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Mason Mantla, Chair
Wek'èezhìı Land and Water Board
PO Box 32
Wekweètì, NT X0E 1W0, Canada

09 November 2022

Dear Mr. Mantla,

Subject: **2022 Annual Dam Safety Review – A418 Dike**

Please find attached the Dam Safety Review (DSR) Report for 2022 for the A418 Dike. The inspection covers the following facilities referenced in the Diavik Diamond Mines (2012) Inc. (DDMI) Type A Water Licence (W2015L2-0001):

- A418 Dike (Part G Conditions 30b and 31)

The post dam safety review recommendations from Tetra Tech (independent reviewer), and DDMI's actions and Implementation Plan for the A418 Dike are provided in Table 2 of this letter.

Please do not hesitate to contact Kofi Boa-Antwi at kofi.boa-antwi@riotinto.com or Kyla Gray (kyla.gray@riotinto.com;867-445-4922) with any questions or concerns.

Yours sincerely,

Angela Bigg	Mufaro Chivasa
President & COO Operations	Manager, DDMI Technical

Cc: Marie-Eve Cyr, WLWB
Anneli Jokela, WLWB
Joseph Heron, GNWT Lands

Attachments: Report on A418 Dike Dam Safety Review, Tetra Tech – November 2022

Rio Tinto

Table 1: Priority Descriptions

Priority	Description
1	A high probability or actual dam safety issue considered immediately dangerous to life, health or the environment, or a significant risk of regulatory enforcement.
2	If not corrected, could likely result in dam safety issues leading to injury, environmental impact or significant regulatory enforcement; or a repetitive deficiency that demonstrates a systematic breakdown of procedures.
3	Single occurrences of deficiencies or non-conformances that alone would not be expected to result in dam safety issues.
4	Best Management Practice - Further improvements are necessary to meet industry best practices or reduce potential risks.

Rio Tinto

Table 2: Tetra Tech 2022 DSR Recommendations and DDMI Implementation Plan

Location	Recommendation Description	Source of Recommendation	Priority Level	Recommended Timeline/Status	2022 Comments and Recommended Actions
			A418 Dike – Past Recommendations		
A418 Dike	Granular Filter Material (Zone 1A) Reserve Piles • If piping is encountered on A418 Dike, there are currently no reserve piles of granular filter material easily accessible for dike repairs. It is understood that reserve piles of Zone 1A material produced for the A21 Dike are available on site. Regardless, it should be ensured that equipment can mobilize rapidly and access DPS-6, if required.	2019 DSI	3	TBD	**Will discuss with Engineer of Record, to determine priority of item, or if completed and add to the A418 DSI Implementation plan. Currently no need for staging stockpiles at Dikes. Material can be mobilized from Crusher area and central stockpiles as needed.**
A418 Dike	Relief Well RW6 Cleaning • Clean Relief Well RW6 at Station 0+725 of the A418 Dike where sand has accumulated due to a probable suction of surrounding sand into the well when direction of flow was changed from being upward to downward.	2018 DSI	3	TBD	**Will discuss with Engineer of Record to determine priority of item, or if completed and add to the A418 DSI Implementation plan.**
			A418 Dike – New DSR Recommendations		
A418 Dike	Erosion Protection between Stations 0+530 to 0+600 and Stations 0+700 to 0+750	2022 DSR	3	2023	**Will discuss with Engineer of Record to determine priority of item and add to**

Location	Recommendation Description	Source of Recommendation	Priority Level	Recommended Timeline/Status	2022 Comments and Recommended Actions
	• Erosion protection was not observed and appeared to be missing from the upstream slope between Stations 0+550 and 0+580. • Upstream erosion protection is oversteepened and near vertical along the upstream slope between Stations 0+530 to 0+600 and Stations 0+700 to 0+750.				**the A418 DSI Implementation plan as required.**
A418 Dike	Emergency Response Test • It is unknown when the last ERP Test was conducted for the A418 Dike.	2022 DSR	3	2023	**A desktop exercise for A418 Dike will be conducted.**
A418 Dike	Failure Modes and Effects Assessment • The current FMEA for the A418 Dike does not include any PFMs that were identified in the 2004 final design (NKSL 2004a, Figure 14.1) as well as several other PFMs identified in by the CDA (2016). • The current FMEA was last updated in September 2020.	2022 DSR	4	2023	**Will revise and update the FMEA for the Dikes at DDMI. Workshop planned with engineer of record to close this recommendation.**
A418 Dike	Thermosyphon Group Ground Temperature Thresholds • Most ground temperatures measured from thermistors in thermosyphon groups	2022 DSR	3	2023	**Will review ground temperature TARP levels for the thermistors and thermosyphons to reflect current design and**

