Lake during mining operations in Vault Pit.

The purpose of this report is to present the detailed design of Vault Dike including the design basis, criteria, assumptions as well as the results of the recently completed geotechnical investigation. A proposed construction schedule and the estimated material quantities are also presented in this document.

1.1 Background

AEM will start exploiting Vault Pit in 2014. This open pit mine is located approximately 8 km from the main Meadowbank site, and will supply 60 to 80% of the total ore production from 2014 to 2016, and 100% of the total ore production during the last year of the life of mine, expected to be in 2017

Vault Pit is located within the footprint of two existing lakes: Phaser Lake and Vault Lake. In order to allow the dewatering of these lakes and isolate Vault Pit during mining activities from Wally Lake, Vault Dike will be constructed across a shallow creek which connects Vault and Wally lakes.

1.2 Mandate

AEM has mandated SNC-Lavalin Inc. (SLI) to prepare the detailed engineering and related technical specifications for the construction of Vault Dike. SLI's detailed engineering is based on current site conditions as interpreted from the available information: AEM's input on the site specific data, SLI's geotechnical investigation, thermistor string data from November to December 2012 and interpretations of applicable laws, regulations and guidelines.

1.3 Content of the Study

The following tasks were performed by SLI as part of this detailed engineering:

1. Review of available technical data and other relevant information;
2. Preparation of a design criteria and design basis;
3. Programme preparation for and supervision of a geotechnical investigation campaign including the installation of a thermistor strings;
4. Interpretation of thermistor string data collected over a period of 1 month;

5. Preparation of the detailed design of Vault Dike, including thermal and slope stability modelling and estimation of the construction material quantities;
6. Preparation of construction drawings and technical specifications for Vault Dike.

2 REGULATION, CODES, GUIDELINES AND STANDARDS

The detailed engineering of the Vault Dike was carried out in SI units in accordance with Laws, Guidelines and Standards listed in Table 2-1.

Table 2-1: Legal Tools and Guidelines for Dike Construction

Legal Tool or Guidelines	Reference
Nunavut	
Water & Surface Rights Tribunal Act	Nunavut Water Board
Northwest Territories and Nunavut Regulations	C.R.C., c. 1516, Territorial Land Act
Federal	
CDA – Dam Safety Guidelines, 2007	Canadian Dam Association (CDA)
Others	
Loi sur la Sécurité des barrages (Quebec)	L.R.Q., S-3.1.01

3 PARAMETERS, CRITERIA AND DESIGN BASIS

As presented in the Vault Dike Design Basis (SLI, 2012), the dike will have to comply with specific criteria presented below.

3.1 Geotechnical Parameters

The geotechnical parameters used for Vault Dike design are based on values in the literature or derived from previous studies on similar Meadowbank projects. The thermal parameters of the Vault Dike foundation soil were confirmed and/or adjusted through a calibration using thermal modeling (see section 4.4.2.1). The parameters used for the slope stability and thermal analyses are presented in Table 3-1.

It is important to point out the Meadowbank Mine Dike Review Board finds the parameters listed in Table 3-1 as being appropriate for the type and scale of the structure being designed; see Appendix D.

Table 3-1: Geotechnical Parameters

Material	Parameter (see legend below)							
	c (kPa)	Φ (°)	γ_d (kg/m³)	W_v (m³/m³)	k_u (kJ/day/m/°C)	k_f (kJ/day/m/°C)	c_{vu} (kJ/m³/°C)	c_{vf} (kJ/m³/°C)
Water	NA	NA	1,000	1	193 (2.2 W/m/°C)	52 (0.6 W/m/°C)	4,187	1,880
Till[1]	0	34	1,870	0.31	155 (1.8 W/m°C)	207 (2.4 W/m°C)	2,900	2,000
Bedrock[1]	NA	NA	2,710	0.005	251 (2.9 W/m°C)	251 (2.9 W/m°C)	2,500	2,500
0-20 mm	0[1]	34[1]	2,250[1]	0.05[2,3,4]	160[2,3,4] (1.85 W/m°C)	185[2,3,4] (2.14 W/m°C)	2,070[2,3,4]	1,870[2,3,4]
0-20 mm amended with 6% bentonite[2]	0	32	2,200	0.02	60 (0.7 W/m°C)	60 (0.7 W/m°C)	1,750	1,670
0-150 mm[5]	0[1]	36[1]	2,000[1]	0.01	70[3,4] (0.8 W/m°C)	40[3,4] (0.45 W/m°C)	1,500[3,4]	1,475[3,4]
Bituminous liner	0	34	NA	--	--	--	--	--
Rockfill (0-600mm)[5]	0[1]	45[1]	2,000[1]	0.02[2,3,4]	95[2,3,4] (1.1 W/m°C)	70[2,3,4] (0.8 W/m°C)	1,850[2,3,4]	1,900[2,3,4]

Notes:
1. Parameters used by Golder given to SLI by AEM, emails dated November 21st and December 3rd, 2012
2. Parameters estimated from SLI experience with similar materials in northern Canada
3. Filion, Côté and Konrad, 2011
4. Lebeau and Konrad, 2007
5. Worst thermal parameters have been applied for the expected conditions

Legend:
C = Cohesion,
Φ = Angle of internal friction,
γ_d=Dry density
W_v = Total unfrozen volumetric water content
K_u = Unfrozen thermal conductivity
K_f = Frozen thermal conductivity
C_{vu} = Unfrozen volumetric heat capacity
C_{vf} = Frozen volumetric heat capacity

3.2 Hydrological Data

Refer to the Water Management Plan 2012 (SLI, 2012a).

3.3 Air Temperature Data

AEM provided SLI with daily mean air temperature data from 2009 to 2011, which are presented in Figure 3-1. These temperatures were recorded at the main Meadowbank site (8 km away from Vault Dike) and were determined to be adequate for the purpose of the present thermal analyses, since Vault Dike will be dismantled after a service life of only about 5 years, in 2017. Consequently, the impact of climate change was not considered. The air temperature modifier *n* factors used are shown in Table 3-2.

Figure 3-1: Observed Temperature at the Meadowbank Main Site

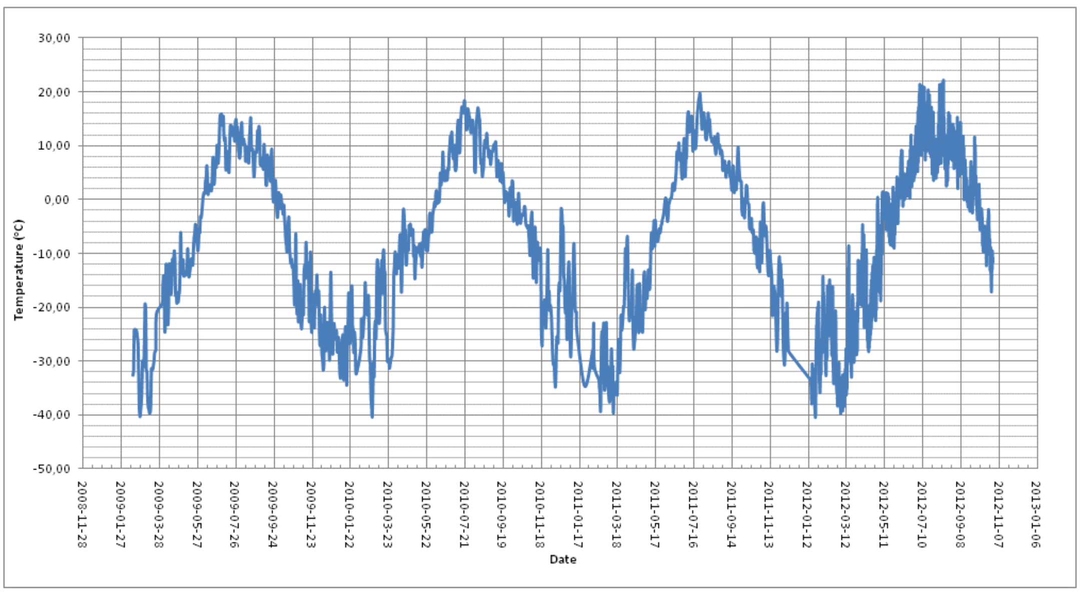


Table 3-2: Air Temperature Modifier n Factor

Site	n factor	
	n_f (frozen)	n_u (unfrozen)
Meadowbank	0.6	1.5

Note:
n-factors were estimated based on similar projects in northern Canada, and were adjusted during the numerical model calibration process (See Appendix C)

3.4 *Topography and Bathymetry*

Topographic and bathymetric data were provided by AEM and are presented on the construction drawing included in Appendix A.

3.5 *Geotechnical Investigation*

The field investigation was performed in two phases: the first phase by a geotechnical firm took place in November 2012, and the second phase was undertaken by the AEM geotechnical team in December 2012. The investigation was done with a top hammer air track drill rig, supported on ice to determine the elevation of the bedrock underneath the creek between the Vault and Wally Lakes, as well as at the abutments. During Phase 1 geotechnical investigation, an accurate characterization of the cuttings was not possible because the ice was not in contact with the creek bed. Therefore, a second field investigation was undertaken by AEM to complete and/or validate the data at a few selected locations, specifically the bedrock elevation along the shore.

At first, three (3) thermistor strings were installed, as shown on Figure B-1 in Appendix B. Recorded temperatures from November 17th to December 16th, 2012 are presented in Figure 3-2 to Figure 3-6. Figure 3-3, Figure 3-5 and Figure 3-7 present soil temperature variations over time, at different elevations in the field.

Thermistors VDTH-1 and 2 show the expected vertical soil temperature profile. However, the temperature profile at thermistor VDTH-3 is considered unusual. Two (2) phenomena may be at the origin of that particular temperature distribution:

1. The thermistor string installation was difficult due to the presence of water. In fact, field staff considered the thermistor installation inadequate. The thermistor contact with the surrounding soil may not be continuous, and surface water may have infiltrated into the soil/bedrock. Furthermore, it was not possible to check if the hole was completely filled with granular material.

2. Warm water (slightly above 0^{o}C) flowing through the soil could account for the observed behavior as demonstrated by a numerical modeling (see appendix C).

Figure 3-2: VDTH-1 Vertical Temperature Profile

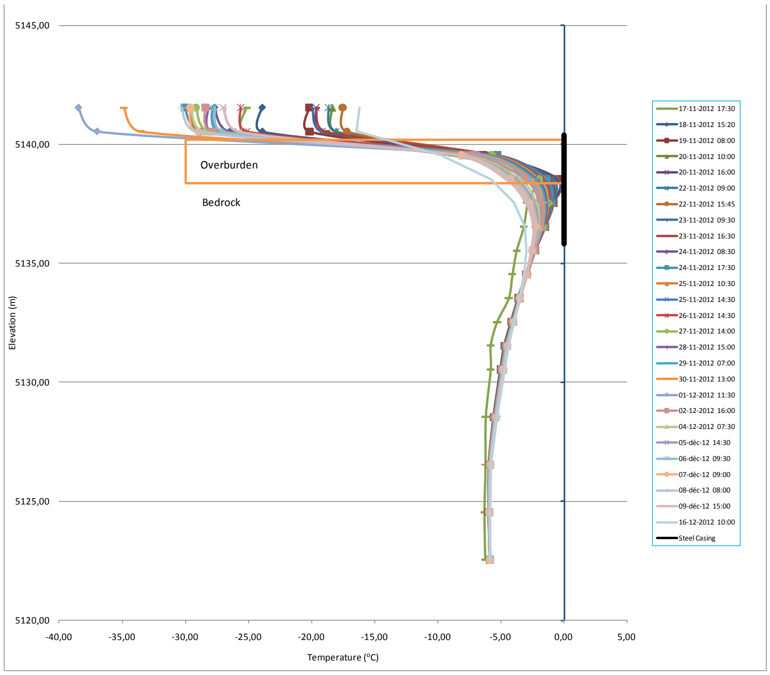


Figure 3-3: VDTH-1 Bead Temperature vs. Time

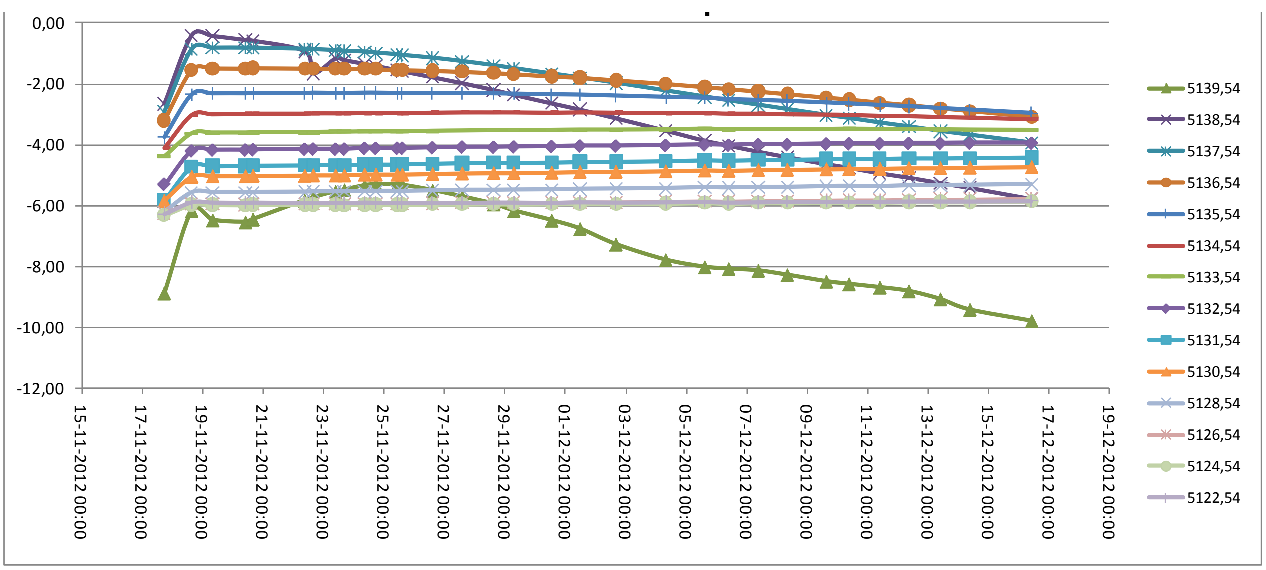


Figure 3-4: VDTH-2 Vertical Temperature Profile

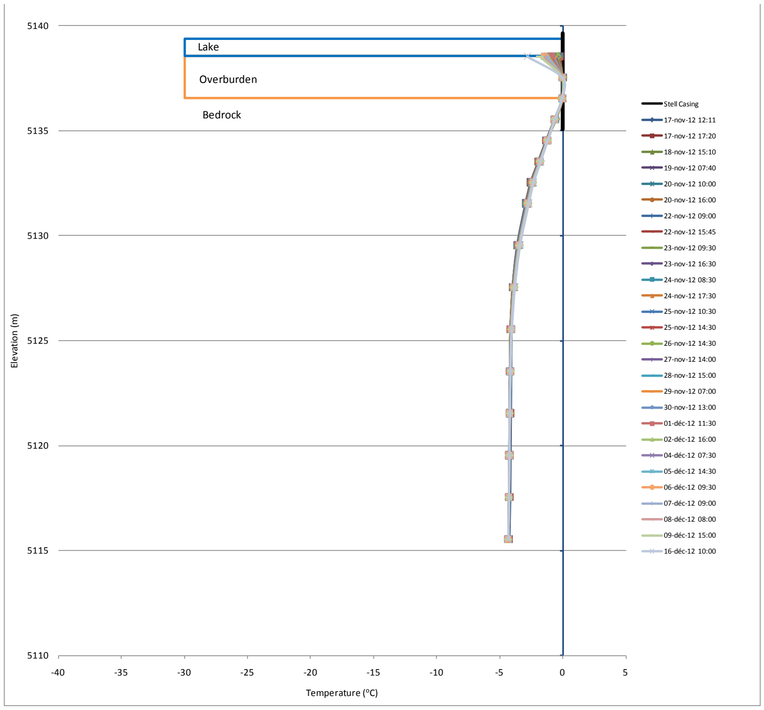


Figure 3-5: VDTH-2 Bead Temperature vs Time

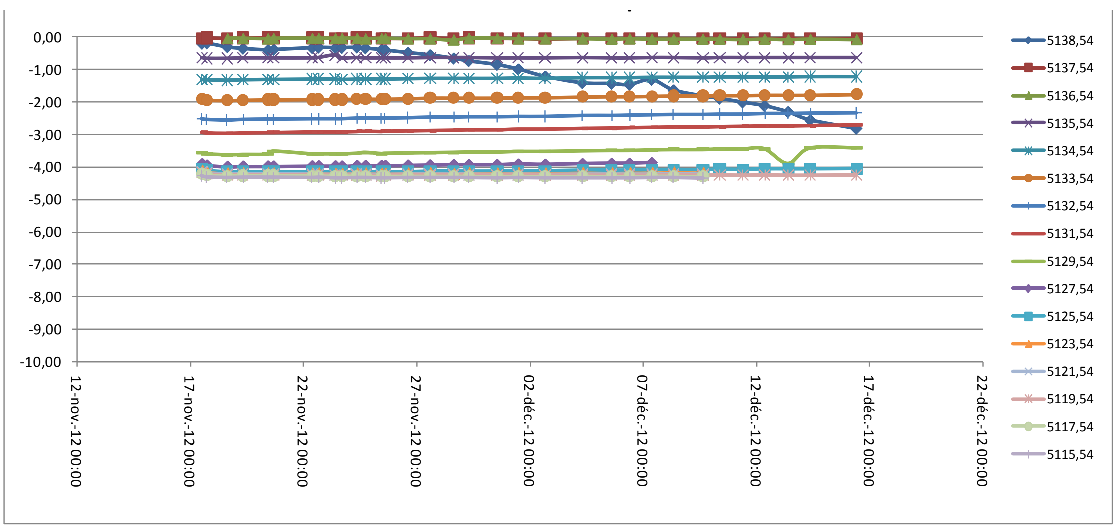


Figure 3-6: VDTH-3 Vertical Temperature Profile

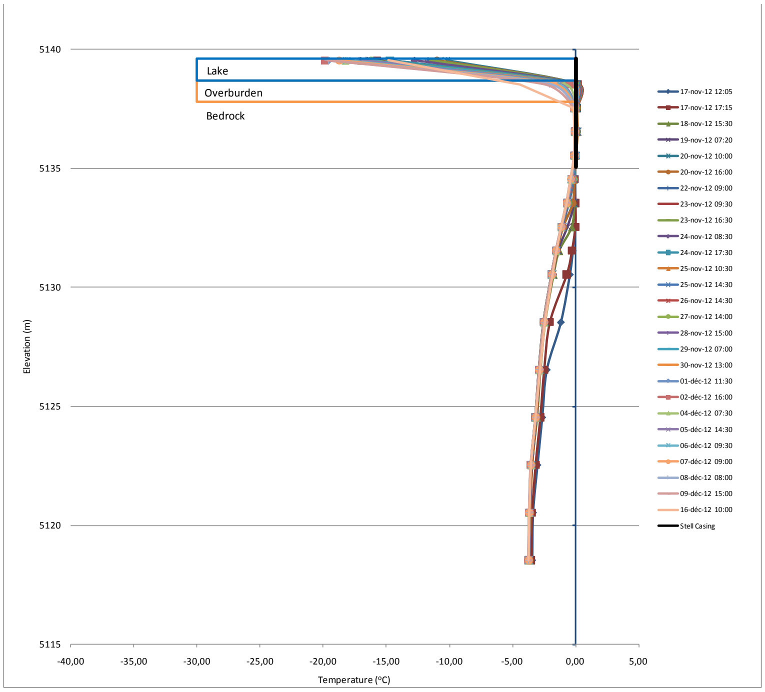
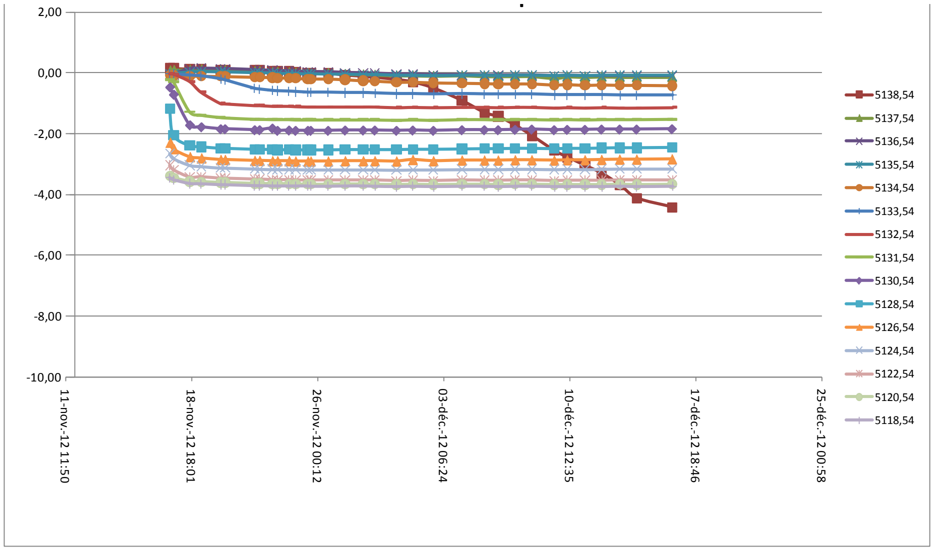


Figure 3-7: VDTH-3 Bead Temperature vs. Time



3.6 Dam Consequence Category

As recommended by the Canadian Dam Association (CDA, 2007), Vault Dike was classified according to the incremental consequences of failure. The classification system is based on the highest potential consequence of dam failure, including loss of life, environmental impact and cultural and/or economic loss.

Considering the items below, the Vault Dike classification was determined to be *Low*:

- Vault Pit will be in operation for only four (4) years;
- Vault Dike will retain water with a maximum depth of 1.5 m, and the impact of failure will be limited;
- Vault Dike is located more than 500 m away from the mining area;
- The population at risk (workers) at the site is temporary;
- Possible loss of life is estimated to be between 0 and 10;
- No significant fish or wildlife habitat will be lost, affected or deteriorated by a dike failure;
- No infrastructure or important economic loss would occur following a dike failure.

3.7 Seismic Criteria

CDA (2007) also provides recommendations on the Earthquake Design Ground Motion (EDGM) for each dam consequence classification, as presented in Table 3-3.

Table 3-4 presents the Meadowbank peak horizontal ground acceleration for various return periods, which were provided by the Geological Survey of Canada (GSC)[1]. These parameters were not updated since the Meadowbank project site is located in an area of low seismicity. Moreover, these EDGM[2] values were used to be consistant with parameters used for other dikes built at site. It should also be noted that updating of these parameters was not part of in SLI's scope of work.