Location	Recommendation Description	Source of Recommendation	Priority Level	Recommended Timeline/Status	2022 Comments and Recommended Actions
	exceeded the current TARP Levels outlined in the ERP (i.e., single beads exceeding -2°C, group of beads exceeding -5°C).				**performance. Documentation will be updated in 2023 as part of yearly update.**
A418 Dike	<u>Seismic Stability Assessment Updates</u> • Seismic stability assessments for the A418 Dike are not based on the current seismic hazard values available from Earthquakes Canada. • Post-seismic stability (i.e., post-earthquake loading conditions) has not been assessed for the A418 Dike, as recommended by the CDA (2019).	2022 DSR	3	2023	**Will review with Engineer of Record for this facility to ensure stability assessments are current for the National Building Code of Canada seismic hazard values. Post-seismic stability will also be reviewed.**
A418 Dike	<u>Dike Safety Management System Documentation Revisions</u> • Revisions were identified following review of the DSMS documentation and should be completed during the next annual update.	2022 DSR	4	2023	**Will review facility specific documentation and update in 2023, in accordance with best practices.**

2022 Dam Safety Review

A418 Dike
Diavik Diamond Mine, Northwest Territories, Canada


PRESENTED TO

Diavik Diamond Mines (2012) Inc.

NOVEMBER 9, 2022
ISSUED FOR USE
FILE: 704-ENG.EARC03226-03

Tetra Tech Canada Inc.
14940 - 123 Avenue
Edmonton, AB T5V 1B4 CANADA
Tel 780.451.2121 Fax 780.454.5688

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EXECUTIVE SUMMARY

Tetra Tech Canada Inc. (Tetra Tech) was retained by Diavik Diamond Mines (2012) Inc. (DDMI), a wholly-owned company of the Rio Tinto Group, to conduct a Dam Safety Review (DSR) of the A418 Dike. The A418 Dike is an *Active* water retaining structure that was constructed to allow dewatering and mining of the A418 kimberlite pipe at the Diavik Diamond Mine (Diavik or the Mine), Northwest Territories (NT), Canada. This DSR is a requirement under the Mine's current Water Licence (Number *W2015L2-0001*, the Water Licence) issued by the Wek'èezhìi Land and Water Board.

Diavik is located on East Island, a 17 km^2 island within Lac de Gras, which is approximately 300 km northeast of Yellowknife, NT. The Mine is north of the treeline in a region of continuous permafrost. Diavik comprises three open pits for mining (both open pit and underground) four kimberlite pipes: A154 (A154N and A154S), A418, and A21. The A418 Open Pit is located directly south of the A154 Open Pit and is separated from the lake by the A418 Dike. The dike is a crescent-shaped structure that trends northeast-southwest, abutting with the A154 Dike at its north end and the East Island at is south end. An island in Lac de Gras (Island C) was incorporated into the profile of the A418 Dike.

The A418 Dike is a zoned rockfill embankment structure with a central cutoff wall comprised of a plastic concrete diaphragm wall with jet grout columns anchored into bedrock. The dike's primary function is to separate the A418 kimberlite pipe from Lac de Gras to allow for mining; therefore, the structure does not have a spillway. The area separated from Lac de Gras by the A418 Dike is approximately 55 hectares, including areas that were dry land prior to mining. Construction of the A418 Dike began in 2005 and was completed in 2006.

This DSR undertaken by Tetra Tech included a documentation review, site inspection, staff engagement, dam safety analysis, geotechnical and hydrotechnical assessments, dam safety risk controls (DSRC) review, and regulatory conformance review, all done in accordance with the Canadian Dam Association (CDA) guidelines and Diavik's Water Licence. Tetra Tech understands that this is the third DSR undertaken for the A418 Dike and concluded the following:

- DDMI staff and the Engineer of Record (EOR) have a good understanding and are well qualified to fulfill their roles and responsibilities as they relate to the A418 Dike's DSRC;
- A site inspection of the A418 Dike observed that the structure was generally in good condition and consistent with those described in the 2021 Annual Inspection and Performance Evaluation; however, two areas of erosion protection along the upstream slope of the dike were observed to have deficiencies and are recommended to be assessed;
- It is unknown when the last Emergency Response Plan Test was conducted and it is recommended that a formal test be completed for the A418 Dike;
- The CDA Consequence Classification of *Very High* that is currently assigned to the A418 Dike is appropriate for the structure;
- The current Failure Modes and Effects Assessment (FMEA) generally identifies and addresses the Potential Failure Modes (PFMs) for the A418 mine workings; however, several PFMs related to failure of the A418 Dike are not included. Accordingly, it is recommended that the FMEA be updated, in consultation with the EOR, to capture the PFMs identified in the 2004 final design as well as those identified in this DSR;
- The instrumentation and performance monitoring program for the A418 Dike is comprehensive and aligns with the PFMs identified for the structure; however, several ground temperatures measured from thermistors in thermosyphon groups exceed the current Trigger Action Response Plan (TARP) Levels outlined in the ERP.

Accordingly, it is recommended that the Ground Temperature TARP Levels for the thermistors in thermosyphon groups be reviewed and updated to reflect current design and performance requirements;

- The overall level of geotechnical design for the A418 Dike is adequate, including the design basis and criteria selected as well as the geotechnical investigations and analyses performed; however, seismic stability assessments for the dike are not based on current seismic hazard values and post-seismic stability has not been evaluated. Accordingly, it is recommended that the seismic stability assessments for the A418 Dike be reviewed and updated based on current seismic hazard values and CDA guidance;
- The A418 Dike is currently in regulatory conformance with Diavik's Water Licence conditions;
- This DSR of the A418 Dike has identified six new dam safety issues, including one deficiency and five non-conformances, that should be addressed in a timely manner to improve and maintain dam safety;
- It is understood that Fine Processed Kimberlite from Diavik's Process Plant will be deposited into the A418 mine workings (open pit and underground) starting in 2023 until the end of mine life in the first quarter of 2026, which represents a substantial change to the downstream environment of the structure. Accordingly, it is recommended that the A418 Dike's design, roles and responsibilities, consequence classifications, FMEA, and DSRCs be reviewed and updated to ensure that the requirements for a Tailings Storage Facility (TSF) are met as the dike converts to the A418 TSF.

Based on the DSR completed, the A418 Dike is operating safely and performing as intended. Current operation of the dike largely conforms to the CDA guidelines; however, there are some identified dam safety issues that are recommended to be addressed in a timely manner to improve and maintain dam safety. The next DSR for the A418 Dike is recommended be conducted in the summer of 2027.

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ACRONYMS & ABBREVIATIONS

Acronyms/Abbreviations	Definition
ACES	Automated Coastal Engineering System
AEP	Annual Exceedance Probability
AIPE	Annual Inspection and Performance Evaluation
AMEC	AMEC Environment & Infrastructure, a division of AMEC Americas Limited
CDA	Canadian Dam Association
DDMI	Diavik Diamond Mines (2012) Inc.
DGRB	Diavik Geotechnical Review Board
DOR	Designer of Record
DPS	Dike Pumping Station
DSMS	Dam Safety Management System
DSR	Dam Safety Review
DSRC	Dam Safety Risk Controls
EDGM	Earthquake Design Ground Motion
EOR	Engineer of Record
EPP	Emergency Preparedness Plan
ERP	Emergency Response Plan
FMEA	Failure Modes and Effects Assessment
FPK	Fine Processed Kimberlite
FS	Factor of Safety
ICMM	International Council on Mining and Metals
IDF	Inflow Design Flood
MAC	Mining Association of Canada
MCE	Maximum Credible Earthquake
MDWL	Maximum Design Water Level
MIWL	Maximum Instantaneous Water Level
MNWL	Maximum Normal Water Level
NAPEG	Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists
NIWSF	North Inlet Water Storage Facility
NIWTP	North Inlet Water Treatment Plant
NKSL	Nishi-Khon/SNC-Lavalin Limited
NT	Northwest Territories

Acronyms/Abbreviations	Definition
OMS	Operations, Maintenance, and Surveillance
PFM	Potential Failure Mode
PGA	Peak Ground Acceleration
PKMW	Processed Kimberlite Mine Workings
PMF	Probable Maximum Flood
PMP	Probable Maximum Precipitation
Rio Tinto	Rio Tinto Group
SLI	SNC-Lavalin Inc.
SSARR	Streamflow Analysis and Reservoir Regulation
TARP	Trigger Action Response Plan
Tetra Tech	Tetra Tech Canada Inc.
TSF	Tailings Storage Facility
VWP	Vibrating Wire Piezometer
Water Licence	DDMI Water Licence Number *W2015L2-0001* (WLWB 2021)
WLWB	Wek'èezhìi Land and Water Board
WMP	Water Management Plan

LIMITATIONS OF REPORT

This report and its contents are intended for the sole use of Diavik Diamond Mines (2012) Inc. and their agents. Tetra Tech Canada Inc. (Tetra Tech) does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than Diavik Diamond Mines (2012) Inc., or for any Project other than the proposed development at the subject site. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on Use of this Document attached in Appendix A.

1.0 INTRODUCTION

Tetra Tech Canada Inc. (Tetra Tech) was retained by Diavik Diamond Mines (2012) Inc. (DDMI), a wholly-owned company of the Rio Tinto Group (Rio Tinto), to conduct a Dam Safety Review (DSR) of the A418 Dike. The A418 Dike is an *Active* water retaining structure that was constructed to allow dewatering and mining of the A418 kimberlite pipe at the Diavik Diamond Mine (Diavik or the Mine), Northwest Territories (NT), Canada. This DSR is a requirement under the Mine's current Water Licence (Number *W2015L2-0001*, the Water Licence) issued by the Wek'èezhìi Land and Water Board (WLWB 2021).

The objective of this DSR is to assess and evaluate the safety of the A418 Dike against failure modes, in order to make a statement on the overall safety of the dike. It will confirm that the design, construction, operations, and maintenance of the A418 Dike conforms with the applicable standards and governing regulatory requirements. This DSR will also identify deficiencies or non-conformances that require improvement or remedial actions.

This report was prepared by Tetra Tech's DSR team and presents the outcome of a technical review completed for Diavik's A418 Dike. This report also includes a review of any previously stated dike safety issues, while developing a list of new deficiencies and non-conformances identified during this DSR. Conclusions and recommendations on dike safety and other aspects of the A418 Dike were compiled and added to this report.

Tetra Tech originally submitted a proposal for the A418 Dike DSR work on March 28, 2022. Authorization to proceed with this work was received from DDMI via email on April 6, 2022 (*DDMI Purchase Order Number 3105067854*).

1.1 Scope of Services

The scope of services to be performed includes a third-party DSR of the A418 Dike. A detailed scope of services for the DSR was outlined in a Tetra Tech's proposal document.

Tetra Tech performed this DSR in accordance with relevant national and international guidelines, including guidance from the Canadian Dam Association (CDA), the Mining Association of Canada (MAC), and the International Council on Mining and Metals (ICMM). Guidance documents that are considered relevant to this DSR include:

- *CDA Dam Safety Guidelines (CDA 2013);*
- *CDA Technical Bulletin: Dam Safety Reviews (CDA 2016);*
- *CDA Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (CDA 2019);*
- *CDA Technical Bulletin: Hydrotechnical Considerations for Dam Safety (CDA 2007);*
- *A Guide to Audit and Assessment of Tailings Facility Management (MAC 2011);*
- *A Guide to the Management of Tailings Facilities (MAC 2019); and*
- *Global Industry Standard on Tailings Management (ICMM 2020).*

The scope of services for the A418 Dike DSR included the following:

- Documentation Review of the supplied information, including:
  - Annual Inspection and Performance Evaluation (AIPE) reports;

  - Construction Record reports;
  - Detailed Design reports;
  - Geotechnical Investigation reports;
  - Instrumentation and Performance Monitoring data; and
  - Dam Safety Risk Control (DSRC) documents.
- Site Inspection of the A418 Dike and its supporting infrastructure;
- Roles and Responsibilities Review, including interactions with staff responsible for the operation and maintenance of the A418 Dike;
- Consequence Classification Review of the classifications assigned to the A418 Dike;
- Dike Safety Assessments of the geotechnical and hydrotechnical engineering analyses performed for the A418 Dike; and
- Identification of Dam Safety Issues, including deficiencies and non-conformances.

1.2 Dam Safety Review Team

The Tetra Tech team that completed this DSR included the following members:

- Nigel Goldup, M.Sc., P.Eng. – Dam Safety Review Engineer and Geotechnical Reviewer;
- Thomas Bradshaw, P.Eng. – Dam Safety Review Engineer and Geotechnical Reviewer;
- Dan Hajduković, Ph.D., P.Eng. (BC) – Hydrotechnical Reviewer; and
- David Moschini, P.Eng. – Hydrotechnical Reviewer.

Both Dam Safety Review Engineers are registered as Licensees with the Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists (NAPEG). The DSR team followed industry best practices throughout the review process as well as avoiding conflicts of interest.