[1] Source: Seismic Risk Calculation for Meadowbank Project Site, Geological Survey of Canada, Natural Resources Canada 2003. Meadowbank Gold Project, Integrated Report on Evaluation of Tailings Management Alternatives, Cumberland Resources Ltd., February 2007.

[2] EDGM: Earthquake design ground motion.

Table 3-3: Criteria for Design Earthquakes

Dam class [1]	EDGM Annual Exceedance Probability (AEP) for Associated Dam Class[2]
Low	1:500 yr
Significant	1:1 000 yr
High	1:2 500 yr
Very High	1:2 500 yr
Extreme	1:10 000 yr

Notes:
[1] Dam classification is based on the potential consequences of dam failure (see section 3.6).
[2] AEP levels for EDGM have to be used for mean rather than median estimates of the hazard

Table 3-4: Earthquake Design Peak Ground Acceleration

Annual Exceedance Probability (AEP)	Maximum Horizontal Ground Acceleration (g)[1]
1:100 yr	0.018
1:200 yr	0.025
1:475 yr	0.034
1:975 yr	0.044

Note:
[1] Values are associated with the firm ground

3.8 Stability Criteria

The minimum acceptable factors of safety for static and pseudo-static loading conditions and dike crest deformation are presented in Table 3-5.

Table 3-5: Minimum Acceptable Safety Factors and Crest Deformation

Loading Condition	Factor of Safety
Static	1.5
Pseudo-static	1.1
Post-Liquefaction	1.2
Maximum allowable crest deformation	0.5 m

3.9 Dike Crest Elevation and Freeboard Criteria

The Vault Dike crest elevation must be high enough to impound runoff corresponding to a selected return-period spring freshet. As presented in SLI (2012a), the design flood consists of the combinaison of the melting of a 100-year return period snow cover with the 100-year return period rainfall occuring between January 1st and the start date of the dewatering of Vault Lake. The 100-year return period was chosen based on Vault Dike classification (see section 3.6), as recommended by the CDA (2007). The estimated water level in Spring 2013 for Vault Lake used for this design is 5,140.41 m (SLI, 2012a).

Thus, it is assumed that AEM would start pumping as soon as possible in spring 2013, in order to maintain the water elevation in Vault Lake at its normal level (5,139.52 m). However, to provide additional protection in case of a pumping delay or pump breakdown, Vault Dike will be sealed with a bituminous membrane sandwiched between a bedding and a cover layers composed of 0-20 mm amended with 6 % of bentonite up to elevation 5,141 m.

According to CDA (2007), the freeboard should be sufficient to avoid or minimize the risk of dam overtopping by waves created under the critical wind speed selected for the design. This freeboard shall also be sufficient to prevent excessive frost heave or crest settlement due to thaw.

The minimum freeboard requirement is 2.0 m above the design maximum water level[3]. This criterion has been used for similar dikes at the Meadowbank mine site. The final Vault Dike crest elevation will thus be 5,142.5 m, i.e. nearly 3.0 m above the normal water level in Vault and Wally Lakes.

A low point is present on the east side of Vault Lake at elevation 5,140.77 m, 0.36 m above Vault Lake's Spring 2013 estimated maximum water level. On the assumption that pumping will maintain the Vault Lake water level at 5,139.52 m and that an access road will be built on the east side of the Vault Lake, it was concluded that a saddle dam was not necessary.

3.10 Design Basis

The initial design basis was established based on the information available at the time (September 2012). Some items which were assumed in the design basis were confirmed during the field investigation, while others were modified prior to the detailed design. These are presented below:

- Creek water depth is between 0.5 m to 1.5 m within the dike footprint
- The overburden thickness beneath the dike foot print is approximately 2.5 m (see appendix B) instead of 5.0 m, as initially assumed
- Thermistor strings have confirmed that there is no talik beneath the Vault Dike footprint (see section 3.5). However, the temperature profile suggests that water could flow between the Vault and Wally Lakes, into the overburden and about 1 meter of bedrock during the thawing period.

4 VAULT DIKE DESIGN

4.1 General

The Vault Dike design was developed in order to meet the following objectives:

- Limit and/or stop water infiltration form Wally Lake into Vault Pit by :
  - Sealing the Wally Lake side slope of the dike with a bituminous liner;
  - Increase the permafrost strength under the dike;
  - Limit thaw penetration.
- Retain the maximum design water level in Vault Lake for 2013;

[3] Based on communication between SLI and AEM on July 11th 2012

- Allow dewatering of Vault Lake and mining in Vault Pit;
- Be stable under static and dynamic loading.

The Vault Dike design was developed based on available information, assumptions and numerical modelling. The key assumptions are:

- AEM will control the water level in Vault Lake during the 2013 freshet;
- AEM will re-establish the minimum freeboard with granular fill after settlement, whenever required;
- The Vault Dike classification is ***Low*** as per CDA (2007);
- The Vault Dike service life is five (5) years;
- AEM will monitor the construction of the structure to ensure conformance with the specifications;

4.2 Frost-Heave

The materials used for the construction of Vault Dike are not susceptible to frost-heave. Furthermore, the underlying frozen till will not be subject to freeze and thaw cycles hence limiting the risk of heaving. However, if heaving occurs, AEM will have to undertake corrective measures.

4.3 Settlement Analysis

Settlement analyses were not performed during this study. If settlement occurs, AEM will re-establish the minimum 2.0 m freeboard height with granular fill. The Vault Dike construction procedure, construction material and soil foundation are similar to the existing South Camp Dike, which has performed reasonably well for the past few years. As outlined in section 4.7.2, all settlements must be recorded. Excessive total of differential settlements should be reported to senior staff or SLI and corrective actions or measures shall be taken in time.

In his regard, Vault Dike foundation preparation activities, which consist of the removal of all ice and snow accumulation within the dike footprint, should minimize the disturbance of the foundation soil.

4.4 Numerical Analysis

Temp/W finite elements numerical tool was used for thermal modelling, and Slope/W was used to evaluate the stability of the dike slope. These tools are part of the GeoStudio 2012 software suite developed by GEOSLOPE International Ltd. of Calgary. They were chosen because:

- They are commonly used in engineering practice in Canada and elsewhere in the world;
- The capability and accuracy of the software are considered adequate for engineering design purposes

4.4.1 Stability Analysis

The parameters used for the slope stability analysis of Vault Dike are presented in Table 3-1. Table 4-1 and Figure 4-1 present the results of static loading and Figure 4-2 those of pseudo-static loading stability analyses. The pseudo-static analyses were carried out using a seismic coefficient of 0.034 (see Table 3-4). The results of the analyses show that the dike has adequate factor of safety under static and dynamic loading. Vault Dike foundation materials are frozen, hence are not liquefiable. In addition, the construction materials are considered resistant to liquefaction, therefore no post-liquefaction stability analysis was performed.

Table 4-1: Obtained Static and Pseudo-Static FoS

Loading Condition	**Obtained FoS**	
	Upstream (Wally Lake side)	Downstream (Vault Lake side)
Static	1.495 (shallow slip surface) 2.163 (deep slip surface)	1.533 (shallow slip surface) 2.680 (deep slip surface)
Pseudo-static	1.392 (shallow slip surface) 1.991 (deep slip surface)	1.421 (shallow slip surface) 2.416 (deep slip surface

Figure 4-1: Upstream (Wally Lake side) and Downstream (Vault Lake side) Slope Stability (Static Loading)

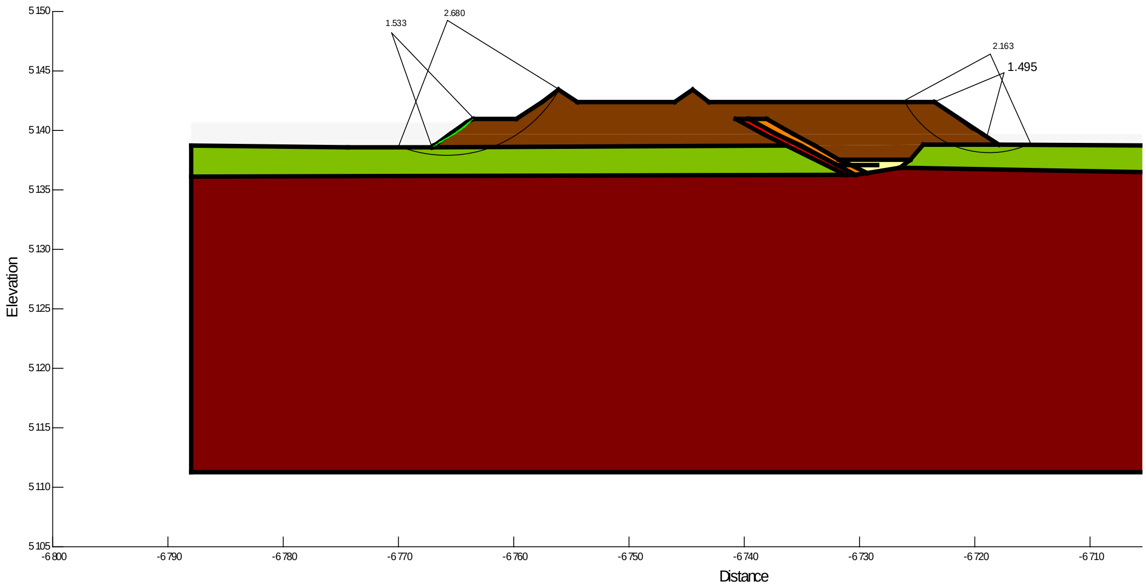
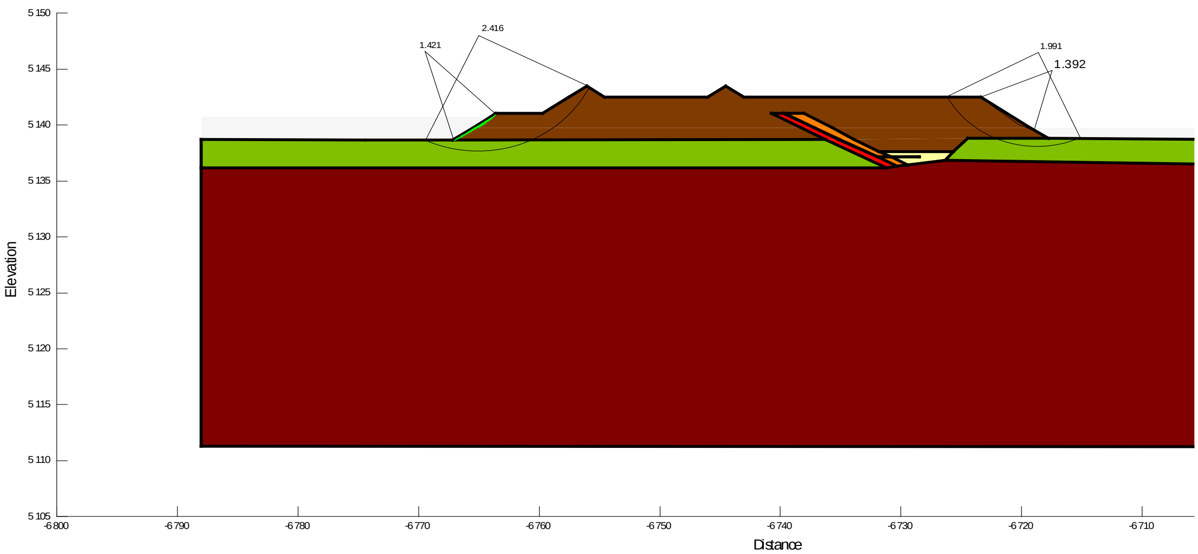


Figure 4-2: Upstream Slope (Wally Lake side) and Downstream (Vault Lake side) Slope Stability (Pseudo-Static Loading)



4.4.2 Thermal Analysis

For the thermal analysis, only conductive heat transfer was evaluated since advective heat transfer was not part of SLI's mandate.

Temp/W's capability to adequately model conductive heat transfer was validated by comparing numerical results to the Neumann's solution (see Appendix C).

A calibration of the thermal model was performed over the temperatures range observed in the field. This step allowed SLI to validate the thermal parameters of the foundation soil by matching numerical temperatures over observed ones (see section 4.4.2.1 and Appendix C).

The air temperatures used in the model are shown in Figure 3-1 and were coupled with the freezing and thawing *n* factors given (see Table 3-2) to estimate the surface temperatures. The calibrated thermal parameters used in this analysis are presented in Table 3-1.

Fixed thermal parameters were considered adequate for this design; therefore Temp/W's simplified thermal material model was used.

4.4.2.1 1D Calibration

In order to calibrate the numerical model, it was run for 6 years to: (1) establish an adequate vertical soil temperature profile and (2) compare the numerical temperature profile for year 7 to that observed. Soil thermal parameters and *n* factors were then adjusted to obtain a satisfactory match between the numerical and observed temperature profiles.

The 1D calibration was performed on a 23 m long vertical column with a width of 0.1 m. The soil stratigraphy used for the calibration process is based on that derived from the field investigation (see appendix B). When necessary, water depth and the overburden thickness were slightly modified to improve the match between the observed and the numerically generated profiles.

Initial soil temperatures are presented in Table 4-2. The bottom boundary condition is a fixed temperature corresponding to the temperature observed at the deepest thermistor bead, and the top surface boundary condition corresponds to the recorded mean Meadowbank air temperature coupled with an appropriated *n* factor.

Table 4-2: Initial Soil Temperature

Material	Initial Temperature (°C)
Water	0.1
Till	0.1
Bedrock	-3.0

4.4.2.2 Thermal Behaviour Prediction

Temp/W was used to establish the thermal regime through and below Vault Dike until 2017, assuming that no water seeps through its foundation. A typical Vault Dike cross section used for Temp/W modelling is presented in Appendix C. Staged construction was not included in the model, but the initial temperature of the construction soils considered winter condition (-20°C).

Expected water levels in Vault Lake during spring and Summer 2013 (5,139.4 or 5,141.0 m) do not have any major impact on Vault Dike's thermal behaviour. If the foundation permafrost strength increases for a period of 21 days before the start of construction, the key trench temperature may be 2°C colder during the first year. The impact of the pre-construction freezing process diminishes over time and is not observed in spring 2014. If warm water (5°C) infiltrates the rockfill base in summer 2013, it will warm but will not thaw the key trench and underlying materials (see Figure C-22 in Appendix C).

4.5 Construction Material

Table 4-3 shows the construction materials that will be used during the dike construction.

Table 4-3: Material Used

Material	Use
Crushed rock (0-20 mm) amended with 6% of bentonite[1]	Key trench bottom, Vault Dike abutment between elevations 5,140.5 and 5,141.0 m
0-20 mm	Bedding and cover materials in direct contact with the geomembrane
0-150 mm	Transition zone material between 0-20 mm and the rockfill
Rockfill (0-1,200 mm)	Dike fill, access road foundation, thermal cap
Bituminous liner	Seepage cutoff

Note:

1. Considering that 2% of the bentonite is usually lost during the mixing and construction processes, the mixing should be realize with 8% of sodium bentonite.

4.6 Typical Section

The typical section chosen is a rockfill dike with an impervious upstream liner consisting of a bituminous geomembrane (BGM). Fine and coarse granular materials are placed between the liner and the rockfill. The liner will be used to seal the dike up to elevation 5,140.5 m. A plug of 0-20 mm amended with bentonite will seal the dike abutment between elevations 5,140.5 and 5,141.0 m. The BGM will be buried at the upstream toe in the key trench between two layers of 0-20 mm amended with bentonite.

Prior to any rockfill placement, a working platform should be built on a satisfactory foundation. The platform should have a minimum width of 15 m and a thickness of 1.5 m.

All ice and snow encountered within the final footprint of Vault Dike should be excavated and properly disposed of prior to placing any granular material.

The typical section described above was previously used at the site with good performance (South Camp Dike). See Appendix A for the design drawing.

4.7 Vault Dike Instrumentation and Monitoring

4.7.1 Thermistor Strings

Three (3) thermistor strings should be installed per section to monitor Vault Dike and the thermal behaviour of its foundation. At this point, only one critical section has been identified in the deepest section of the dike.

Based on field observations, the SLI engineer on site may recommend that the thermal behaviour of an additional section be monitored. The additional thermistors should be installed under the direction of the SLI engineer.

To evaluate the post-construction performance of Vault Dike, the temperature on the upstream and downstream sides of the key trench should be monitored to a depth of 20 m beneath the dike crest (+/- 15 m below creek bed). The temperature beneath the liner should also be monitored. The thermistor strings located beneath the BGM should be installed during dike construction and the two other thermistor strings should be installed once the dike construction has been completed.

Thermistor bead spacing should be selected to detect possible leaks in the liner and/or to detect any water in Vault Dike. To do so, the thermistor bead spacing should follow the recommendations presented in Table 4-4. Thermistor strings with sixteen (16) beads was used to ensure continuity with other thermistor strings installed at the site.

Based on field observations, the SLI engineer may consider that at the additional thermistor strings are required which should be installed under his direction.

Table 4-4: Thermistor String Bead Spacing

Bead n°	VDTH13-01 (Elevation in m)	VDTH13-02 (spacing in m)	VDTH13-03 (Elevation in m)
16	5142.5	15	5142.5
15	5141.5	14	5141.5
14	5141.0	13	5141.0
13	5140.5	12	5140.5
12	5140.0	11	5140.0
11	5139.5	10	5139.5
10	5139.0	9	5139.0
9	5138.0	8	5138.0
8	5137.0	7	5137.0
7	5136.0	6	5136.0
6	5135.0	5	5135.0
5	5133.0	4	5133.0
4	5131.0	3	5131.0
3	5129.0	2	5129.0
2	5126.0	1	5126.0
1	5122.5	0	5122.5

Notes:
Bead n° 1 is located at the thermistor string bottom extremity
Bedrock estimated to be at bead 14 or 13 for vertical thermistor string

4.7.2 Settlement Plates

No settlement plates are required for Vault Dike. However, its crest must be surveyed every 2 weeks during the 2013 thaw period to ensure that no unexpected settlement occurs during Vault lake dewatering. Once Vault Lake has been emptied, AEM should survey the Vault Dike crest following the same schedule as for the other dikes.

4.7.3 Inspection

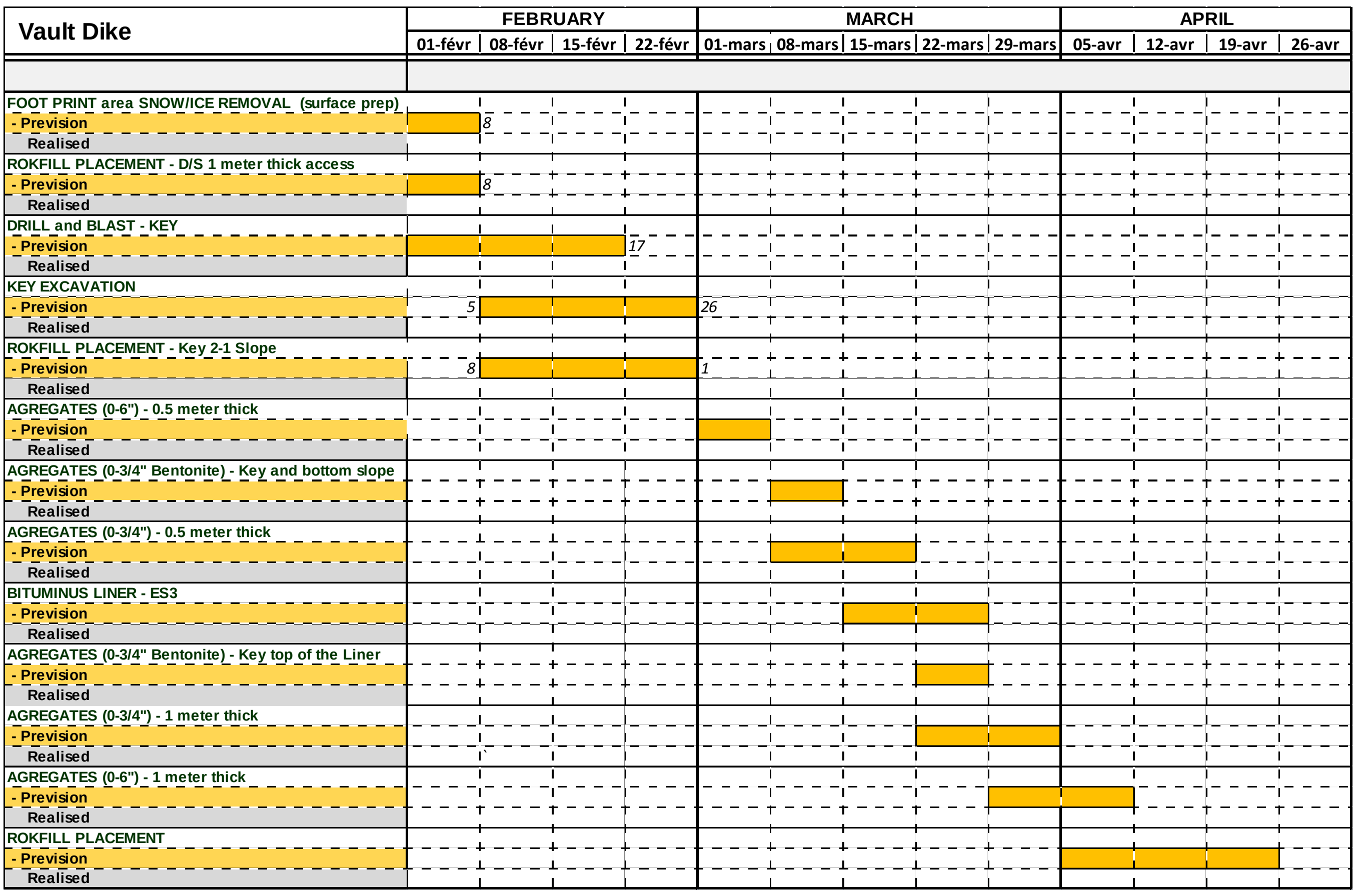
AEM should undertake a visual inspection of Vault Dike especially during spring and summer 2013. AEM should note any water ex-filtration, unusual crest settlement or cracks and should contact SLI. SLI recommends that a visual inspection of the dike be carried out on a regular basis, whenever the thermistor string data is collected. The inspection of Vault Dike should also be included in Meadowbank's global annual dike inspection.

5 CONSTRUCTION

5.1 Construction Period and Schedule

The construction of Vault Dike should begin in February 2013. During this period, ice will act as a cofferdam such that the earthworks can be executed under dry conditions. Dike construction, including instrumentation installation, is estimated to take 11 to 12 weeks. Earthworks should be completed by the last week of April 2013. The proposed schedule provided by AEM on December 10th, 2012 is presented in Table 5-1.

Table 5-1: Proposed Schedule (2013)



5.2 Pre-Construction Works

Prior to any heavy-equipment work, the thermistors installed during the geotechnical investigation in November 2012 should be removed.

As for other pre-construction work, AEM should expose the key trench to cold temperatures as soon as possible. The key trench should be blasted and kept free of snow in order to increase the strength of the permafrost within the dike foundation. The alignment of the key trench, in addition to its width and depth are presented on the design drawing in Appendix A. The proposed pre-construction foundation preparation will have a positive impact on the thermal behaviour of the dike foundation, as noted in section 4.4.2.2 and Appendix C.

AEM should also build a rockfill pad on the east abutment of the dike, wide enough for construction equipment traffic.

5.3 Construction Procedure

The construction area will be at least 60 m wide and must be cleaned of all snow and ice before construction of the dike downstream shell (working platform) begins (see design drawing in Appendix A). A detailed working procedure must be proposed by the contractor and approved by the SLI engineer on site and by the AEM technical representant as well. Dike construction must always be carried under the supervision of an SLI representative.

The 0-20 mm stone amended with sodium bentonite must be mixed on site. Great care must be taken to minimize the amount of bentonite powder lost during the mixing process, hauling and placement of this material. Detailed mixing, hauling and placement procedures must be proposed by the contractor and approved by the SLI engineer on site and by the AEM technical representant as well. The mixing process must always be performed under the supervision of the SLI engineer.

5.4 Quality Assurance/Quality Control (QA/QC)

Prior to construction, the role of the QA/QC/Owner must be clearly defined.

Inspec-Sol and AEM will be responsible for QC during construction (earthworks and liner installation); SLI will be responsible for QA during construction; and AEM will be responsible for the QC during pre-execution works (drill and blast), in addition to overseeing the maintenance of the trench and survey of the work (stakeout/survey of zones and verifications).

AEM will also be responsible for data collection and transfer to SLI.

AEM will be responsible for preparing the “as-built” report.

The QA/QC program, to be prepared by SLI will be included in the technical specifications.

6 ESTIMATED QUANTITIES

Table 6-1 and Table 6-2 present the estimated quantities of the construction materials for Vault Dike. These quantities are based on the results of the site investigation as well as the available topographic and bathymetric data. SLI estimates that the quantities presented in Table 6-1 and Table 6-2 are reasonably accurate. However, it should be noted that field observations during construction may lead to design and construction related modifications, which may in turn affect these quantities.

Table 6-1: Estimated Quantity of Material

Material	Total cubic meters (SLI)
0-20 mm + Bentonite	1,100 m^3
0-20 mm	1,600 m^3
0-150 mm	1,500 m^3
Rock fill (0-600 mm)	26,000 m^3
Bituminous liner	2,600 m^2

Table 6-2: Estimated Quantity of Material to be Excavated

Material	Total cubic meters (SLI)
Ice	4,000 m^3
Overburden (frozen till with shattered bedrock)	8,500 m^3

7 PERSONNEL

This report was prepared by Jean-François St-Laurent and Yohan Jalbert, and verified by Getahun Haile.

We trust that this report is to your satisfaction; should you have any question, please do not hesitate to contact me.

SNC LAVALIN INC.

Prepared by:

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Senior Geotechnical Specialist
Sustainable Mine Development
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JFSTL/YJ/GH/sh

8 REFERENCES

Canadian Dam Association CDA (2007). Dam Safety Guidelines.

SLI (2012), Report: 610548-2020-4GEC-0001_00 Vault Dike design, September 2012.

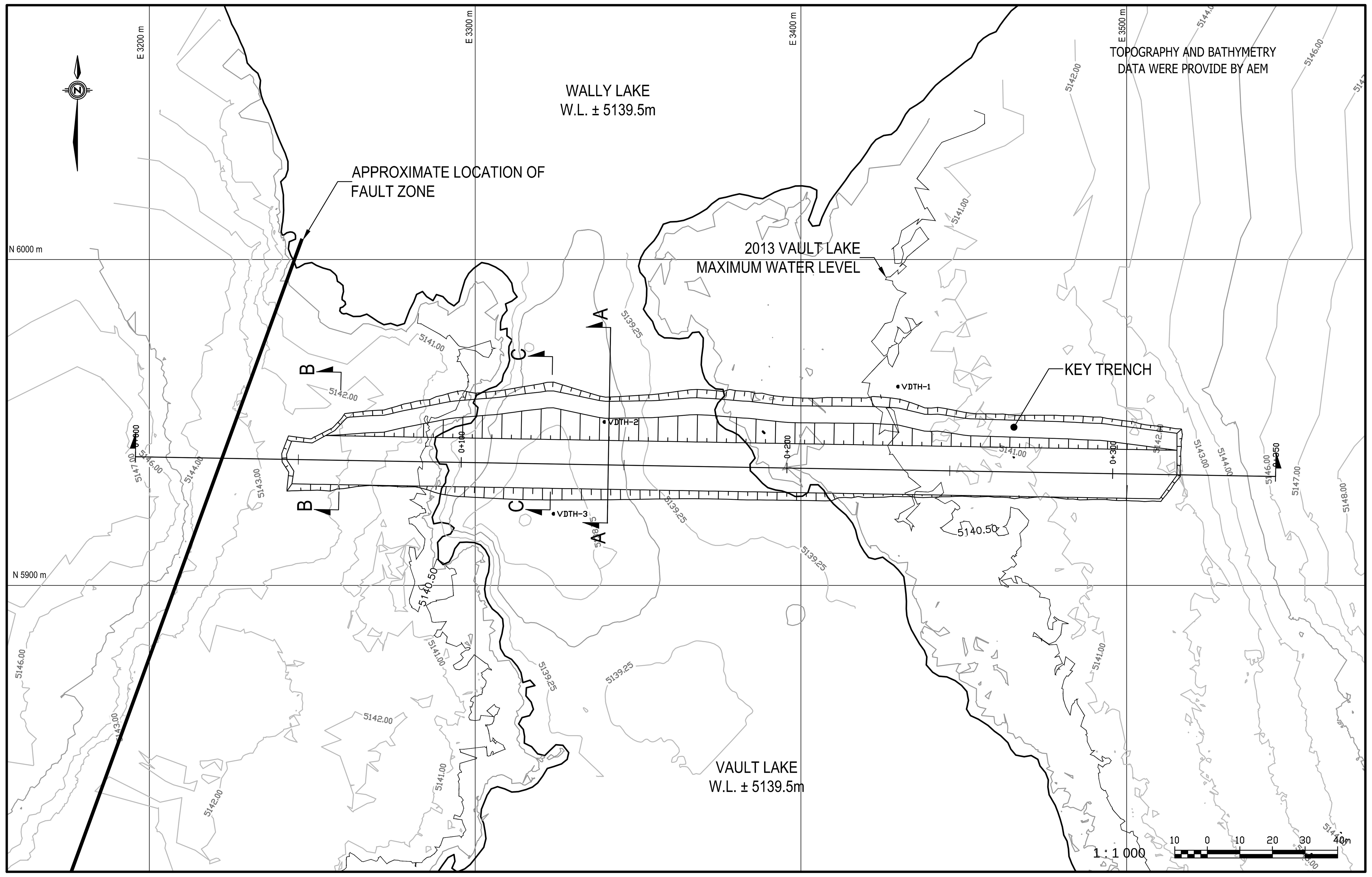
SLI (2012a), Report: 610756-0000-40ER-0001_00 Water Management Plan 2012, November 2012.

Fillion, M.-H., Côté, J. & Konrad, J.-M., Thermal radiation and conduction properties of materials ranging from sand to rock-fill, Canadian Geotechnical Journal, NRC Research Press, 2011, 48, 532-542.

Lebeau, M. & Konrad, J.-M., The effect and Significance of natural convection in rockfill dams under cold climate conditions, OttawaGeo2007, pp. 2084-2091.

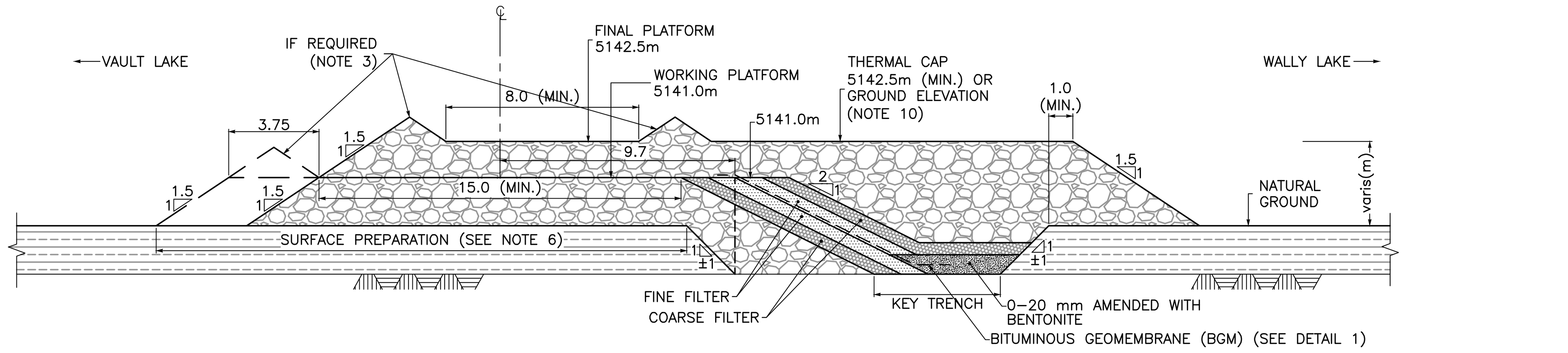
APPENDIX A

DRAWING



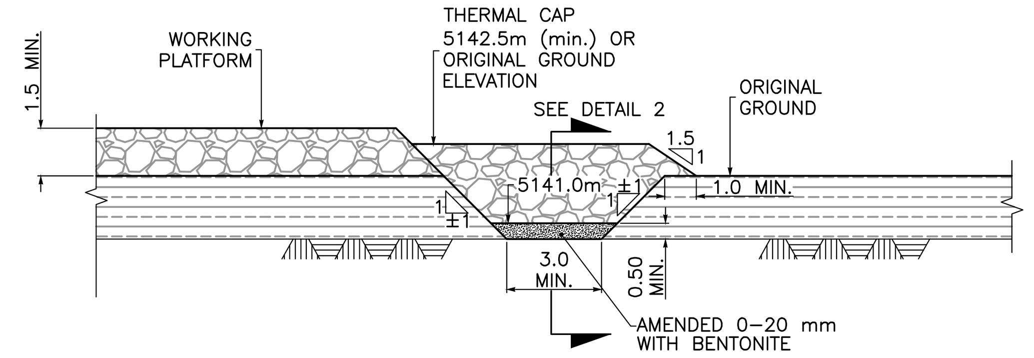
PLAN VIEW - VAULT DIKE

SCALE 1:1000



TYPICAL SECTION A-A
BEDROCK ELEVATION BELOW 5140.5m

SCALE 1:200



TYPICAL SECTION B-B
BEDROCK ELEVATION ABOVE 5140.5 m

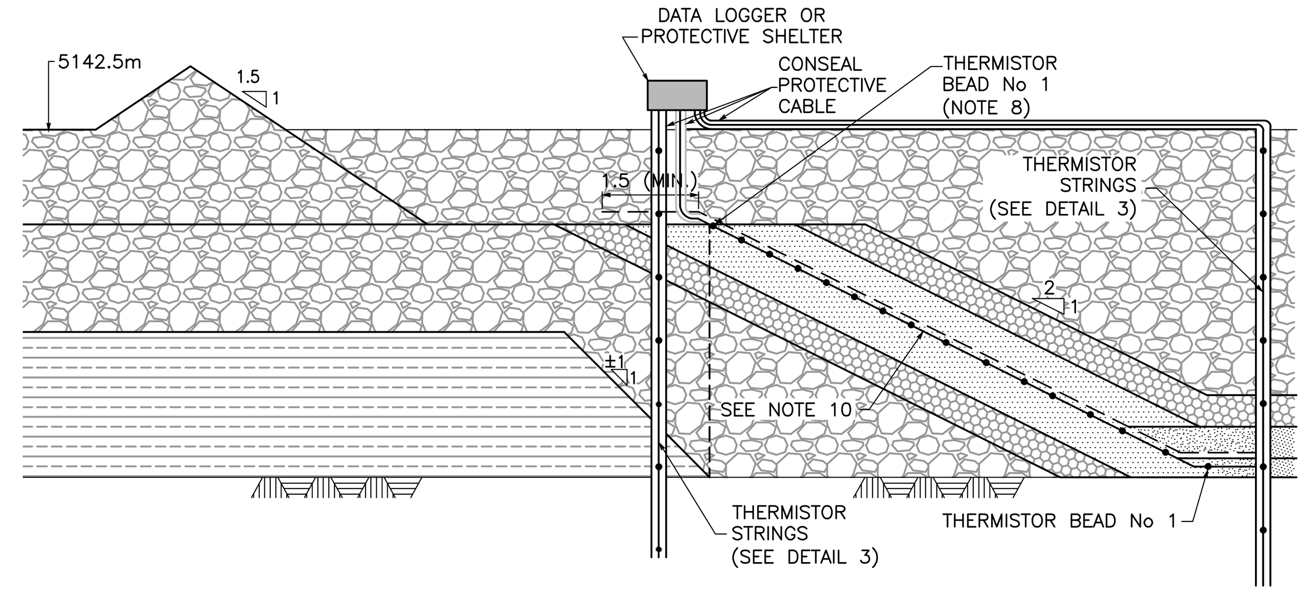
SCALE 1:200

LEGEND

- ROCKFILL
- ICE RICH/POOR TILL
- COARSE FILTER (0–150 mm)
- FINE FILTER (0–20 mm)
- 0–20 mm AMENDED WITH BENTONITE
- BEDROCK

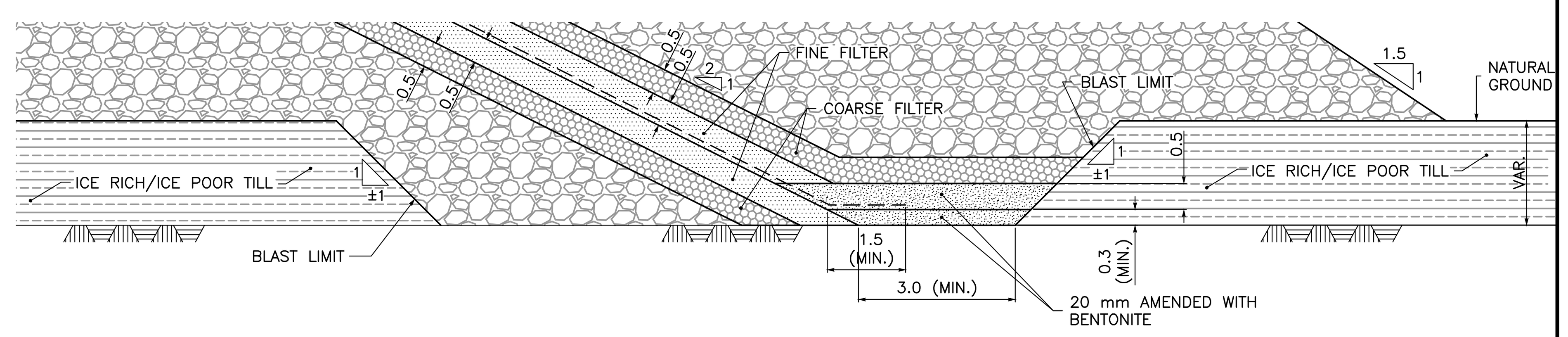
NOTES:

1. ALL COORDINATES AND ELEVATIONS SHOWN RELATE TO THE MINE SYSTEM, TOPOGRAPHY AND BATHYMETRY DATA WERE PROVIDED BY AEM.
2. ALL DIMENSIONS ARE IN METERS (EXCEPT DETAIL 3)
3. SAFETY BERMS WILL BE REQUIRED IN THE VICINITY OF WATER OR IF PLATFORM IS HIGHER THAN 3.0 m. HEIGHT OF THE SAFETY BERMS WILL BE FIXED ACCORDING TO THE SIZE OF THE HAULING TRUCK USED FOR THE CONSTRUCTION AND WILL BE SPECIFIED BY AEM DURING CONSTRUCTION.
4. BLAST SHOULD REACH BEDROCK AND A MINIMUM DEPTH OF 2.0m.
5. LINER BEDDING AND COVER FILTERS MATERIALS (0–20 mm AND 0–150 mm) SHALL BE PLACED PRIOR TO ALLOW ANY VEHICLE CIRCULATION.
6. SURFACE PREPARATION INCLUDE ICE REMOVAL PRIOR THE PLACEMENT OF FILLS WITHIN THE FOOTPRINT AREA OF THE DIKE.
7. LINER SHALL BE INSTALLED HORIZONTALLY AFTER THE APPROVAL OF THE CONTRACTOR'S PLAN BY THE DESIGNER.
8. SHOWN THERMISTOR BEAD SPACING IS NOT REPRESENTATIVE.
9. THERMAL CAP SHALL BE PLACED BEFORE THE THAW SEASON.
10. INCLINED THERMISTOR STRING SHALL BE BURIED INTO A FINE SAND FILL.



TYPICAL SECTION C-C
THERMISTOR STRINGS INSTALLATION

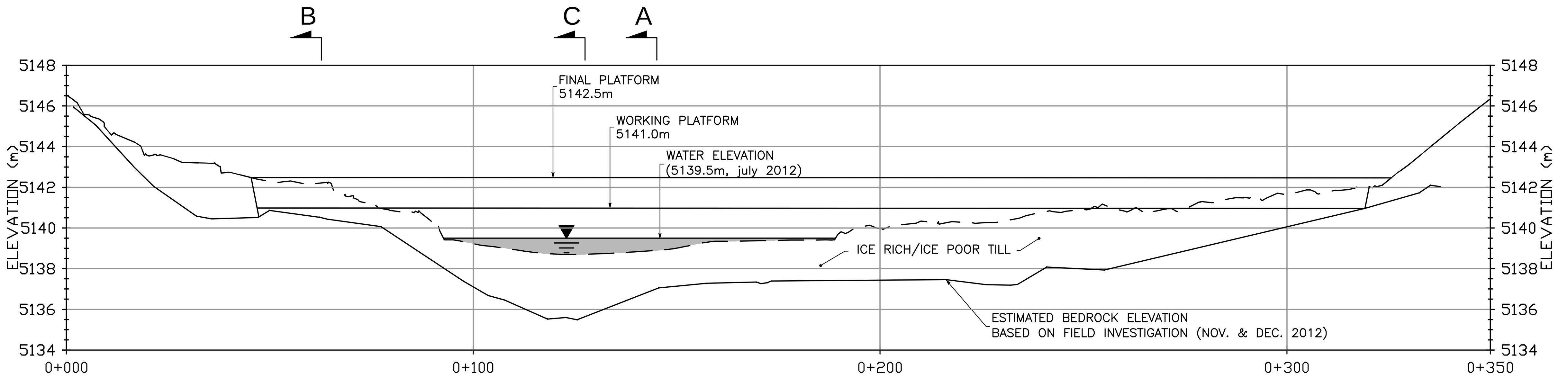
SCALE 1:100



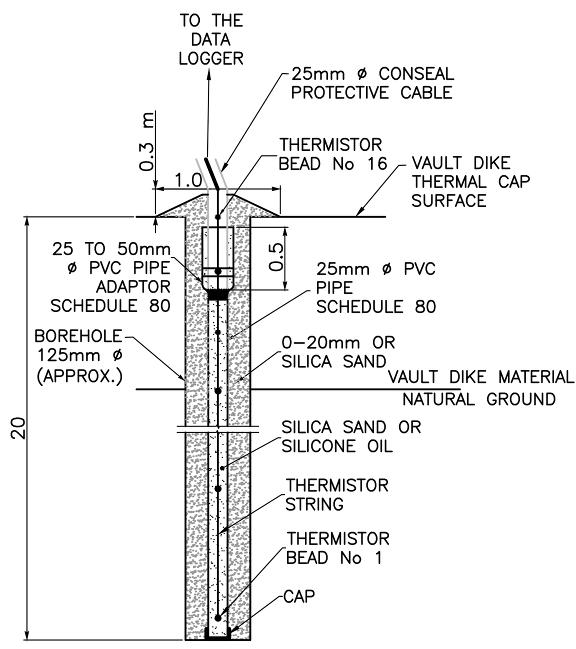
DETAIL 1 - ANCHORING LINER

20 mm AMENDED WITH BENTONITE

SCALE 1:100

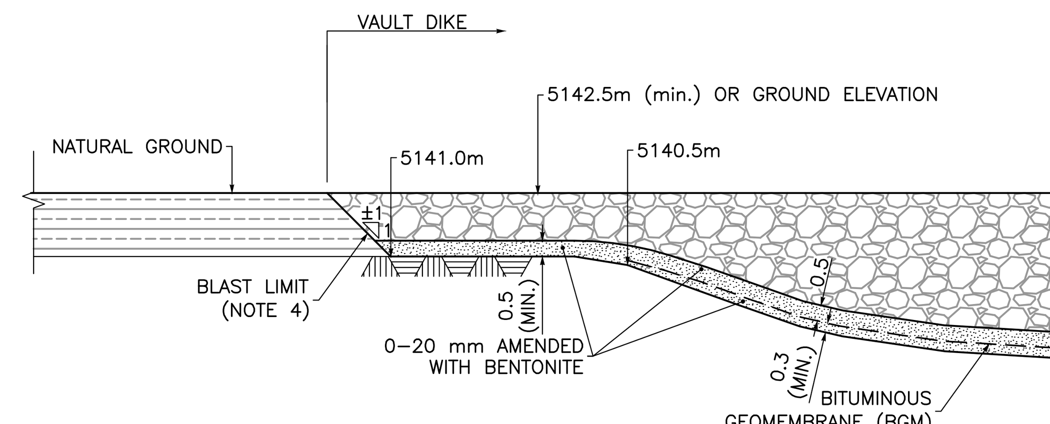


PROFIL OF VAULT DIKE
HORIZONTAL SCALE 1:1000
VERTICAL SCALE 1:200



DETAIL 3
VERTICAL THERMISTOR STRING INSTALLATION

SCALE 1:50



DETAIL 2
DIKE ABUTMENT ALONG THE KEY TRENCH

N.T.S.