1.3 Previous Dam Safety Reviews

Tetra Tech understands that this is the third DSR performed for the A418 Dike. The first DSR undertaken for the dike was completed in 2012 by AMEC Environment & Infrastructure, a division of AMEC Americas Limited (AMEC 2012). The second and most recent DSR was completed in 2018 by Tetra Tech (2018).

Per Diavik's Water Licence (Part G, Condition 30. b), DDMI are to conduct DSRs for "the A418 Dike in 2017 and every five (5) years thereafter, or at a frequency approved by the Board" (WLWB 2021). This aligns with the DSR frequency suggested by the CDA for dikes with a consequence classification of *Very High* (CDA 2013, Table 5-1). Based on this, a DSR was due to be conducted for the A418 Dike in 2022 which is the purpose of this report.

1.4 Limitations

This DSR report and its contents are intended for the sole use of DDMI and their agents. Tetra Tech does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the report when the report is used or relied upon by any Party other than DDMI, or for any Project other than the development at Diavik. Any such unauthorized use of this report is at the sole risk of the user. Use of this document is subject to the Limitations on Use of this Document attached in Appendix A.

Comments in this report are professional opinions, derived in accordance with current standards of professional practice based on Tetra Tech's engineering experience, judgement, and the information provided. Tetra Tech's review team has exercised usual and customary care in the conduct of its review but offers no warranties. The responsibility for the design, construction, maintenance, operation, and closure of the A418 Dike remains fully with DDMI and their consultants.

2.0 FACILITY DESCRIPTION

Diavik is a diamond mine located approximately 200 km south of the Arctic Circle and 300 km northeast of Yellowknife, NT (64°30' North, 110°20' West). The Mine is situated on East Island, a 17 km^2 island at the bottom of Lac de Gras. Lac de Gras is the headwater of the Coppermine River, which drains northwards into the Arctic Ocean at Coronation Gulf. Diavik is located above the treeline in a region of *Continuous* permafrost.

The Mine has been operating since 2003 and is serviced by air at the Diavik Aerodrome (DVK) and by land via the seasonal Tibbitt to Contwoyto Winter Road. Diavik comprises three open pits for mining (both open pit and underground) four kimberlite pipes: A154 (A154N and A154S), A418, and A21. Each open pit is partially surrounded by a water retention dike located in Lac de Gras off the shore of the East Island.

The A154 Open Pit is located at the northeast corner of the Mine and is separated from Lac de Gras by the A154 Dike. The A418 Open Pit is located directly south of the A154 Open Pit and is separated from the lake by the A418 Dike, which abuts the A154 Dike at its north end. The A21 Open Pit is located at the south end of the Mine and is separated from Lac de Gras by the A21 Dike. Construction of the A154, A418, and A21 water retention dikes was completed in 2002, 2006, and 2018, respectively.

2.1 Site Conditions

2.1.1 Climate

Diavik is located within a subarctic climate region (Köppen Climate Classification: *Dfc*), characterized by long, cold winters and short, cool summers. Daylight hours range between 4 hours/day in the winter and 20 hours/day in the summer. The Diavik meteorological station, operated by DDMI, shows a mean annual air temperature of -8.4°C, with the coldest month (January) having a typical temperature of -27°C and the warmest month (July) having a typical temperature of +13°C.

In 2021, a climate analysis update was completed for the Mine based on data collected up to 2019 from the Diavik meteorological station (Golder 2021). Updated climate parameters for rainfall, snowfall, precipitation, potential snowmelt depth, probable maximum flood depth, temperature, and wind can be found in the 2021 climate analysis update.

2.1.2 Topography and Lakes

The topography around Diavik is characterized by a large number of shallow lakes with low hummocky terrain. The Mine is located north of the treeline in a subarctic tundra environment. Prior to the development of Diavik, East Island had a relatively flat topography ranging between approximately 415 m along the Lac de Gras shoreline to approximately 435 m.

Lac de Gras covers an area of approximately 580 km^2 with an average depth of approximately 15 m and a watershed area of approximately 3,980 km^2. Water levels within the lake generally fluctuate between 415.5 m and 416.0 m in elevation during normal conditions.

2.1.3 Geology

Diavik is located in the centre of the Slave Geological Province of the Canadian Shield, which hosts the largest area of Archean rocks. Geology in the area typically includes three principal units: lakebed sediments, glacial till, and bedrock. Lakebed sediments typically consist of fine-grained soils ranging from silt to silty clay. Sediments are typically non-plastic and have very low organic content.