No EMIS.	REV.	DATE (Y/M/D)	PURPOSE OF ISSUE	TRANSMISSION LETTER No
1	00	2013/01/14	ISSUED WITH DESIGN REPORT NOT FOR CONSTRUCTION	

ISSUE REGISTER

No	REVISION DESCRIPTION	DATE (Y/M/D)	DESIGNED	VERIFY	APPROVED	REVISOR ENG.	OIQ No

THIS DRAWING IS REPRESENTATIVE OF THE ORIGINAL WORK OF THE DESIGN ENGINEER AND REVISOR ENGINEERS

REVISION REGISTER

No	REFERENCE DRAWINGS NUMBER
1	VAULT DIKE INVESTIGATION -TAMROCK - NOV. 2012.XLSX

PROFESSIONAL SEAL

ORIGINAL HAS BEEN SEALED.

SNC·LAVALIN
Sustainable Mine Development
Global Mining & Metallurgy
SNC LAVALIN INC.
5500, boul. des Galeries, bureau 200
Québec (Québec)
Canada G2K 2E2

PREPARATION	APPROVAL
DESIGNED: Y. JALBERT	PROJECT DISCIPLINE ENGINEER: G. HAILE
DRAWN: E-V. STAICU	CLIENT: AEM
CHECKED: J-F. ST-LAURENT	DATE: 2012/10/22
SCALE: AS SHOWN	

CLIENT: AGNICO-EAGLE

PROJECT: VAULT DIKE

TITLE: CONSTRUCTION OF VAULT DIKE

PROJECT No	SUBDIVISION	SUBJECT	SERIAL	REV.
610548	2020	4G DD	0001	00

STDSLIA1HEN – FRAME A1 HORIZONTAL ENGLISH

LAST SAVE: 2013/01/14 – 2:24pm
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APPENDIX B

FIELD INVESTIGATION

Table B-1 Location and Description of Boreholes (SLI Investigation)

BH ID	Easting	Norting	Elevation	Snow thickness	Ice+Water Thickness	Bottom of Dense Material		Elevation	Depth of Rock		Elevation	End of hole****		Elevation	Details*
	(m)	(m)	(masl)	(inch/m)	(m)	(feet)	(m)	(masl)	(feet)	(m)	(masl)	(feet)	(m)	(masl)	
BH12-1	$3 439,80	5963,81	5140,38	6 to 9/ 0.15 - 0.2		8,0	2,4	5137,95	8,0	2,4	5 137,95	17,0	5,2	5135,20	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-2	3430,36	5965,39	5140,20	6 to 9/ 0.15 - 0.2		6,0	1,8	5138,37	6,0	1,8	5 138,37	15,0	4,6	5135,63	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-3	3419,12	5956,36	5140,05	6 to 9/ 0.15 - 0.2		7,0	2,1	5137,92	7,0	2,1	5 137,92	16,0	4,9	5135,17	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-4	3400,29	5971,38	5139,73	6 to 9/ 0.15 - 0.2		8,5	2,6	5137,14	8,5	2,6	5 137,14	17,5	5,3	5134,40	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-5	3389,47	5957,47	5139,85	6 to 9/ 0.15 - 0.2		7,5	2,3	5137,57	7,5	2,3	5 137,57	16,5	5,0	5134,82	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-6	3382,14	5949,22	5139,71	6 to 9/ 0.15 - 0.2		8,5	2,6	5137,12	8,5	2,6	5 137,12	17,5	5,3	5134,37	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-7	3367,09	5953,83	5139,50	6 to 9/ 0.15 - 0.2		9,0	2,7	5136,75	9,0	2,7	5 136,75	18,0	5,5	5134,01	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-8***	3354,77	5961,41	5139,49												
BH12-9	3358,08	5942,19	5139,47		0,3	6,0	1,8	5137,34	6,0	1,8	5 137,64	15,0	4,6	5134,90	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-10***	3349,10	5938,42	5139,53												
BH12-11	3321,15	5950,29	5139,40		0,76	11,5	3,5	5135,13	11,5	3,5	5 135,89	20,5	6,2	5133,15	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet at 1.8 m.
BH12-12	3317,86	5939,23	5139,43		0,76	13,5	4,1	5134,56	13,5	4,1	5 135,32	22,5	6,9	5132,58	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-13	3308,61	5958,49	5139,45	6 to 9/ 0.15 - 0.2		6,0	1,8	5137,62	6,0	1,8	5 137,62	15,0	4,6	5134,88	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet at 0.9 m.
BH12-14***	3293,97	5940,28	5139,53												
BH12-15***	3286,14	5946,24	5140,25												
BH12-16	3366,51	5968,41	5139,97	6 to 9/ 0.15 - 0.2		10,75	3,3	5136,69	10,75	3,3	5 136,69	19,8	6,0	5133,95	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-17	3349,18	5969,11	5139,93	6 to 9/ 0.15 - 0.2		10,0	3,0	5136,88	10,0	3,0	5 136,88	19,0	5,8	5134,14	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet at 1.1 m.
BH12-18	3376,05	5969,72	5140,29	6 to 9/ 0.15 - 0.2		8,5	2,6	5137,70	8,5	2,6	5 137,70	17,5	5,3	5134,95	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-19	3383,13	5971,06	5140,14	6 to 9/ 0.15 - 0.2		6,5	2,0	5138,16	6,5	2,0	5 138,16	15,5	4,7	5135,41	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-20	3389,49	5972,70	5140,22	6 to 9/ 0.15 - 0.2		8,0	2,4	5137,78	8,0	2,4	5 137,78	17,0	5,2	5135,04	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-21	3429,43	5931,51	5140,10	6 to 9/ 0.15 - 0.2		10,0	3,0	5137,05	10,0	3,0	5 137,05				Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-22***	3413,66	5938,76	5139,85												
BH12-23	3395,85	5949,36	5139,61	6 to 9/ 0.15 - 0.2		6,0	1,8	5137,78	6,0	1,8	5 137,78	15,0	4,6	5135,04	
BH12-24	3386,06	5942,05	5139,58	6 to 9/ 0.15 - 0.2		5,0	1,5	5138,06	5,0	1,5	5 138,06	14,0	4,3	5135,31	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-25	3377,27	5941,82	5139,52	6 to 9/ 0.15 - 0.2		7,0	2,1	5137,39	7,0	2,1	5 137,39	16,0	4,9	5134,64	Overburden consists of brown silty medium sand, some gravel/boulders.
BH12-26	3366,41	5935,68	5139,58	6 to 9/ 0.15 - 0.2		7,5	2,3	5137,29	7,5	2,3	5 137,29	16,5	5,0	5134,55	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-27	3342,74	5925,46	5139,41		0,3	9,5	2,9	5136,22	9,5	2,9	5 136,52	18,5	5,6	5133,78	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-28	3288,46	5915,24	5139,57		0,76	9,5	2,9	5135,91	9,5	2,9	5 136,67	18,5	5,6	5133,93	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet at 1.8 m.
BH12-29	3300,43	5919,35	5139,50		0,15	7,0	2,1	5137,22	7,0	2,1	5 137,37	16,0	4,9	5134,62	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet at 0.9 m.
BH12-30***	3287,01	5902,64	5139,57												
BH12-31	3303,62	5909,34	5139,53	6 to 9/ 0.15 - 0.2		6,0	1,8	5137,70	6,0	1,8	5 137,70	15,0	4,6	5134,96	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet.
BH12-32***	3355,97	5932,47	5139,60												
BH12-33***	3291,76	5927,29	5139,58												
BH12-34***	3278,02	5918,63	5140,05												
BH12-35	3302,10	5932,08	5139,49	6 to 9/ 0.15 - 0.2		11,0	3,4	5136,14	11,0	3,4	5 136,14	20,0	6,1	5133,39	Overburden consists of brown silty medium sand, some gravel/boulders, very moist to wet at 1.2 m.
TH1**	3429,82	5961,01	5140,18	6 to 12		6,0	1,8	5138,35	6,0	1,8	5 138,35	59,8	18,2	5121,97	Overburden consists of brown silty medium sand, some gravel/boulders.
TH2**	3339,66	5950,16	5139,38		0,81	3,0	0,9	5137,66	3,0	0,9	5 137,66	80,8	24,6	5114,75	Overburden consists of brown silty medium sand, some gravel/boulders.
TH3**	3324,07	5921,97	5139,62		0,81	3,0	0,9	5137,90	3,0	0,9	5 137,90	72,3	22,0	5117,60	Overburden consists of brown silty medium sand, some gravel/boulders, wet.

* It should be noted that the "Tam Rock" air rotary drill returns highly disturbed pulverized cuttings of the soil and rock. As result, it is not possible to collect undisturbed samples. The subsurface strata described above are based on examination of the cuttings, the behaviour of the drilling equipment and the driller's experience.

** Elevation of TH2 & TH3 are top of Ice.

*** Boreholes which have not been drilled because drill beign down.

**** Bedrock was confirmed by drilling into it a minimum of 9 feet.

Table B-2 Location and Description of Boreholes (AEM Investigation, Stage 1)

Air Track Investigation - Vault Dike Area

Agnico-Eagle Mine - Meadowbank Division

Hole ID	Easting	Northing	Surface Elevation	Total lenght	Lenght in Bedrock	Wet / Dry	Overburden (ice thickness included)	Overburden (ice thickness included)	Roc Elevation
		VAULT		Feet	Feet		Feet	Meters	Meters
1	3439,80	5963,81	5140,38	11	3	D	8	2,44	5137,95
2	3430,36	5965,39	5140,20	9	3	D	6	1,83	5138,37
3	3419,12	5956,36	5140,05	10	3	W	7	2,13	5137,92
4	3400,29	5971,38	5139,73	11,5	3	D	8,5	2,59	5137,14
5	3389,47	5957,47	5139,85	10,5	3	D	7,5	2,29	5137,57
6	3382,14	5949,22	5139,71						
7	3367,09	5953,83	5139,50	14	5	W	9	2,74	5136,75
8	3354,77	5961,41	5139,49	13	4,5	W	8,5	2,59	5136,90
9	3358,08	5942,19	5139,47	11	5	W	6	1,83	5137,64
10	3349,10	5938,42	5139,53	15	5	W	10	3,05	5136,49
11	3321,15	5950,29	5139,40	18	6,5	W	11,5	3,51	5135,89
12	3317,86	5939,23	5139,43	19	5,5	W	13,5	4,11	5135,32
13	3308,61	5958,49	5139,45	11	5	W	6	1,83	5137,62
14	3293,97	5940,28	5139,53						
15	3286,14	5946,24	5140,25						
16	3366,51	5968,41	5139,97	15	4,25	W	10,75	3,28	5136,69
17	3349,18	5969,11	5139,93	15	5	W	10	3,05	5136,88
18	3376,05	5969,72	5140,29	14	5,5	D	8,5	2,59	5137,70
19	3383,13	5971,06	5140,14	12	5,5	D	6,5	1,98	5138,16
20	3389,49	5972,70	5140,22	12	4	D	8	2,44	5137,78
21	3429,43	5931,51	5140,10						
22	3413,66	5938,76	5139,85						
23	3395,85	5949,36	5139,61	11	5	D	6	1,83	5137,78
24	3386,06	5942,05	5139,58	10	5	W	5	1,52	5138,06
25	3377,27	5941,82	5139,52	12	5	W	7	2,13	5137,39
26	3366,41	5935,68	5139,58	12	4,5	W	7,5	2,29	5137,29
27	3355,97	5932,47	5139,60	14	4,5	W	9,5	2,90	5136,70
28	3342,74	5925,46	5139,41	14	4,5	W	9,5	2,90	5136,52
29	3300,43	5919,35	5139,50	12	5	W	7	2,13	5137,37
30	3288,46	5915,24	5139,57						
31	3303,62	5909,34	5139,53	11	5	W	6	1,83	5137,70
32	3287,01	5902,64	5139,57						
33	3291,76	5927,29	5139,58						
34	3278,02	5918,63	5140,05						
35	3302,10	5932,08	5139,49	16	5	W	11	3,35	5136,14

Table B-3 Location and Description of Boreholes (AEM Investigation, Stage 2)

Air Track Investigation - Vault Dike Area

Agnico-Eagle Mine - Meadowbank Division

Hole ID	Easting	Northing	Surface Elevation	Total lenght	Lenght in Bedrock	Wet / Dry	Overburden (ice thickness included)	Overburden (ice thickness included)	Roc Elevation	Notes
	VAULT			Feet	Feet		Feet	Meters	Meters	
100	3193,176077	5978,491961	5145,2	7	6	D	1	0,30	5144,8952	
101	3194,837474	5963,499909	5145,825	10	6	D	4	1,22	5144,6058	
102	3196,459408	5948,653003	5146,375	9	6	D	3	0,91	5145,4606	
103	3198,08954	5933,643646	5146,865	8	6	D	2	0,61	5146,2554	
104	3199,754909	5918,702665	5146,543	9	6	D	3	0,91	5145,6286	
105	3208,092476	5979,124286	5143,993	10	6	D	4	1,22	5142,7738	
106	3209,745277	5964,221094	5144,197	10	6	D	4	1,22	5142,9778	
107	3211,391384	5949,306361	5144,204	10	6	D	4	1,22	5142,9848	
108	3213,065456	5934,316142	5143,87	9	6	D	3	0,91	5142,9556	
109	3214,821332	5919,376737	5144,642	8	2	D	6	1,83	5142,8132	
110	3223,081196	5979,923139	5143,551	12	6	D	6	1,83	5141,7222	
111	3224,900822	5964,917214	5143,656	14	6	D	8	2,44	5141,2176	
112	3226,462666	5950,004649	5143,046	16	6	D	10	3,05	5139,998	
113	3228,108002	5935,027631	5142,616	12	6	D	6	1,83	5140,7872	
114	3229,786707	5920,175527	5142,375	11	6	D	5	1,52	5140,851	
115	3239,761391	5965,633301	5142,364	16	10	D	6	1,83	5140,5352	
116	3241,438862	5950,668665	5141,859	14	6	D	8	2,44	5139,4206	
117	3243,16352	5935,71054	5142,008	10	6	D	4	1,22	5140,7888	
118	3244,772101	5920,79669	5142,22	13	6	D	7	2,13	5140,0864	
119	3254,786445	5966,381708	5141,308	10	6	D	4	1,22	5140,0888	
120	3256,459354	5951,362444	5141,504	7	6	D	1	0,30	5141,1992	
121	3258,23951	5936,394834	5141,945	11	6	D	5	1,52	5140,421	
122	3269,866417	5966,988309	5141,231	17	6	D	11	3,35	5137,8782	
123	3271,475945	5952,088639	5141,396	9	6	D	3	0,91	5140,4816	
124	3273,166791	5937,104636	5140,955	9	6	D	3	0,91	5140,0406	
125	3284,871157	5967,70916	5140,794	10	6	D	4	1,22	5139,5748	
126	3299,852938	5968,46109	5139,989	14	6	D	8	2,44	5137,5506	
127	3314,901313	5969,124661	5139,438	10	6	W	4	1,22	5138,2188	
128	3329,955523	5969,847147	5139,399	15	6	W	9	2,74	5136,6558	
TH-2 A	3326,247647	5949,206613	5139,359	17	6	W	11	3,35	5136,0062	SMOOTH & CONSTANT PENETRATION OF THE BIT IN THE ROCK, OVERBURDEN S & G.
TH-2 B	3333,109847	5949,221143	5139,387	18	6	W	12	3,66	5135,7294	ERRATIC PENETRATION IN THE ROCK, OVERBURDEN S & G.
TH-2 C	3339,965129	5958,008356	5139,385	17	6	W	12	3,66	5135,7274	SMOOTH & CONSTANT PENETRATION IN THE ROCK, OVERBURDEN S & G.
TH-2 D	3350,68618	5950,43874	5139,399	15	4	W	11	3,35	5136,0462	COULD NOT DRILL MOTRE THAN 4' IN THE ROCK, SOFT OVERBURDEN FALL & BLOCK THE HOLE, SAND.
TH-2 E	3357,911688	5952,304758	5139,466	16	6	D	10	3,05	5136,418	SMOOTH DESCENT IN THE ROCK, 4' BOULDER IN THE OVERBURDEN PORTION
TH-2 F	3341,187397	5940,290679	5139,36	14	6	W	8	2,44	5136,9216	SMOOTH & CONSTANT PENETRATION OF THE BIT IN THE ROCK, OVERBURDEN S & G.
									0	
									0	
200	3461,743204	5969,927723	5141,019	9	6	D	3	0,91	5140,1046	
201	3476,900212	5970,79369	5141,484	10	6	D	4	1,22	5140,2648	
202	3492,038926	5971,613773	5142,046	10	6	D	4	1,22	5140,8268	
203	3507,226516	5972,496315	5143,069	10	6	D	4	1,22	5141,8498	
204	3522,365358	5973,269708	5143,767	16	-		16	4,88	5138,8902	BOULDERS ENCOUNTERED ON THE ENTIRED LENGTH DRILLED; COULD NOT DRILL FURTHER
205	3537,466206	5974,058117	5144,647	NOT DRILLED					5144,647	
206	3539,017037	5989,12944	5144,518	13	6	D	7	2,13	5142,3844	
207	3535,978846	5958,928754	5145,042	NOT DRILLED					5145,042	
208	3534,492589	5943,787401	5144,745	NOT DRILLED					5144,745	
209	3533,040157	5928,714377	5144,129	13	6	D	7	2,13	5141,9954	
210	3519,304768	5943,083139	5142,935	NOT DRILLED					5142,935	
211	3520,781603	5958,14565	5143,812	10	6	D	4	1,22	5142,5928	
212	3505,717054	5957,350658	5142,28	12	6	D	6	1,83	5140,4512	
213	3504,175931	5942,285315	5141,911	NOT DRILLED					5141,911	
214	3489,052017	5941,488361	5141,331	12	6	D	6	1,83	5139,5022	
215	3490,450604	5956,499469	5141,591	10	6	D	4	1,22	5140,3718	
216	3475,307305	5955,711072	5141,098	NOT DRILLED					5141,098	
217	3473,885758	5940,559829	5140,842	NOT DRILLED					5140,842	
218	3458,777871	5939,791705	5140,763	NOT DRILLED					5140,763	
219	3460,226368	5954,941008	5140,859	10	6	D	4	1,22	5139,6398	
220	3443,56272	5938,993858	5140,584	11	6	D	5	1,52	5139,06	