Glacial till typically underlies the lakebed sediments. The till was deposited during glacial retreat (i.e., ablation till) and consists of an unsorted deposit with grain sizes ranging from clay-sized particles to boulders. Tills predominantly consist of sandy silts with some gravels. In some areas, fines (silts and clays) content is lower near the upper surface of the Glacial Till, indicating a period of glaciofluvial action prior to the formation of Lac de Gras. The thickness of the till layer is generally controlled by its undulating contact with the underlying bedrock.

The bedrock units at Diavik mainly consist of rock from the Archean, Proterozoic, or Eocene geological periods. Bedrock is primarily composed of three main lithological units:

1. Greywacke-Mudstone Metaturbidites (metasedimentary rock);
2. Biotite-Hornblend Tonalites to Quartz Diorites (diorite); and
3. Mica Granites and Suites (granite to granodiorite).

The Mica granite and granodiorite rocks are concentrated in the northern area of East Island, the metasedimentary rocks are located within an east-west running central area of the island, and the diorites are situated in the southern area of the island.

2.1.4 Permafrost

Diavik is located within a zone of *Continuous* permafrost, meaning that 90% to 100% of land area is expected to be underlain by permafrost (NRC 2009). The Mine is approximately 100 km north of the northern limit of *Extensive Discontinuous* permafrost (i.e., 50% to 90% of land area underlain by permafrost). The presence of snow, organic matter, or nearby lakes impacts the ground thermal regime. Lac de Gras acts as a significant heat source, preventing freezing of ground in most submerged areas; however, permafrost does exist below shallow areas of the lake, where water is less than approximately 2 m deep.

Typical permafrost depths measured under various islands in Lac de Gras range from 60 m to 100 m, while the permafrost under East Island has been measured at 380 m thick. Inland areas of East Island are underlain by permafrost to a maximum depth of approximately 150 m (BGC 2014). Minor and local areas of patterned ground have been identified on East Island.

The seasonal active layer in the vicinity of the Mine typically ranges from 1.5 m to 2.0 m deep in glacial till deposits, 2.0 m to 3.0 m deep in well-drained granular deposits (e.g., eskers), and up to 5.0 m deep in bedrock. In poorly drained areas (e.g., bogs), the active layer is less than 1.0 m in depth (DDMI 2019).

Ground temperature data indicates a range of mean annual ground temperatures from approximately -3°C to -6°C, depending on the instrumentation's location relative to Lac de Gras, surface cover, and stratigraphy. The data shows that the depth of permafrost decreases and ground temperatures increase towards Lac de Gras, with a talik below the lake itself (i.e., an area of unfrozen ground beneath the lake).

2.1.5 Seismicity

Seismicity at Diavik is relatively low and no active faults have been identified in the vicinity of the Mine. Seismic hazard values for Diavik were obtained from Earthquakes Canada, using the 2020 National Building Code of Canada Seismic Hazard Tool, and are included in Appendix B. Seismic hazard values for the Mine, including peak ground accelerations (PGA) and the annual exceedance probability (AEP) for Site Class C, are summarized in Table 2-1.

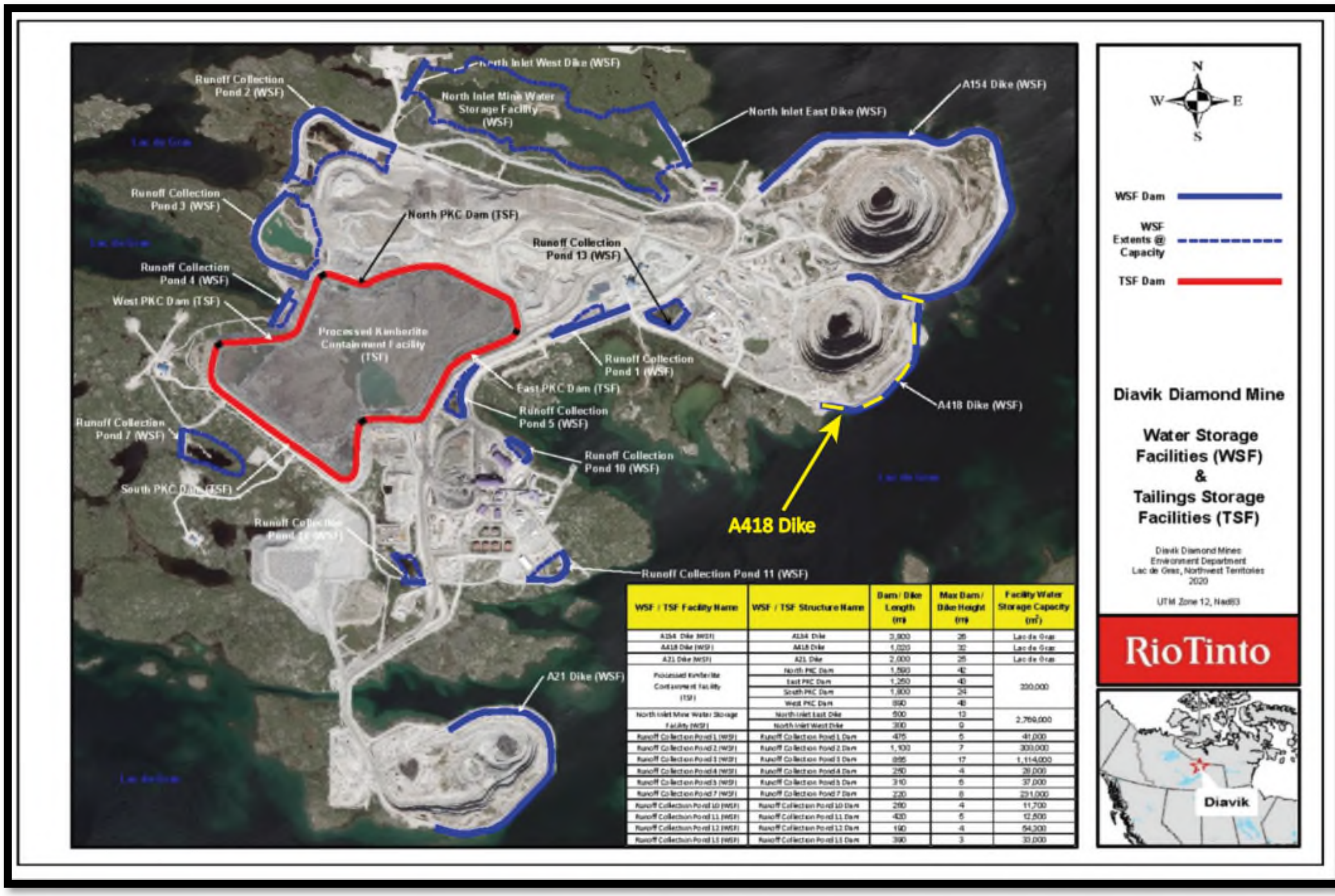
Table 2-1: Diavik Seismic Hazard Values

Return Period (years)	Probability of Exceedance in 50 Years (%)	Peak Ground Acceleration (g)	S_a (0.2) (g)
475 Years	10	0.0113	0.0247
1,000 Years	5	0.0205	0.0436
2,475 Years	2	0.0409	0.0832

Seismic Hazard Values shown for Site Class C obtained from Earthquakes Canada's 2020 National Building Code of Canada Seismic Hazard Tool.

2.2 A418 Dike Description

The A418 Dike is a water retaining structure designed to enable dewatering of the A418 kimberlite pipe, via separation from the adjacent Lac de Gras, and allow for open pit and underground mining. It is located on the east side of the Mine, directly south of the A154 Dike, as shown on Figure 2-1.



WSF / TSF Facility Name	WSF / TSF Structure Name	Dam / Dike Length (m)	Max Dam / Dike Height (m)	Facility Water Storage Capacity (m³)
A154 Dike (WSF)	A154 Dike	3,900	28	Lac de Gras
A418 Dike (WSF)	A418 Dike	1,020	32	Lac de Gras
A21 Dike (WSF)	A21 Dike	2,000	25	Lac de Gras
Processed Kimberlite Containment Facility (TSF)	North PKC Dam	1,590	42	330,000
	East PKC Dam	1,250	40	
	South PKC Dam	1,800	24	
	West PKC Dam	890	48	
North Inlet Mine Water Storage Facility (WSF)	North Inlet East Dike	500	13	2,769,000
	North Inlet West Dike	300	9	
Runoff Collection Pond 1 (WSF)	Runoff Collection Pond 1 Dam	475	5	41,000
Runoff Collection Pond 2 (WSF)	Runoff Collection Pond 2 Dam	1,100	7	303,000
Runoff Collection Pond 3 (WSF)	Runoff Collection Pond 3 Dam	895	17	1,114,000
Runoff Collection Pond 4 (WSF)	Runoff Collection Pond 4 Dam	250	4	28,000
Runoff Collection Pond 5 (WSF)	Runoff Collection Pond 5 Dam	310	6	37,000
Runoff Collection Pond 7 (WSF)	Runoff Collection Pond 7 Dam	220	8	231,000
Runoff Collection Pond 10 (WSF)	Runoff Collection Pond 10 Dam	280	4	11,700
Runoff Collection Pond 11 (WSF)	Runoff Collection Pond 11 Dam	420	5	12,500
Runoff Collection Pond 12 (WSF)	Runoff Collection Pond 12 Dam	190	4	54,300
Runoff Collection Pond 13 (WSF)	Runoff Collection Pond 13 Dam	390	3	33,000