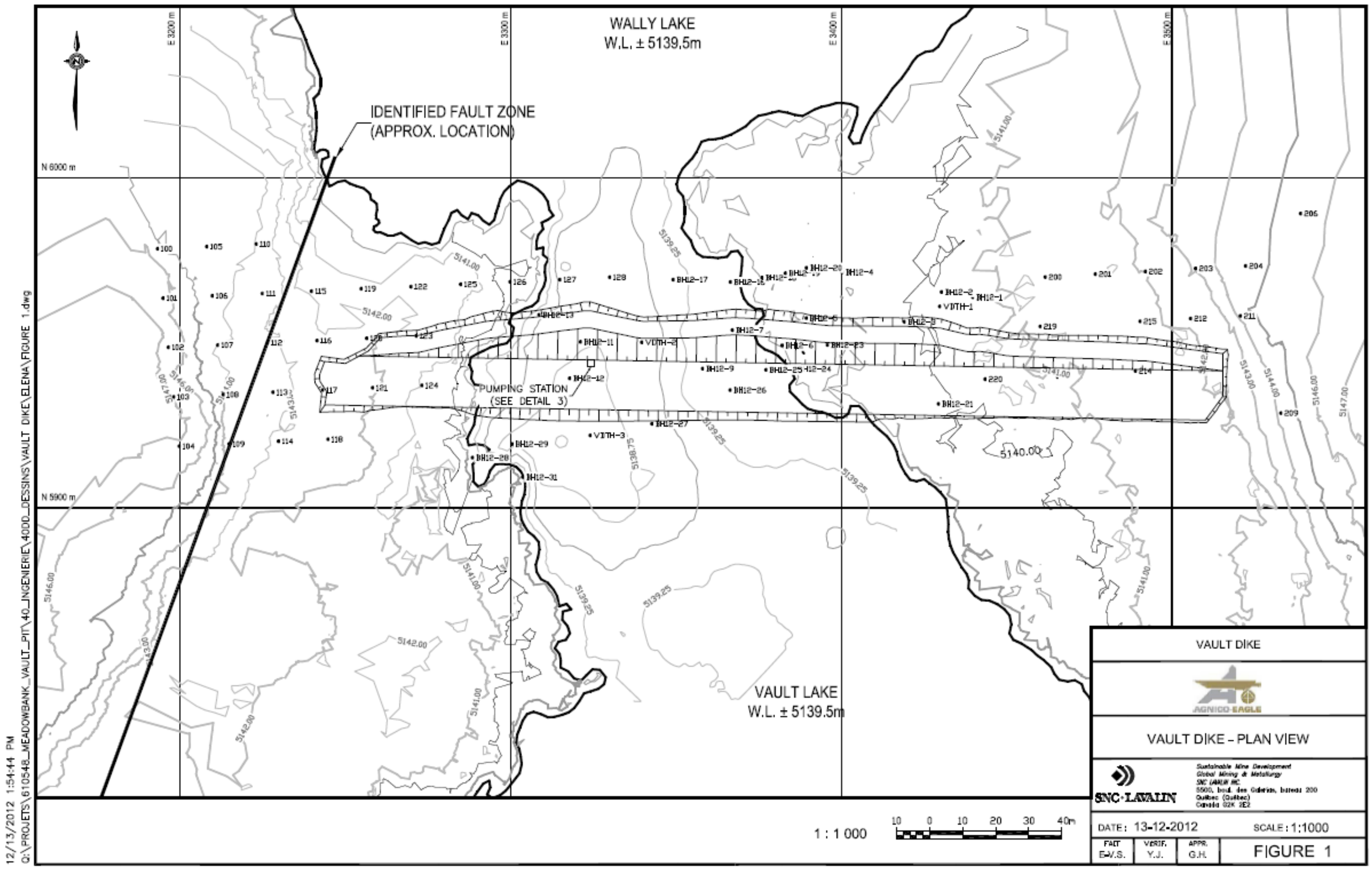

Figure B-1 Borehole and Thermistor String Locations

Picture B-1 Drilling Through Ice and Water Underneath

Picture B-2 Drilling at the Abutment

Table B-4 Observed Soil Temperature at VD-TH1

Bead	B #1	B #2	B #3	B #4	B #5	B #6	B #7	B #8	B #9	B #10	B #11	B #12	B #13	B #14	B #15	B #16
Final El. (m)	5141,54	5140,54	5139,54	5138,54	5137,54	5136,54	5135,54	5134,54	5133,54	5132,54	5131,54	5130,54	5128,54	5126,54	5124,54	5122,54
Depth (m)	-1,45	-0,45	0,55	1,55	2,55	3,55	4,55	5,55	6,55	7,55	8,55	9,55	11,55	13,55	15,55	17,55
Correction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
17-11-2012 17:30	-25,14	-25,27	-8,86	-2,65	-2,92	-3,21	-3,76	-4,10	-4,39	-5,31	-5,82	-5,82	-6,21	-6,24	-6,32	-6,26
18-11-2012 15:20	-23,93	-23,93	-6,16	-0,40	-0,86	-1,53	-2,35	-3,02	-3,63	-4,20	-4,72	-5,04	-5,57	-5,95	-5,97	-5,87
19-11-2012 08:00	-20,19	-20,16	-6,47	-0,43	-0,83	-1,49	-2,32	-3,00	-3,61	-4,17	-4,70	-5,02	-5,56	-5,95	-5,97	-5,88
20-11-2012 10:00	-18,38	-18,05	-6,53	-0,56	-0,83	-1,49	-2,32	-2,99	-3,61	-4,17	-4,69	-5,02	-5,56	-5,96	-5,98	-5,89
20-11-2012 16:00	-19,64	-19,19	-6,44	-0,59	-0,83	-1,48	-2,31	-2,98	-3,60	-4,16	-4,68	-5,01	-5,56	-5,95	-5,97	-5,88
22-11-2012 09:00	-18,67	-18,08	-5,82	-0,93	-0,86	-1,49	-2,31	-2,98	-3,59	-4,15	-4,67	-5,00	-5,56	-5,95	-5,97	-5,90
22-11-2012 15:45	-17,55	-17,21	-5,73	-1,65	-0,87	-1,49	-2,30	-2,97	-3,59	-4,15	-4,67	-4,99	-5,55	-5,94	-5,97	-5,89
23-11-2012 09:30	-19,91	-19,11	-5,53	-1,17	-0,91	-1,50	-2,31	-2,97	-3,58	-4,15	-4,67	-4,99	-5,55	-5,95	-5,97	-5,90
23-11-2012 16:30	-19,64	-18,90	-5,48	-1,22	-0,93	-1,51	-2,31	-2,97	-3,58	-4,15	-4,67	-4,99	-5,55	-5,95	-5,98	-5,90
24-11-2012 08:30	-27,68	-26,47	-5,34	-1,35	-0,95	-1,50	-2,30	-2,96	-3,57	-4,12	-4,65	-4,96	-5,53	-5,93	-5,96	-5,88
24-11-2012 17:30	-30,04	-28,70	-5,30	-1,41	-0,99	-1,51	-2,30	-2,96	-3,57	-4,12	-4,65	-4,96	-5,53	-5,93	-5,96	-5,89
25-11-2012 10:30	-29,68	-28,62	-5,30	-1,56	-1,04	-1,54	-2,31	-2,96	-3,57	-4,12	-4,65	-4,96	-5,53	-5,94	-5,97	-5,90
25-11-2012 14:30	-27,90	-27,26	-5,32	-1,59	-1,07	-1,54	-2,31	-2,96	-3,57	-4,12	-4,64	-4,96	-5,53	-5,93	-5,97	-5,90
26-11-2012 14:30	-25,63	-25,14	-5,49	-1,78	-1,16	-1,57	-2,31	-2,94	-3,55	-4,10	-4,62	-4,95	-5,51	-5,92	-5,95	-5,89
27-11-2012 14:00	-29,13	-28,05	-5,70	-1,98	-1,27	-1,60	-2,31	-2,93	-3,54	-4,08	-4,60	-4,93	-5,49	-5,91	-5,95	-5,89
28-11-2012 15:00	-28,19	-27,84	-5,94	-2,20	-1,40	-1,64	-2,32	-2,93	-3,53	-4,08	-4,59	-4,92	-5,49	-5,91	-5,94	-5,88
29-11-2012 07:00	-27,88	-27,19	-6,16	-2,36	-1,50	-1,68	-2,33	-2,93	-3,53	-4,07	-4,59	-4,92	-5,49	-5,91	-5,95	-5,88
30-11-2012 13:00	-34,87	-33,55	-6,48	-2,64	-1,68	-1,75	-2,35	-2,94	-3,52	-4,06	-4,58	-4,90	-5,48	-5,90	-5,94	-5,89
01-12-2012 11:30	-38,44	-36,96	-6,75	-2,84	-1,81	-1,79	-2,36	-2,93	-3,51	-4,04	-4,56	-4,88	-5,46	-5,88	-5,93	-5,87
02-12-2012 16:00	-28,42	-27,84	-7,26	-3,13	-1,98	-1,88	-2,39	-2,94	-3,51	-4,04	-4,56	-4,87	-5,45	-5,88	-5,93	-5,88
04-12-2012 07:30	-29,54	-28,50	-7,77	-3,53	-2,23	-2,00	-2,43	-2,96	-3,50	-4,02	-4,54	-4,86	-5,43	-5,86	-5,92	-5,87
05-12-2012 14:30	-27,02	-25,82	-8,00	-3,86	-2,43	-2,11	-2,46	-2,96	-3,48	-4,00	-4,51	-4,83	-5,41	-5,85	-5,91	-5,86
06-12-2012 09:30	-27,68	-27,00	-8,06	-4,02	-2,56	-2,17	-2,50	-2,98	-3,50	-4,01	-4,52	-4,84	-5,42	-5,86	-5,92	-5,88
07-12-2012 09:00	-29,61	-28,98	-8,12	-4,22	-2,70	-2,25	-2,54	-2,98	-3,49	-3,99	-4,50	-4,82	-5,40	-5,84	-5,91	-5,87
08-12-2012 08:00	-30,28	-29,10	-8,26	-4,40	-2,84	-2,34	-2,57	-3,00	-3,49	-3,99	-4,49	-4,81	-5,40	-5,84	-5,91	-5,86
09-12-2012 15:00	-27,02	-25,80	-8,48	-4,63	-3,04	-2,45	-2,62	-3,01	-3,49	-3,98	-4,47	-4,79	-5,37	-5,82	-5,90	-5,86
10-12-2012 09:00	-27,59	-26,15	-8,56	-4,75	-3,14	-2,51	-2,65	-3,02	-3,48	-3,97	-4,46	-4,78	-5,36	-5,81	-5,89	-5,86
11-12-2012 09:30	-29,90	-28,66	-8,67	-4,93	-3,29	-2,62	-2,70	-3,05	-3,49	-3,97	-4,46	-4,77	-5,37	-5,81	-5,89	-5,86
12-12-2012 08:30	-34,93	-32,76	-8,79	-5,07	-3,41	-2,70	-2,74	-3,06	-3,49	-3,96	-4,44	-4,76	-5,35	-5,80	-5,87	-5,85
13-12-2012 09:30	-36,23	-35,11	-9,06	-5,25	-3,56	-2,80	-2,80	-3,09	-3,50	-3,96	-4,44	-4,76	-5,34	-5,79	-5,87	-5,85
14-12-2012 09:00	-31,50	-30,04	-9,40	-5,41	-3,69	-2,89	-2,85	-3,11	-3,51	-3,95	-4,44	-4,74	-5,33	-5,79	-5,87	-5,85
16-12-2012 10:00	-16,21	-16,47	-9,77	-5,77	-3,95	-3,09	-2,97	-3,16	-3,52	-3,95	-4,42	-4,72	-5,30	-5,76	-5,86	-5,84

Table B-5 Observed Soil Temperature at VDTH-2

Bead	B #1	B #2	B #3	B #4	B #5	B #6	B #7	B #8	B #9	B #10	B #11	B #12	B #13	B #14	B #15	B #16
Final El. (m)	5138,54	5137,54	5136,54	5135,54	5134,54	5133,54	5132,54	5131,54	5129,54	5127,54	5125,54	5123,54	5121,54	5119,54	5117,54	5115,54
Depth (m)	0,84	1,84	2,84	3,84	4,84	5,84	6,84	7,84	9,84	11,84	13,84	15,84	17,84	19,84	21,84	23,84
Correction	-0,03	0,09	-0,02	0,01	0,00	0,01	0,01	0,03	0,00	0,09	0,03	-0,02	0,01	-0,03	0,00	0,07
17-nov-12 12:11	-0,19	-0,04	-0,04	-0,63	-1,30	-1,90	-2,52	-2,93	-3,56	-3,90	-4,07	-4,12	-4,15	-4,18	-4,20	-4,27
17-nov-12 17:20	-0,18	-0,03	-0,04	-0,66	-1,31	-1,94	-2,54	-2,95	-3,60	-3,95	-4,12	-4,17	-4,18	-4,21	-4,25	-4,31
18-nov-12 15:10	-0,30	-0,04	-0,05	-0,66	-1,32	-1,95	-2,56	-2,96	-3,63	-3,99	-4,15	-4,20	-4,22	-4,24	-4,28	-4,33
19-nov-12 07:40	-0,35	-0,03	-0,04	-0,65	-1,31	-1,94	-2,54	-2,95	-3,62	-3,98	-4,15	-4,19	-4,22	-4,23	-4,27	-4,32
20-nov-12 10:00	-0,39	-0,03	-0,04	-0,65	-1,30	-1,92	-2,53	-2,94	-3,61	-3,98	-4,15	-4,20	-4,22	-4,24	-4,27	-4,32
20-nov-12 16:00	-0,38	-0,03	-0,04	-0,65	-1,30	-1,92	-2,53	-2,94	-3,51	-3,98	-4,15	-4,20	-4,22	-4,24	-4,27	-4,32
22-nov-12 09:00	-0,32	-0,03	-0,04	-0,65	-1,29	-1,91	-2,52	-2,91	-3,60	-3,97	-4,15	-4,20	-4,23	-4,25	-4,28	-4,33
22-nov-12 15:45	-0,31	-0,03	-0,04	-0,63	-1,29	-1,91	-2,52	-2,91	-3,60	-3,97	-4,15	-4,20	-4,23	-4,25	-4,28	-4,32
23-nov-12 09:30	-0,32	-0,04	-0,04	-0,55	-1,29	-1,91	-2,52	-2,91	-3,60	-3,97	-4,15	-4,21	-4,24	-4,25	-4,29	-4,34
23-nov-12 16:30	-0,32	-0,04	-0,05	-0,65	-1,30	-1,91	-2,52	-2,91	-3,60	-3,98	-4,15	-4,21	-4,24	-4,26	-4,29	-4,34
24-nov-12 08:30	-0,31	-0,03	-0,04	-0,63	-1,29	-1,90	-2,49	-2,90	-3,58	-3,96	-4,14	-4,20	-4,23	-4,25	-4,28	-4,33
24-nov-12 17:30	-0,34	-0,03	-0,04	-0,65	-1,29	-1,90	-2,49	-2,89	-3,55	-3,96	-4,14	-4,20	-4,23	-4,25	-4,29	-4,33
25-nov-12 10:30	-0,38	-0,04	-0,05	-0,65	-1,29	-1,90	-2,49	-2,90	-3,59	-3,96	-4,15	-4,21	-4,24	-4,28	-4,30	-4,34
25-nov-12 14:30	-0,39	-0,04	-0,05	-0,65	-1,29	-1,90	-2,49	-2,89	-3,58	-3,96	-4,15	-4,21	-4,24	-4,26	-4,29	-4,34
26-nov-12 14:30	-0,48	-0,04	-0,09	-0,65	-1,28	-1,89	-2,48	-2,88	-3,57	-3,95	-4,15	-4,20	-4,23	-4,25	-4,29	-4,33
27-nov-12 14:00	-0,55	-0,03	-0,04	-0,63	-1,27	-1,87	-2,46	-2,87	-3,56	-3,94	-4,13	-4,19	-4,23	-4,25	-4,29	-4,33
28-nov-12 15:00	-0,65	-0,04	-0,04	-0,63	-1,27	-1,87	-2,46	-2,86	-3,55	-3,93	-4,13	-4,21	-4,23	-4,25	-4,29	-4,33
29-nov-12 07:00	-0,73	-0,03	-0,05	-0,63	-1,27	-1,87	-2,45	-2,85	-3,54	-3,93	-4,13	-4,19	-4,23	-4,25	-4,29	-4,33
30-nov-12 13:00	-0,85	-0,04	-0,05	-0,65	-1,27	-1,87	-2,45	-2,85	-3,54	-3,93	-4,13	-4,20	-4,24	-4,26	-4,30	-4,34
01-déc-12 11:30	-0,98	-0,04	-0,05	-0,65	-1,26	-1,86	-2,44	-2,83	-3,52	-3,91	-4,13	-4,19	-4,23	-4,25	-4,29	-4,33
02-déc-12 16:00	-1,21	-0,05	-0,06	-0,65	-1,27	-1,86	-2,44	-2,83	-3,52	-3,92	-4,13	-4,20	-4,24	-4,26	-4,30	-4,34
04-déc-12 07:30	-1,41	-0,04	-0,05	-0,63	-1,25	-1,84	-2,41	-2,81	-3,50	-3,90	-4,11	-4,18	-4,23	-4,26	-4,29	-4,34
05-déc-12 14:30	-1,43	-0,04	-0,06	-0,65	-1,25	-1,83	-2,41	-2,80	-3,49	-3,89	-4,11	-4,19	-4,23	-4,26	-4,30	-4,34
06-déc-12 09:30	-1,46	-0,04	-0,06	-0,65	-1,25	-1,83	-2,40	-2,79	-3,49	-3,89	-4,11	-4,18	-4,23	-4,26	-4,30	-4,34
07-déc-12 09:00	-1,31	-0,04	-0,06	-0,63	-1,23	-1,82	-2,39	-2,78	-3,47	-3,88	-4,10	-4,18	-4,23	-4,26	-4,29	-4,33
08-déc-12 08:00	-1,63	-0,04	-0,06	-0,63	-1,23	-1,81	-2,38	-2,77	-3,46	-3,87	-4,09	-4,18	-4,22	-4,25	-4,29	-4,33
09-déc-12 15:00	-1,81	-0,04	-0,08	-0,65	-1,23	-1,81	-2,38	-2,77	-3,46	-3,88	-4,10	-4,18	-4,23	-4,26	-4,30	-4,35
10-déc-12 09:00	-1,89	-0,04	-0,06	-0,63	-1,22	-1,80	-2,37	-2,76	-3,44	-3,86	-4,08	-4,18	-4,22	-4,25	-4,29	-4,33
11-déc-12 09:30	-2,01	-0,04	-0,08	-0,63	-1,22	-1,80	-2,37	-2,75	-3,44	-3,86	-4,09	-4,18	-4,23	-4,26	-4,30	-4,34
12-déc-12 08:30	-2,11	-0,04	-0,06	-0,63	-1,22	-1,78	-2,35	-2,74	-3,43	-3,85	-4,07	-4,17	-4,22	-4,25	-4,29	-4,34
13-déc-12 09:30	-2,30	-0,04	-0,08	-0,63	-1,22	-1,78	-2,35	-2,74	-3,91	-3,84	-4,07	-4,17	-4,22	-4,26	-4,30	-4,34
14-déc-12 09:00	-2,56	-0,04	-0,08	-0,63	-1,21	-1,78	-2,34	-2,73	-3,41	-3,84	-4,07	-4,17	-4,22	-4,26	-4,30	-4,34
16-déc-12 10:00	-2,82	-0,04	-0,08	-0,63	-1,21	-1,76	-2,33	-2,71	-3,40	-3,82	-4,06	-4,16	-4,22	-4,25	-4,29	-4,33

Table B-6 Observed Soil Temperature at VD-TH3

Bead	B #1	B #2	B #3	B #4	B #5	B #6	B #7	B #8	B #9	B #10	B #11	B #12	B #13	B #14	B #15	B #16
Final El. (m)	5139,54	5138,54	5137,54	5136,54	5135,54	5134,54	5133,54	5132,54	5131,54	5130,54	5128,54	5126,54	5124,54	5122,54	5120,54	5118,54
Depth (m)	0,08	1,08	2,08	3,08	4,08	5,08	6,08	7,08	8,08	9,08	11,08	13,08	15,08	17,08	19,08	21,08
Correction	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
17-nov-12 12:05	-14,66	0,15	0,08	-0,07	-0,03	-0,08	-0,03	-0,03	-0,23	-0,47	-1,18	-2,30	-2,66	-3,04	-3,38	-3,45
17-nov-12 17:15	-15,72	0,15	0,09	-0,06	-0,03	-0,09	-0,04	-0,04	-0,31	-0,71	-2,05	-2,50	-2,81	-3,19	-3,45	-3,52
18-nov-12 15:30	-17,05	0,12	0,10	0,14	0,02	-0,10	-0,08	-0,28	-1,28	-1,72	-2,39	-2,76	-3,04	-3,43	-3,57	-3,64
19-nov-12 07:20	-16,25	0,12	0,11	0,15	0,03	-0,10	-0,10	-0,63	-1,39	-1,78	-2,43	-2,80	-3,08	-3,42	-3,58	-3,65
20-nov-12 10:00	-10,24	0,10	0,10	0,14	0,02	-0,12	-0,20	-1,00	-1,47	-1,85	-2,48	-2,85	-3,13	-3,47	-3,61	-3,68
20-nov-12 16:00	-10,98	0,10	0,09	0,14	0,02	-0,12	-0,23	-1,01	-1,48	-1,85	-2,48	-2,85	-3,13	-3,47	-3,61	-3,68
22-nov-12 09:00	-11,68	0,08	0,05	0,10	-0,01	-0,14	-0,52	-1,07	-1,52	-1,88	-2,51	-2,88	-3,16	-3,50	-3,64	-3,71
22-nov-12 15:45	-11,43	0,08	0,05	0,09	-0,01	-0,14	-0,54	-1,07	-1,52	-1,88	-2,51	-2,88	-3,17	-3,50	-3,64	-3,71
23-nov-12 09:30	-11,29	0,05	0,03	0,08	-0,02	-0,15	-0,59	-1,09	-1,53	-1,83	-2,53	-2,89	-3,18	-3,52	-3,65	-3,72
23-nov-12 16:30	-11,32	0,05	0,03	0,06	-0,03	-0,16	-0,60	-1,09	-1,53	-1,90	-2,54	-2,89	-3,18	-3,52	-3,65	-3,72
24-nov-12 08:30	-12,75	0,04	0,02	0,06	-0,03	-0,16	-0,61	-1,09	-1,53	-1,89	-2,53	-2,89	-3,18	-3,52	-3,65	-3,72
24-nov-12 17:30	-14,72	0,03	0,00	0,05	-0,03	-0,18	-0,62	-1,10	-1,54	-1,90	-2,54	-2,90	-3,18	-3,53	-3,66	-3,72
25-nov-12 10:30	-16,32	-0,01	-0,01	0,03	-0,06	-0,20	-0,64	-1,11	-1,54	-1,90	-2,54	-2,90	-3,19	-3,53	-3,67	-3,72
25-nov-12 14:30	-16,36	-0,01	-0,01	0,03	-0,04	-0,20	-0,64	-1,11	-1,54	-1,90	-2,54	-2,90	-3,19	-3,53	-3,67	-3,73
26-nov-12 14:30	-16,32	-0,01	-0,01	0,03	-0,06	-0,20	-0,64	-1,11	-1,54	-1,90	-2,54	-2,90	-3,19	-3,53	-3,67	-3,73
27-nov-12 14:00	-16,21	-0,07	-0,04	0,00	-0,06	-0,22	-0,66	-1,11	-1,54	-1,89	-2,53	-2,89	-3,19	-3,53	-3,66	-3,72
28-nov-12 15:00	-17,06	-0,10	-0,06	-0,01	-0,07	-0,26	-0,66	-1,11	-1,54	-1,89	-2,53	-2,89	-3,19	-3,53	-3,66	-3,72
29-nov-12 07:00	-16,45	-0,14	-0,07	-0,02	-0,07	-0,27	-0,67	-1,11	-1,54	-1,89	-2,53	-2,89	-3,19	-3,53	-3,67	-3,73
30-nov-12 13:00	-18,27	-0,21	-0,09	-0,04	-0,09	-0,31	-0,69	-1,13	-1,56	-1,90	-2,53	-2,90	-3,20	-3,55	-3,68	-3,74
01-déc-12 11:30	-19,57	-0,29	-0,09	-0,04	-0,09	-0,31	-0,69	-1,12	-1,54	-1,89	-2,51	-2,85	-3,19	-3,54	-3,67	-3,73
02-déc-12 16:00	-19,88	-0,49	-0,10	-0,07	-0,10	-0,33	-0,70	-1,13	-1,56	-1,90	-2,51	-2,89	-3,19	-3,55	-3,68	-3,74
04-déc-12 07:30	-18,27	-0,91	-0,09	-0,07	-0,09	-0,34	-0,69	-1,12	-1,53	-1,88	-2,50	-2,87	-3,18	-3,53	-3,67	-3,73
05-déc-12 14:30	-16,88	-1,30	-0,12	-0,08	-0,09	-0,35	-0,70	-1,12	-1,53	-1,88	-2,49	-2,87	-3,18	-3,54	-3,67	-3,73
06-déc-12 09:30	-18,14	-1,43	-0,12	-0,08	-0,10	-0,36	-0,70	-1,13	-1,54	-1,88	-2,49	-2,87	-3,18	-3,54	-3,68	-3,74
07-déc-12 09:00	-18,74	-1,72	-0,12	-0,08	-0,09	-0,36	-0,70	-1,12	-1,53	-1,87	-2,48	-2,86	-3,17	-3,53	-3,67	-3,73
08-déc-12 08:00	-19,60	-2,06	-0,12	-0,08	-0,09	-0,36	-0,70	-1,12	-1,53	-1,86	-2,48	-2,86	-3,17	-3,53	-3,67	-3,73
09-déc-12 15:00	-19,64	-2,56	-0,18	-0,10	-0,10	-0,40	-0,72	-1,15	-1,54	-1,88	-2,49	-2,87	-3,18	-3,55	-3,68	-3,74
10-déc-12 09:00	-19,37	-2,77	-0,13	-0,09	-0,09	-0,39	-0,72	-1,13	-1,53	-1,87	-2,48	-2,86	-3,17	-3,54	-3,68	-3,74
11-déc-12 09:30	-19,28	-3,05	-0,14	-0,10	-0,10	-0,41	-0,72	-1,15	-1,54	-1,87	-2,48	-2,86	-3,18	-3,54	-3,68	-3,74
12-déc-12 08:30	-20,07	-3,31	-0,13	-0,10	-0,09	-0,40	-0,72	-1,13	-1,53	-1,86	-2,47	-2,85	-3,17	-3,54	-3,68	-3,74
13-déc-12 09:30	-21,30	-3,69	-0,14	-0,10	-0,09	-0,41	-0,74	-1,15	-1,53	-1,86	-2,46	-2,84	-3,16	-3,53	-3,67	-3,73
14-déc-12 09:00	-21,82	-4,12	-0,14	-0,10	-0,09	-0,41	-0,74	-1,15	-1,53	-1,86	-2,46	-2,84	-3,16	-3,53	-3,68	-3,74
16-déc-12 10:00	-14,87	-4,42	-0,14	-0,10	-0,09	-0,42	-0,74	-1,13	-1,52	-1,85	-2,45	-2,83	-3,16	-3,53	-3,67	-3,73

APPENDIX C

THERMAL MODELLING

C-1: Temp/W validation

C-2: 1D numerical model calibration

C-3: 2D Numerical modeling

C-1: Temp/W validation :

Engineers must be prudent when using numerical analyses tools, even if the tool is well known and commonly used in engineering practice. One of the best known numerical tool validation technique is to compare the tool's results to that of an exact analytical solution, for a simple problem. For heat transfer by conduction with phase change, the most comprehensive exact solution, is Neumann's solution. Temp/W's capability to adequately model heat transfer by conduction was validated by Neumann's exact solution. The comparison between the numerical and analytical results shown in Figures C-1 and C-2, demonstrate the ability of Temp/W to adequately model heat transfer by conduction with phase change for water.

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Figure C-1: Temp/W Validation (freezing)

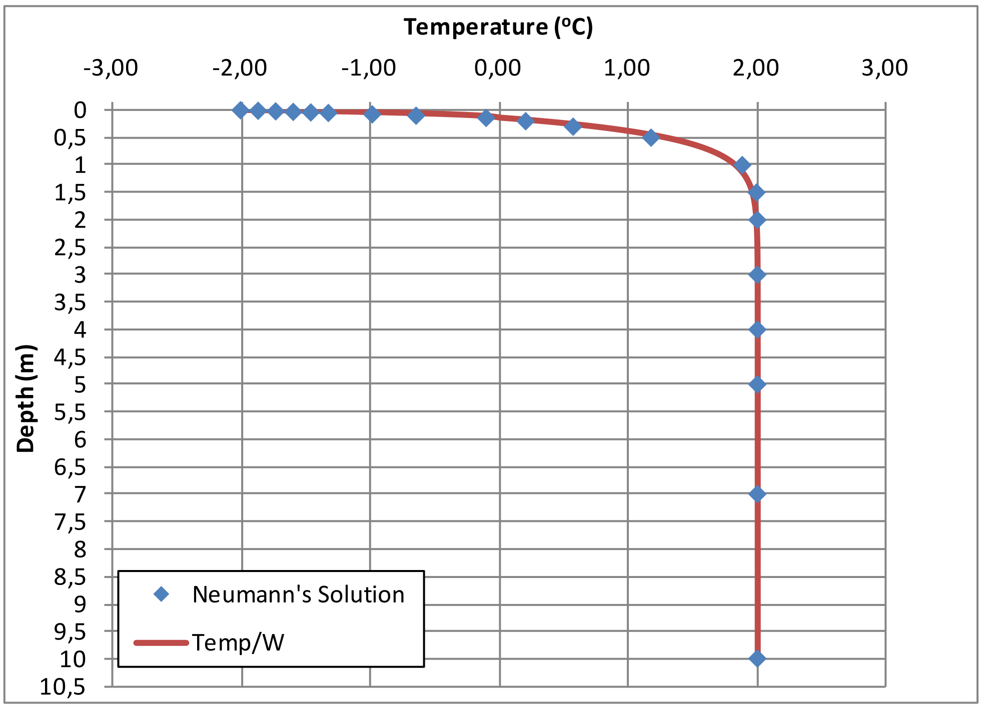
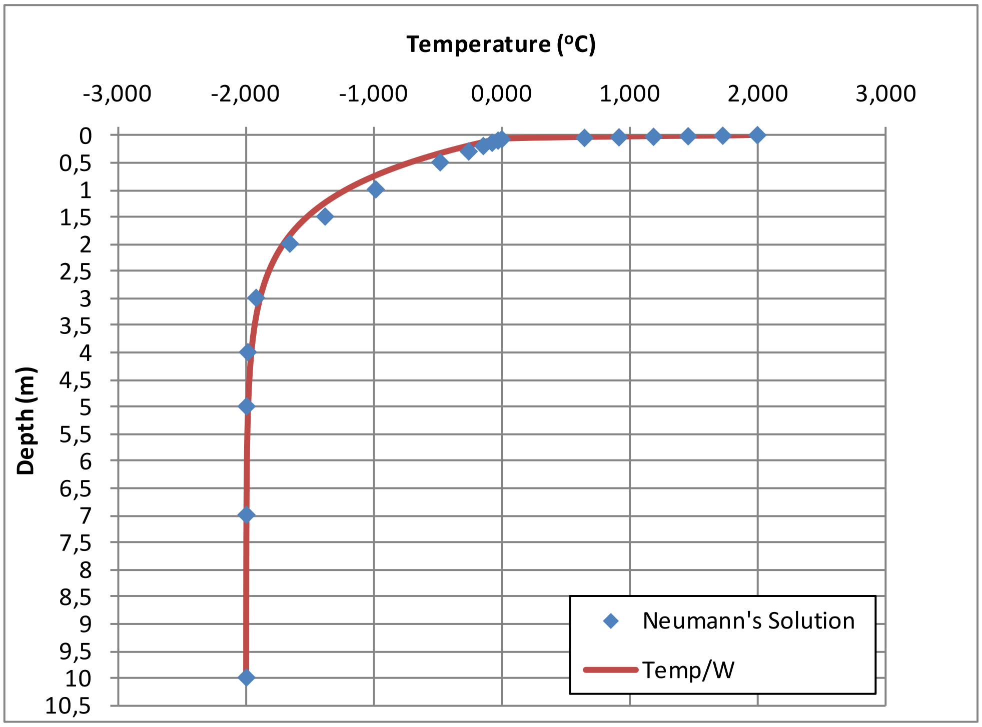


Figure C-2: Temp/W Validation (Thawing)



C-2: 1D numerical model calibration:

The numerical model developed was initially calibrated with a set of observed data. This step validated the estimated thermal properties of the foundation materials (till and bedrock) and ensured that Temp/W adequately modeled the observed behaviour.

For the calibration, the following numerical convergence parameters were used:

- Maximum number of iterations 100;
- Minimum temperature difference 0.1^{o}C;
- Significant digit after the dot = 1;
- Δt = 1 day.

Figures C-3 and C-4 present the numerically generated vertical temperature profiles compared to observation at VD-TH 1 and 2 for November 18th and 26th, 2012.

To simulate the temperature profile observed at VD-TH3 using heat transfer by conduction only, the water depth and overburden thicknesses were adjusted, shattered bedrock layer was added and the thermal properties of the material were modified. The calculated temperature profile did not match that observed in the field (constant temperature at +/- 0^{o}C between 2 to 5 m of depth).

It is considered that this unusual temperature profile may be due to inadequate installation, or contact with warm water flowing through the soil.

To validate this hypothesis, advective heat transfer modelling was peformed.

The objective of this modelling exercise was to demonstrate that water flowing into the soil may modify the thermal profile of the soil comparable to that observed in the field, at VDTH-3. It should be noted that this exercise did not include seepage modelling through the soil, beneath the creek.

However, an exhaustive advective heat transfer modelling was not carried out for the following reasons:

- In-situ soil and bedrock hydraulic parameter are not all available;
- The hydraulic gradient between the lakes and or all of the boundary conditions are currently unknown;
- There is currently no data with which to calibrate the seepage model (such as packer test results);
- Seepage modelling was beyond of SLI’s scope of work.

A simplified numerical model was created, which included a single granular soil. Assumptions concerning hydraulic parameters of the soil and hydraulic boundary conditions were made and are shown on Figures C-5 to C-8.

Figure C-9 presents the impact of warm water flowing through the soil on the vertical thermal profile. This figure shows that the constant temperature observed at VDTH-3 between a depth of 2 and 5 m may be related to a warm water flow phenomenon.

If this is the case, water will be visible during the excavation of the key trench at a location near the thermistor string. It is however impossible to confirm whether or not water was flowing into the Vault Dike foundation between November and December 2012.

Figure C-3: VD-TH1 Numerical vs. Observed Temperature

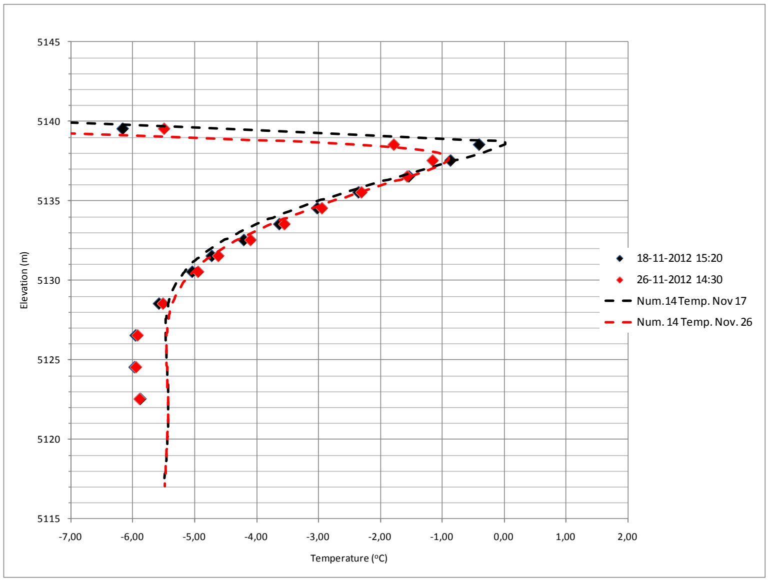


Figure C-4: VD-TH2 Numerical vs. Observed Temperature

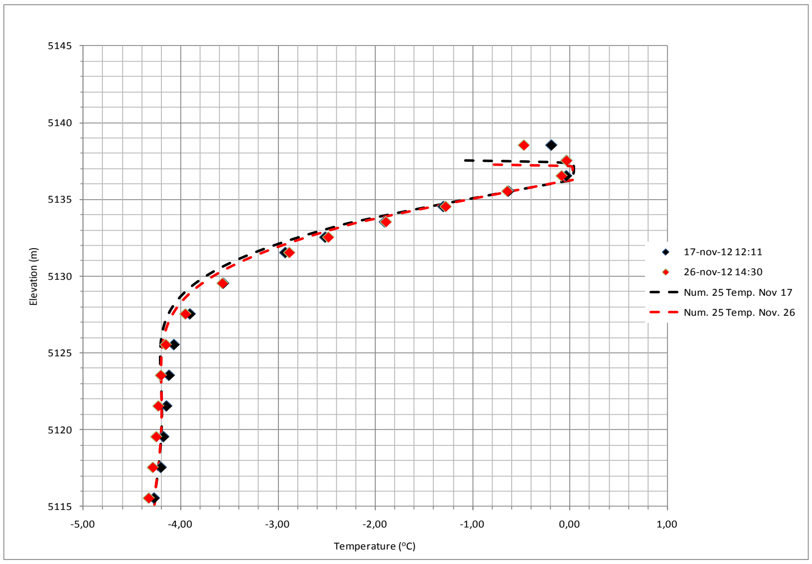


Figure C-5: Simplified 2D Model with Boundary Conditions for VDTH-3

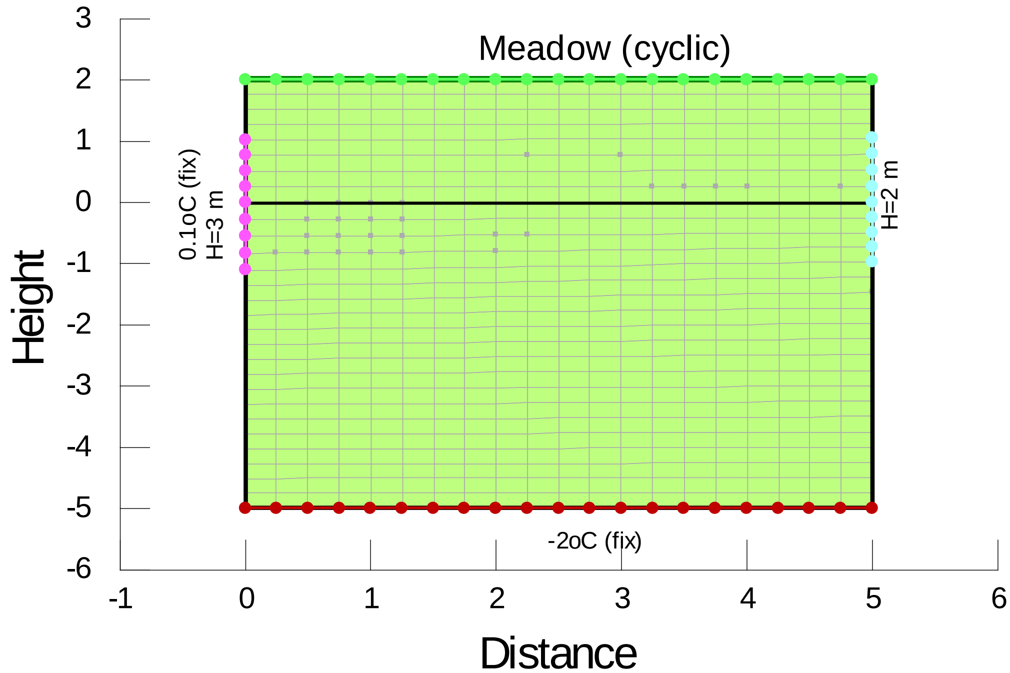


Figure C-6: Assumed Thermal Conductivity vs. Water Content for VDTH-3

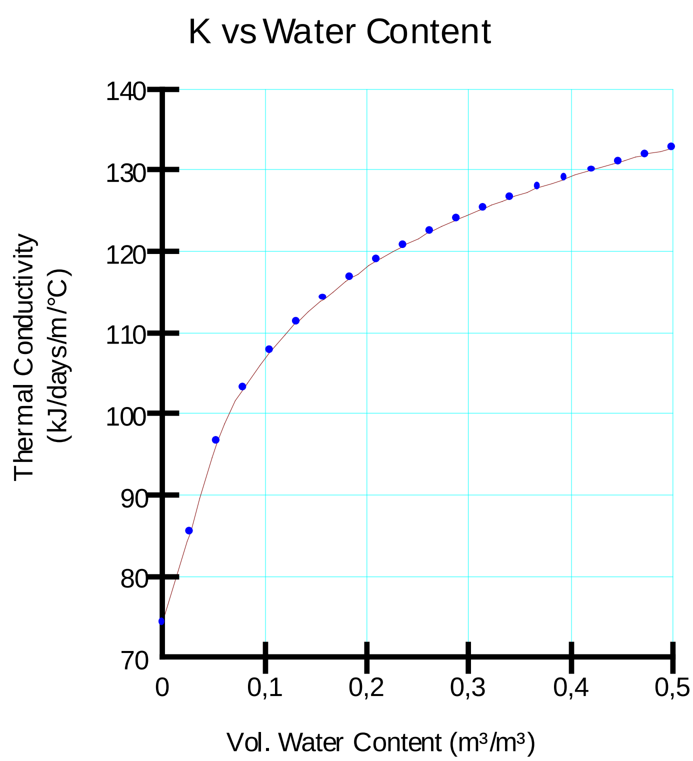


Figure C-7: Assumed Volumetric Heat Capacity vs. Water Content for VDTH-3

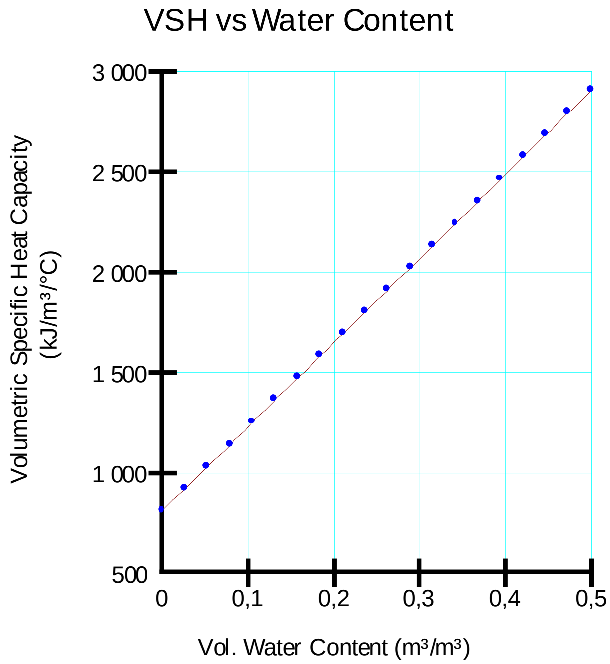


Figure C-8: Assumed Unfrozen Water Content vs. Temperature for VDTH-3

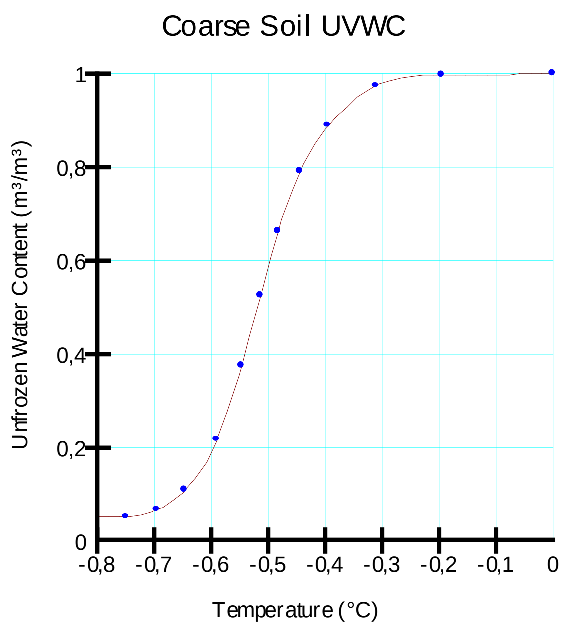
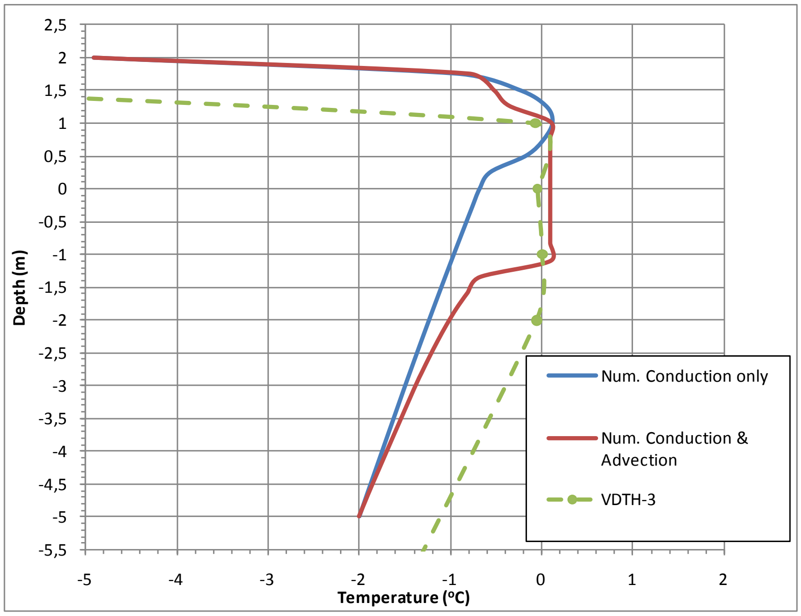


Figure C-9: Advective Heat Transfer Impact on Soil Thermal Profile



C-3: 2D Numerical modeling:

The dike geometry used for the analyses is presented in Figure C-10. The numerical model convergence criteria were kept identical to these used for the model calibration. Quad and triangle meshing was used with an approximate global element size of 0.5 m. Figures C-10a and C-10b show the location of control profile and points. A total of 15 numerical models were produced to predict the thermal behaviour of Vault Dike.

The lateral extension of the numerical model is 52 m downstream and 52 m upstream of the dike centreline, for a total width of 104 m. The vertical extension of the model is 25 m extending into the bedrock for a total height of 32 m.

The numerical thermal model for Vault Dike was performed as described below:

- Run the model for 6 years without Vault Dike, to establish an adequate soil foundation thermal profile;
- Look at the increase in permafrost strength on the overall Vault Dike thermal behaviour by exposing the key trench to air temperature for 21 days (pre-construction work);
- Build Vault Dike instantantly with cold material at -20°C under winter condition;
- Look at the impact of various Vault Lake water levels on the thermal behaviour of Vault Dike;
- Look at the potential impact of warm water (5°C) infiltration through the rockfill on the thermal behaviour of Vault Dike during Summer 2013;
- Run the model until 2017 (4 years) to see the long-term thermal behaviour of the dike.

The pre-construction key trench excavation was modelled to better understand the impact of excavating the key trench on the soil's thermal behaviour (see Figures C-11 and C-12). Figure C-12 show that freezing the key trench for a period of 21 days increases the strength of the permafrost dike foundation down to the elevation 5,125.0 m.

Figure C-13 shows that the impact of excavating the key trench during pre-construction is major, particularly during the first summer 2013. This impact gradually diminishes afterward.

AEM should start pumping Vault Lake as soon as possible in 2013 to maintain the lake level to its normal elevation (5,139.52 m). Considering that pumping equipment may break or that pumping may start later than planned, the following 2 situations were evaluated:

- Situation A: Vault lake water level = 5,139.52 m (as planned) from June to November 2013;
- Situation B: Vault lake water level = 5,140.5 m (2013 maximum water level) from June to November 2013.

To be conservative, the water level in Vault Lake was maintained at a constant elevation. In other words, the water level variations associated with pumping were not modelled. From November 2013 to 2017, Vault Lake was assumed to be empty.

As presented on Figures C-14 to C-20, Vault Dike and the underlying soil thermal behaviour does react as expected, and does not depend on the 2013 Vault Lake water level. The Thermal cap prevents the key trench and the underlying materials from melting, hence stay frozen all year long (this was the case only when conductive heat transfer was considered). A numerical active layer in the 0-600 mm range will reach elevation 5,138.8 m, i.e. 3.7 m below the dike crest and a depth of 2.48 m into the till outside the Vaults Dike footprint (when Vault lake is empty). The difference in the thickness of the active layer is due to the inherent differences in thermal properties and the water content for these 2 soil regions.

Even if the dike rockfill base layer comes in contact with warm water (5^{o}C) during Summer 2013, as shown in Figure C-21, the key trench and the underlying till are kept frozen (see Figures C-22 and C-23).

Figures C-24 and C-25 show the convergence trend of one numerical model. The maximum allowable iteration count was increased to 500 to evaluate the impact over the convergence trend. As shown in Figures C-26 and C-27, the nodal temperature does not decrease much after 100 iterations.

Figure C-10: Simplified VD Typical Section

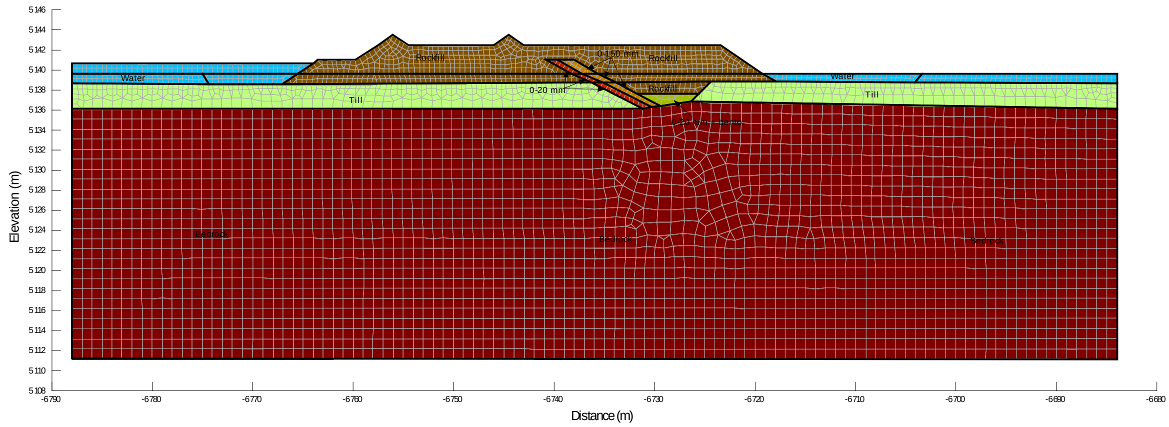


Figure C-10a: Vertical Control Profile Location

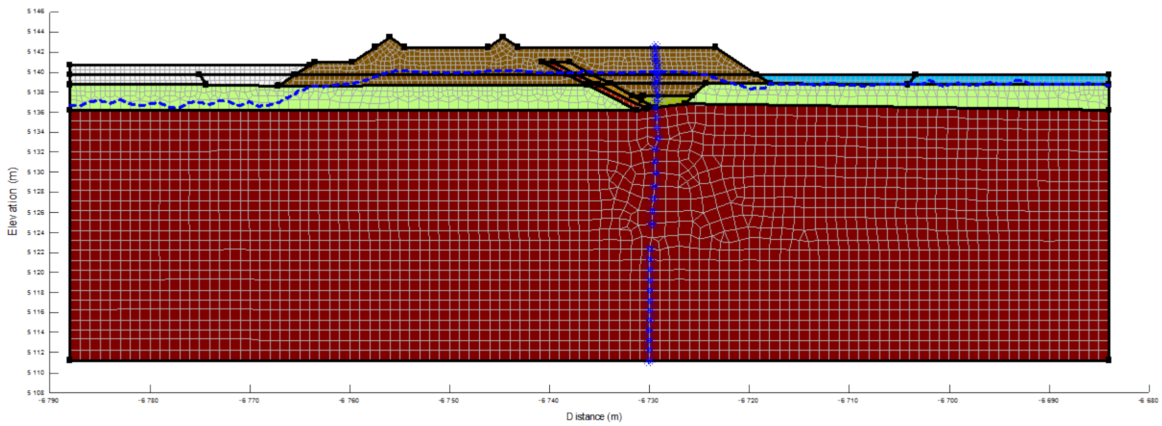


Figure C-10b: Control Point Location

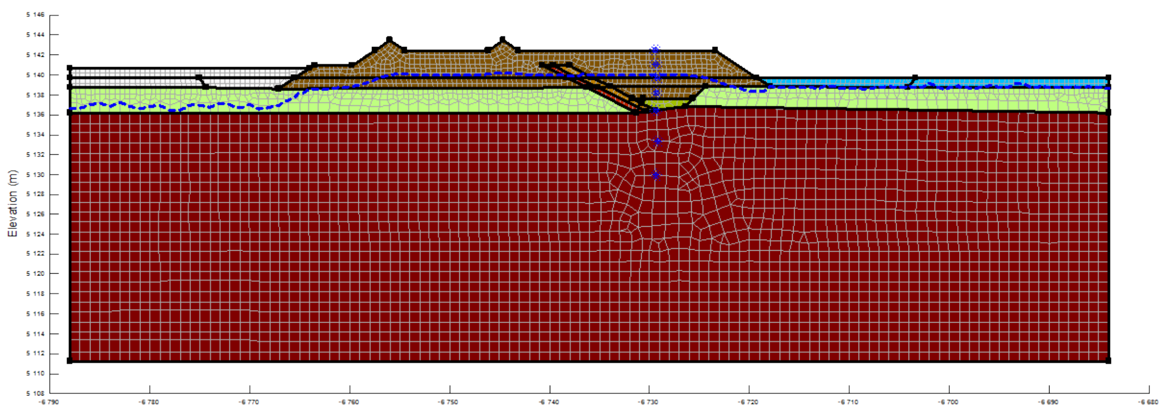


Figure C-11: Pre-construction Key Trench Excavation Impact on Soil Temperature - February 2013

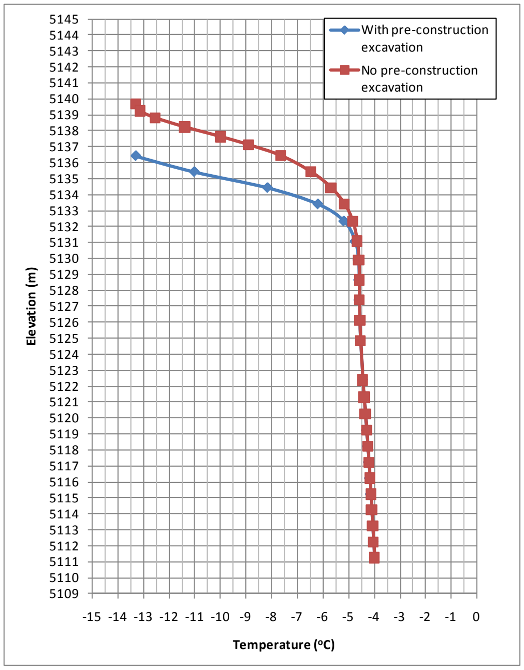


Figure C-12: Pre-construction Key Trench Excavation Impact on Soil Temperature - November 2013

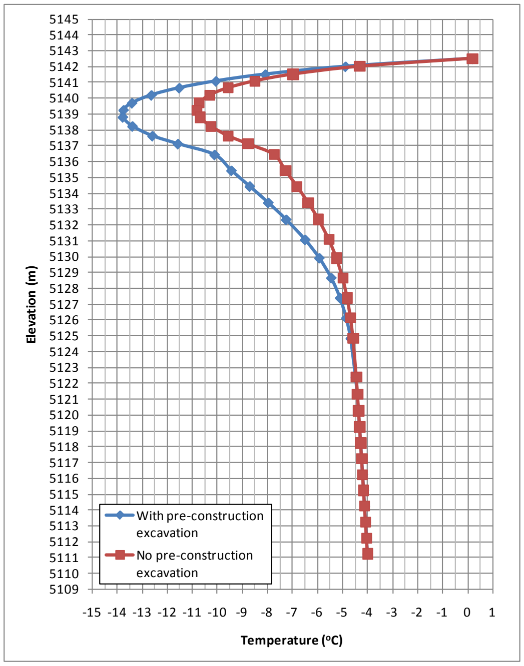


Figure C-13: Daily Key Trench Temperature Evolution 2013 to 2017

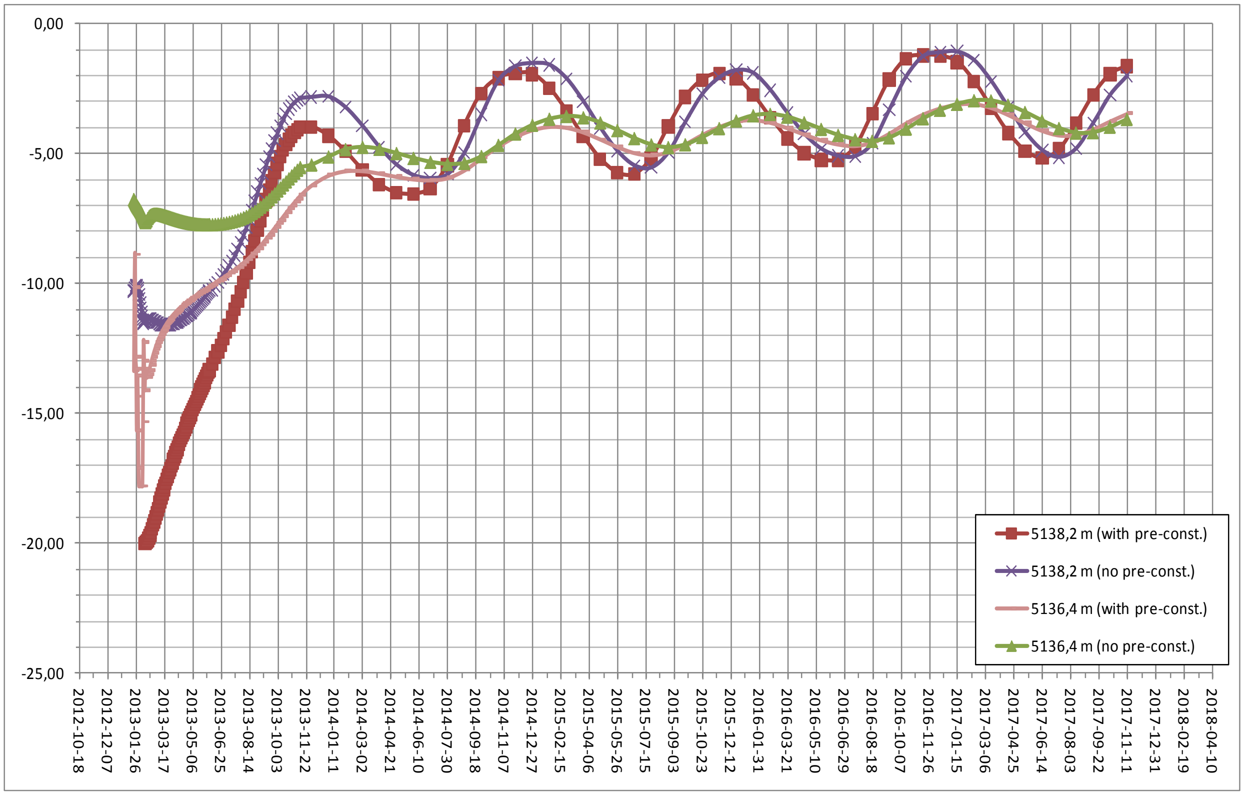


Figure C-14: Soil Temperature June 2013 When the Ice Surface Starts to Melt
(No Pre-Construction Key Trench Excavation)

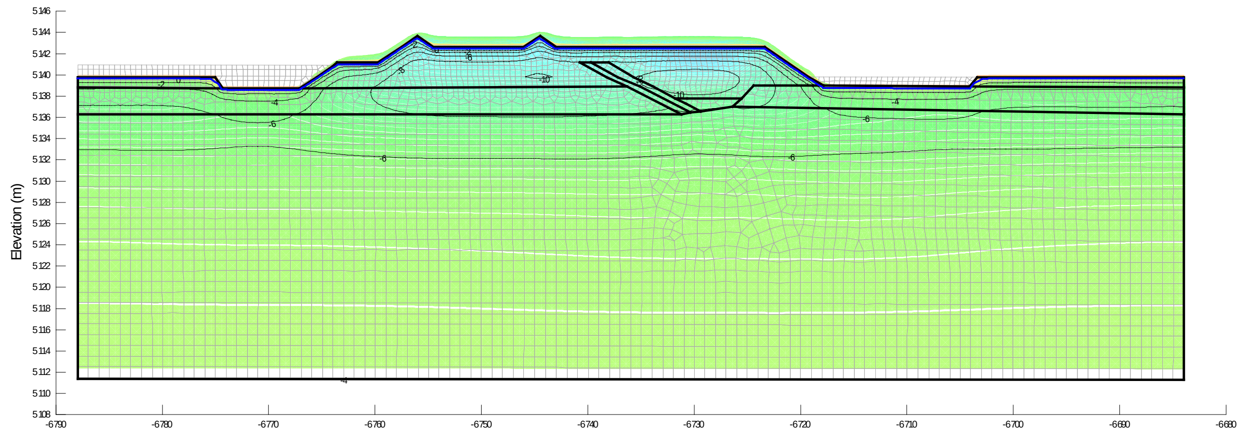


Figure C-15: Soil Temperature June 2013 When the Ice Surface Starts to Melt
(with Pre-Construction Key Trench Excavation)

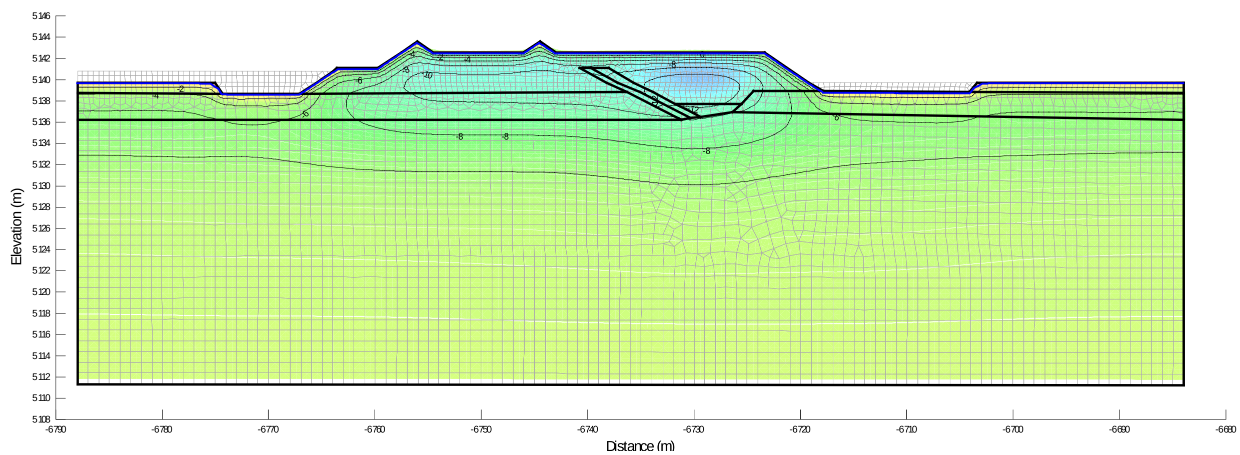


Figure C-16: Soil Temperature November 2013 When the Water Surface Starts to Freeze (No Pre-Construction Key Trench Excavation)

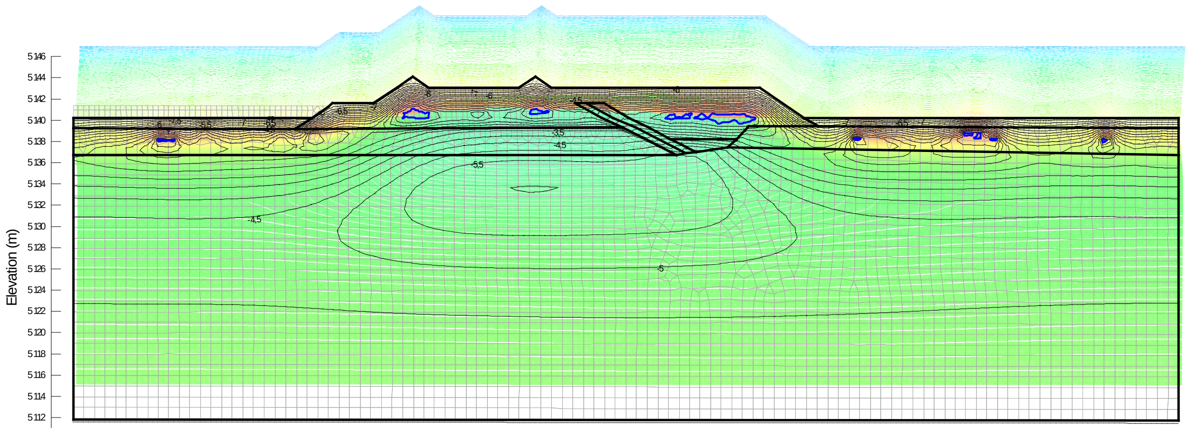


Figure C-17: Soil Temperature November 2013 When the Water Surface Starts to Freeze (with Pre-Construction Key Trench Excavation)

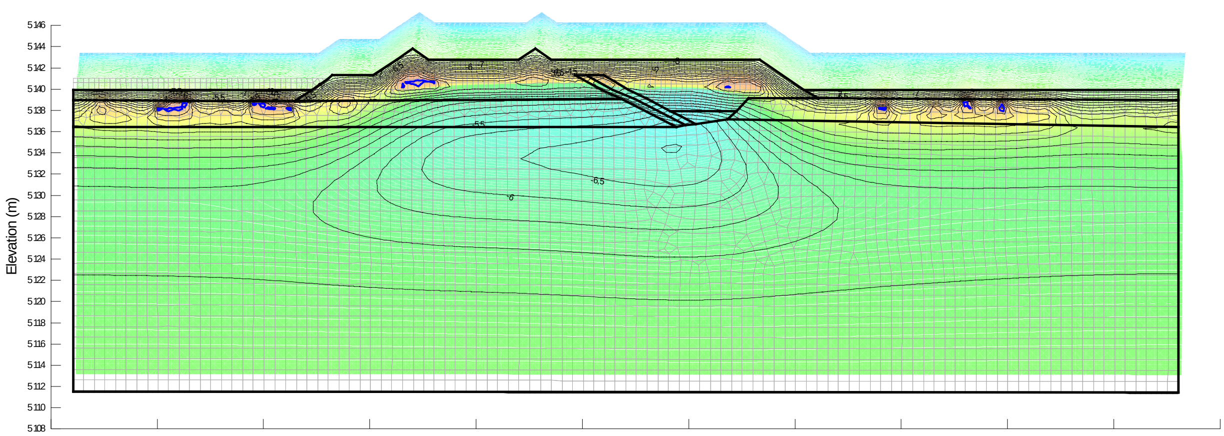


Figure C-18: Vault Lake Water Level Impact on November 2013 Key Trench Vertical Profile (No Pre-Construction Excavation)

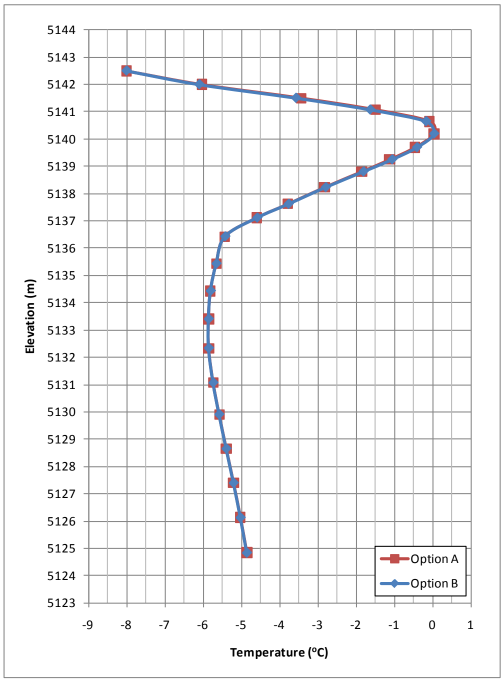


Figure C-19: Vault Lake Water Level Impact on November 2013 Key Trench Vertical Thermal Profile (with Pre-Construction Excavation)

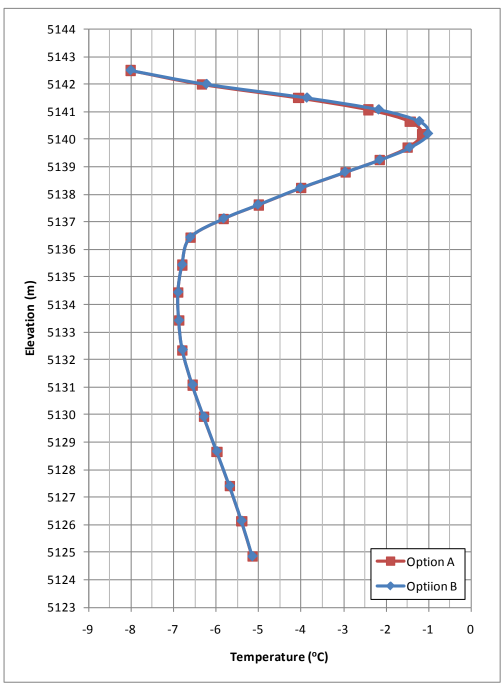


Figure C-20: Vault Lake Water Level Impact Over Key Trench Vertical Temperature Profile June to November 2013

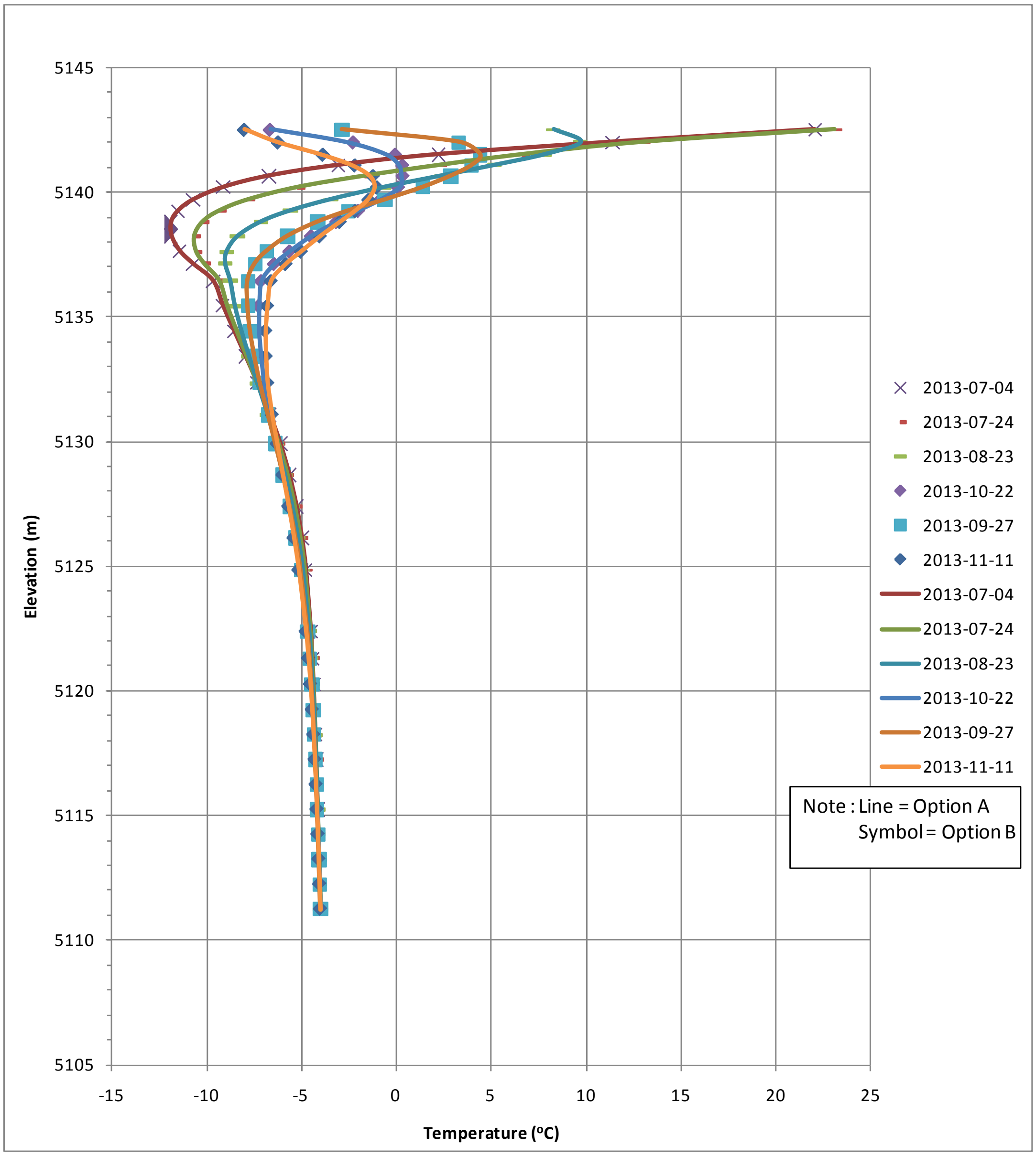


Figure C-21: Warm Water (5°C) Infiltrated Into Rockfill

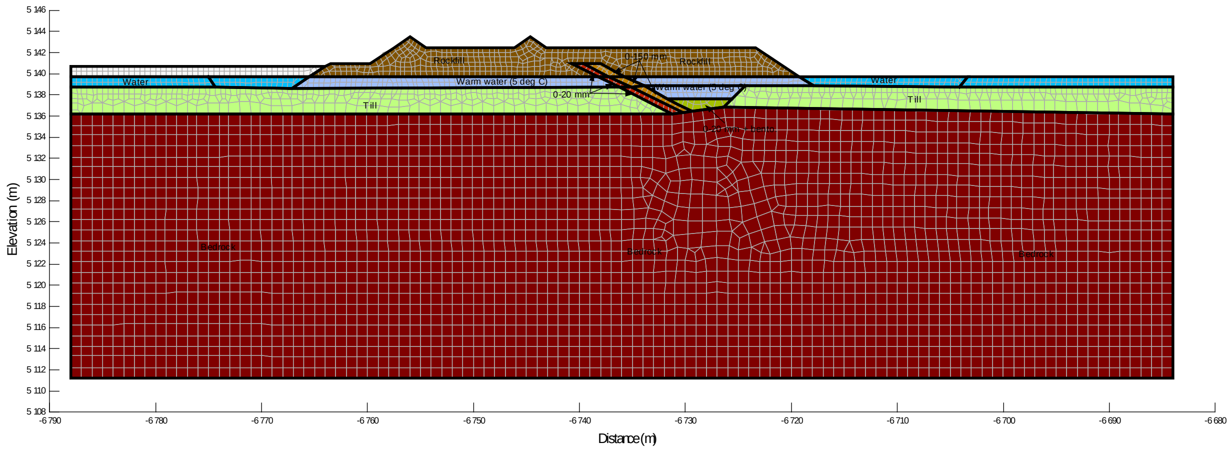


Figure C-22: Soil Temperature November 2013 When Water Surface Start to Freeze With Warm Water (5°C) Infiltration Through Rockfill (with No Pre-Construction Key Trench Excavation)

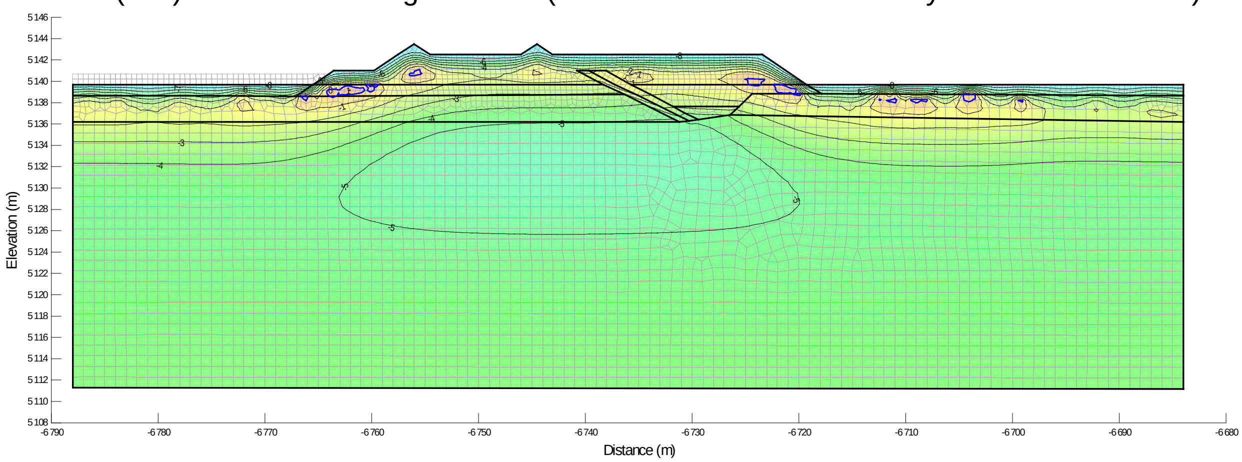


Figure C-23: Warm Water (5°C) Infiltration Through Rockfill (with No Pre-Construction Key Trench Excavation) Impact Over the Daily Key Trench Soil Temperature

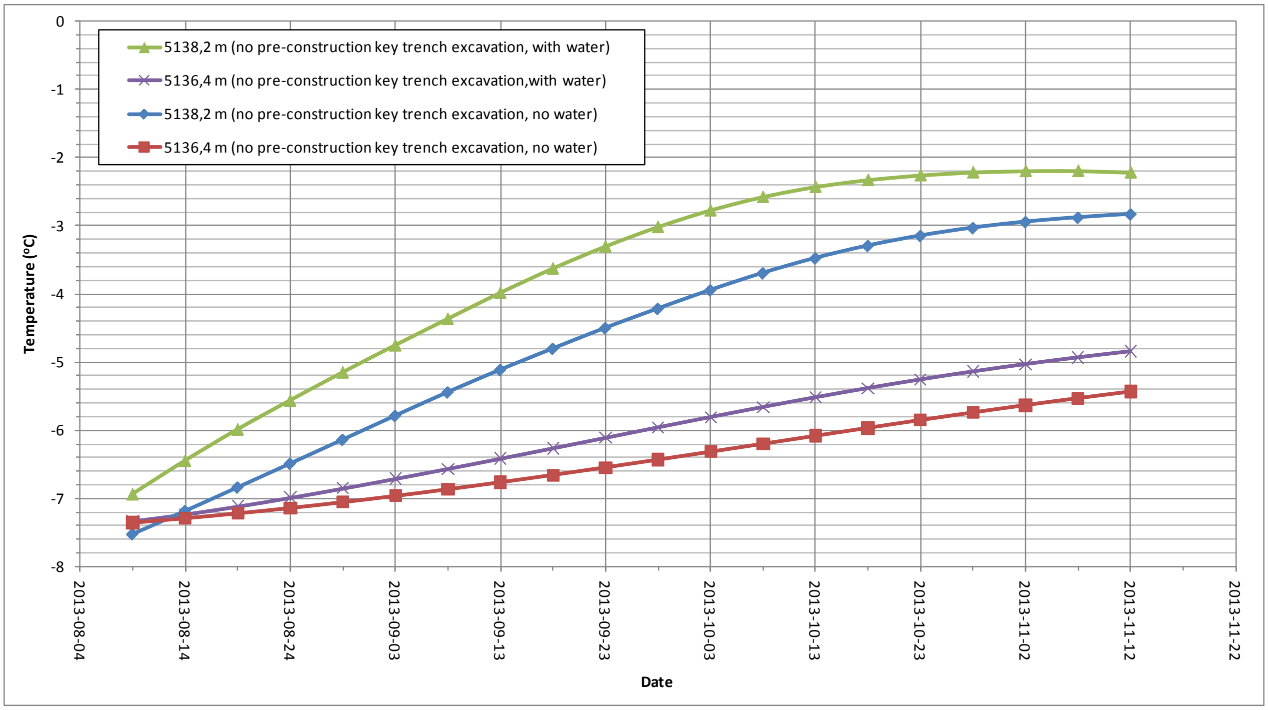


Figure C-24: Convergence Trend for Numerical Modelling 9 (Situation B, No Pre-Construction key, November 2013 to 2017)

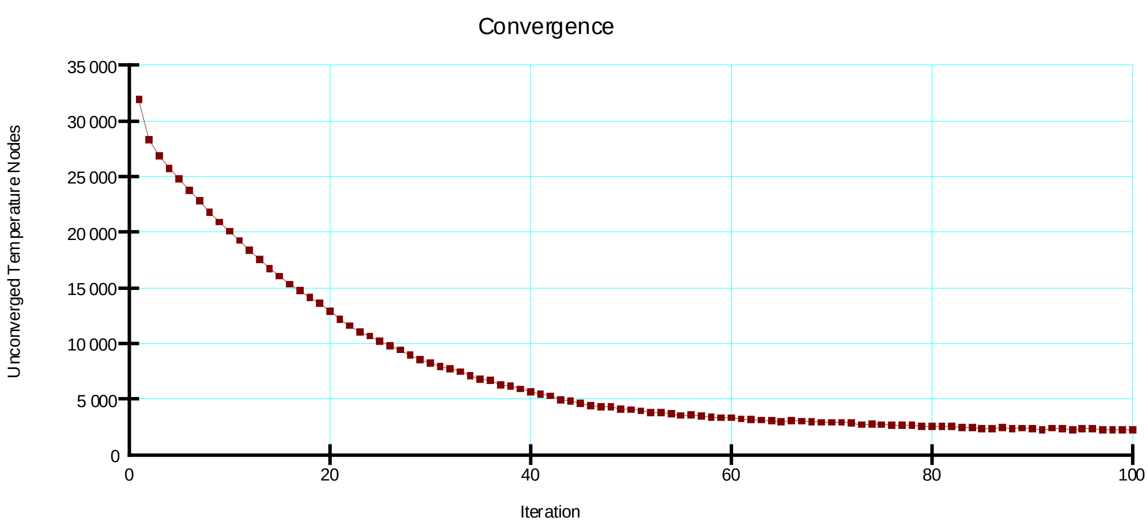


Figure C-25: Iteration Count for Numerical Modelling 9
(Situation B, No Pre-Construction Key, November 2013 to 2017)

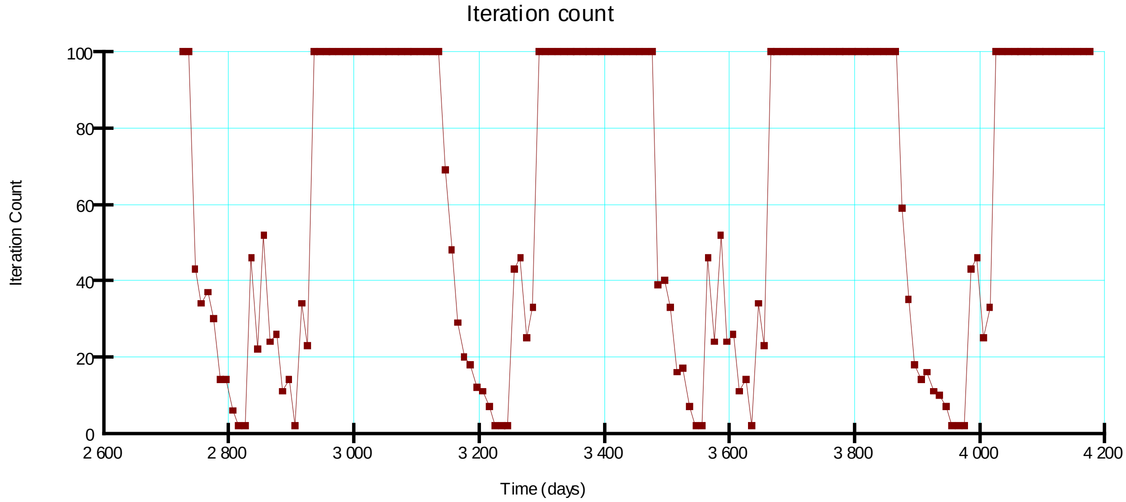


Figure C-26: Convergence Trend for Numerical Modelling 9 (Situation B, No Pre-Construction Key, November 2013 to 2017) with Maximum Iteration Count = 500

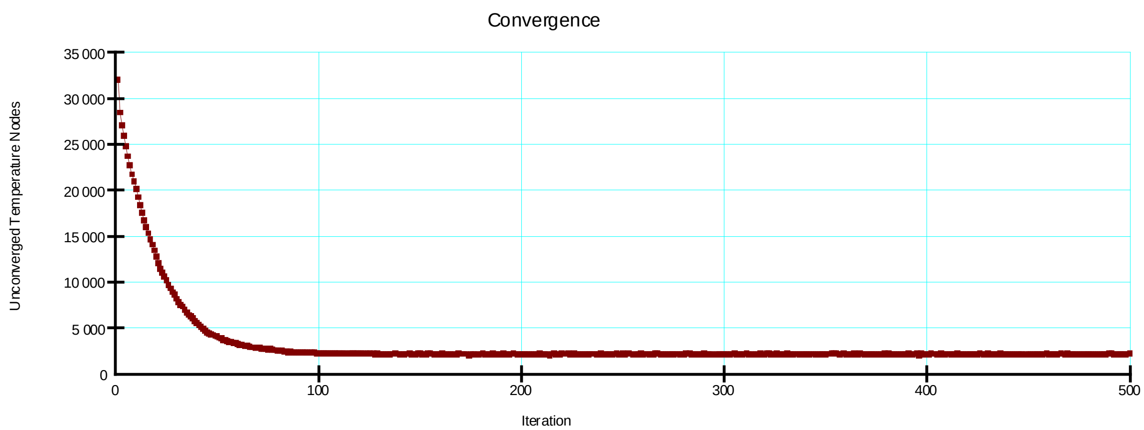
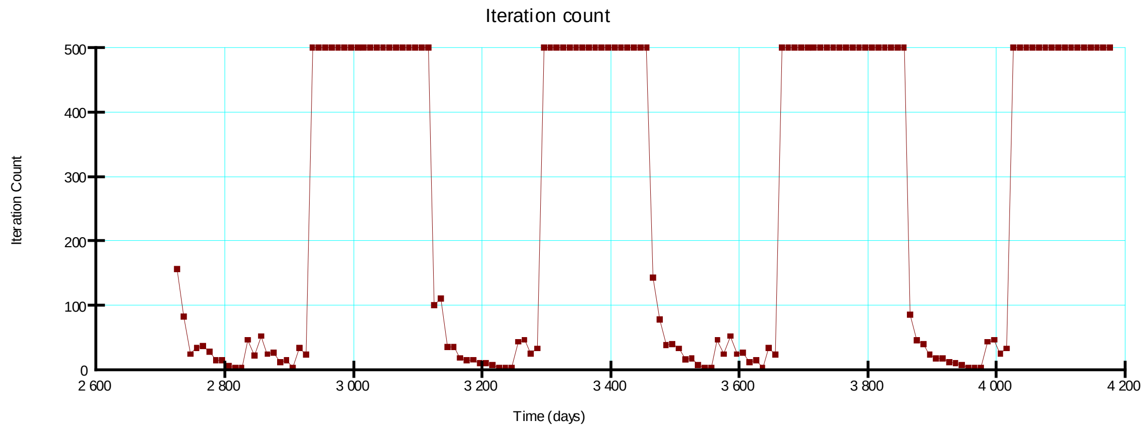


Figure C-27: Iteration Count for Numerical Modelling 9 (Situation B, No Pre-Construction Key, November 2013 to 2017) with Maximum Iteration Count = 500



APPENDIX D

REPORT No. 13

December 19th, 2012

Mr. Dominique Girard, P. Eng.
General Manager
Agnico – Eagle Mines, Meadowbank Division
Baker Lake Office

Email: dominique.girard@agnico-eagle.com

Dear Mr. Girard,

Report No 13
Meadowbank Mine Dike Review Board
Telephone/Webex Conference December 19, 2012

1.0 INTRODUCTION

The conference call with the Dike Review Board was held on December 19th. The Board is now comprised of three members, Mr. D. W. Hayley, Dr. N. R. Morgenstern and Mr. D. A. Rattue. All three members participated in the call.

The objectives were to review the progress of the detailed design for the Vault Dike. This structure is on a fast track with construction set to begin in February 2013.
The activities covered those outlined in the agenda which is included as Attachment A. The list of participants is given in Attachment B.

In the report which follows, the Board's recommendations are underlined.

2.0 PRESENTATIONS

Presentations, assisted by Webex transmission of the PowerPoint images, were made by personnel from Agnico-Eagle Mines (AEM) and SNC-Lavalin Inc. (SLI). These included an overview of the project, the design criteria, the site investigations for the Vault Dike and the results of studies and design for the dike.

The site investigations were conducted in November and December of 2012, and consisted of percussion soundings with a primary objective of establishing the bedrock profile. Three thermistor strings were installed, one on the left abutment and two in the stream bed.

The analytical work included thermal analyses and slope stability analyses.

3.0 COMMENTS BY THE MEADOWBANK DIKE REVIEW BOARD

3.1 Design parameters

The dike classification and the design parameters are appropriate for the type and scale of structure as well as for the limited planned life cycle.

3.2 Site investigations

The investigations were limited in scope, insofar as type of equipment was concerned, with little sampling of the overburden material being possible given the use of percussion drills. Some difficulty was apparently experienced during the installation of the thermistors, perhaps as a result of hole caving which is not uncommon in non-cohesive soils when air powered drill rigs are used. Nevertheless, the primary objectives of the programme were realized. <u>As will be mentioned later, the Board sees a need to perform additional instrument installations immediately prior to the start of construction.</u>

3.3 Stability analyses

Not surprisingly, given the low height and wide footprint, the analyses showed that static and pseudo-static minimum Factors of Safety were achieved for all the cases presented. The Board has no further comments in this regard.

3.4 Thermal analyses

The Board is of the opinion that the thermal analyses were well performed and pertinent to the work in hand. The results not only contributed to the interpretation of the measurements made by the thermistor strings but also permitted ideas to be advanced concerning the construction phases and eventual dike performance. The limited duration of temperature readings since the installations in December do not, by themselves, permit an understanding of the annual cycle of temperatures in the foundation, and particularly in the streambed. The TEMP/W simulations have made a significant contribution in this regard.

The analyses indicate that by constructing the dike in winter and by opening the cut-off trench as early as possible, frozen conditions should be sufficiently well established in the base of the dike to ensure seepage control.

3.5 Dike cross-section

The dike cross-section is conventional and follows precedent gained from other structures at the Meadowbank mine site.

A comparison of thermosyphon freezing and bituminous geomembrane for the creation of the impervious barrier demonstrated a preference for the latter.

Foundation preparation will consist of the removal of ice and snow followed by the excavation, aided by blasting, of a cut-off trench to bedrock.

The Board finds this to be a satisfactory approach for winter work but suggests that well graded, dense, ice poor till as has been encountered elsewhere at the site could also constitute an acceptable foundation. Beneath the extent of the geomembrane, any extensive ground ice should be removed even beyond the nominal width of the key trench. The Board recommends that additional thermistors be installed in advance of construction to assist with decision making process on the required depth of excavation, and to corroborate the simulation of the ground temperature regime.

If no suitable source of till is available, the Board concurs with the use of the bentonite amended 0-20 mm crushed stone as a material in which to anchor the geomembrane. AEM has experience with the use of such material. The Board suggests that the full width of the key trench at the base be backfilled with this material rather than attempting to place several different materials, given the anticipated difficult winter working conditions.

Given the low head, the Board concurs with the idea to place the geomembrane in horizontal bands rather than vertical as would normally be the placing configuration. The quality control for the first (lower) welded joint should be more stringent than subsequent joints which will be located in the freeboard area.

The Board is of the opinion that the pump well shown on the drawing may not be the most appropriate means to control seepage. It is inevitable that the bottom of the dike will become saturated and freezing may be inhibited if warmer water is drawn into the base of the fill by the pump. It is suggested that seepage be controlled at the downstream toe as a first measure with bedrock grouting as a contingency. However, it is believed that seepage quantities will be manageable and that freeze-back will occur in short order.

3.6 Construction management

The organigram presented shows that AEM will take the lead on construction management with various QC and QA services supplied by Inspec-Sol and SLI respectively. This follows the practice established for the central dike construction. Foundation acceptance and field design modifications will be made jointly by AEM and SLI. The Board is in agreement with this approach.

4.0 CONCLUSIONS

The Board is satisfied that the detailed design has advanced to a stage that permits specifications and construction drawings to be prepared, and construction to begin as scheduled. The construction will not be the first to have been carried out in winter conditions at Meadowbank but the Board would like to reiterate that greater diligence is required to ensure that the spirit and the letter of the specifications will be met and that any field design modifications are accomplished in a timely manner.

5.0 ACKNOWLEDGMENTS

The Board wishes to thank the personnel of AEM and SLI for their presentations. The Webex format permitted an efficient sharing of information.

Signed:

Norbert R. Morgenstern, P.Eng.   Don W. Hayley, P.Eng   D. Anthony Rattue, P.Eng.

ATTACHMENT A

AGENDA FOR BOARD MEETING NO. 13

December 19th, 2012

Agnico-Eagle Mines-Meadowbank Division

Meadowbank Dike Review Board

Meeting # 13 – December 19, 2012

Webex conference call

AGENDA

Wednesday, November 19

Webex conference call, start at 8:00 am Central Time

8h00	Connections to Webex
8h05	Welcome and Review of the Agenda - AEM
8h15	Vault project Update - AEM
8h30	Vault dike investigation - SNC
9h00	Vault dike design - SNC
9h45	Vault dike – QA/QC and construction schedule - AEM
10h15	Comments from the board
11h00	Closure

ATTACHMENT B

PARTICPATION AT DECEMBER 2012 CONFERENCE CALL

Participants		
Thomas Lepine	AEM	
Erica Voyer	AEM	
Simon Grenier	SNC-Lavalin Inc	
Yohan Jalbert	SNC-Lavalin Inc	
Jean-Francois St-Laurent	SNC-Lavalin Inc	
Don Hayley	EBA	Dike Review Board
Norbert Morgenstern	Self	Dike Review Board
Anthony Rattue	SNC Lavalin	Dike Review Board

SNC·LAVALIN

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