Figure 2-1: Mine Site Plan (DDMI 2022a)

The dike is a crescent-shaped structure that trends northeast-southwest, abutting with the A154 Dike at its north end and the East Island at is south end, as shown on Figure 2-2. An island in Lac de Gras (Island C) was incorporated into the profile of the A418 Dike.

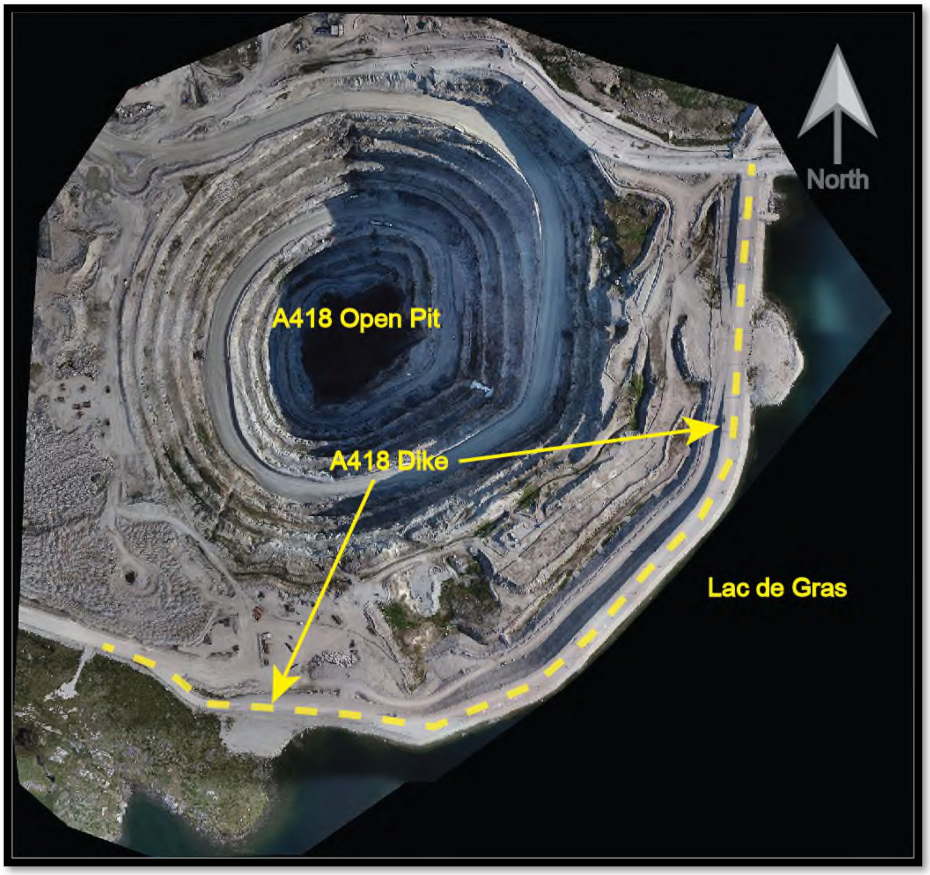


Figure 2-2: A418 Dike Site Plan (DDMI 2022a)

A418 Dike as-built drawings (DDMI 2022b), illustrating the dike's configuration and dimensions, are provided in Appendix C for reference.

2.2.1 Design Summary

The A418 Dike is a zoned rockfill embankment structure with a central cutoff wall comprised of a plastic concrete diaphragm wall with jet grout columns anchored into bedrock and a grout curtain. The dike's primary function is to separate the A418 kimberlite pipe from Lac de Gras to allow for mining; therefore, the structure does not have a spillway. The area separated from Lac de Gras by the A418 Dike is approximately 55 hectares, including areas that were dry land prior to mining.

Design of the A418 Dike was conducted between December 2003 and July 2004 (NKSL 2004a). The dike's design approach is identical to what was adopted for the A154 Dike, while improving on the experience from construction and operation of that structure. Key design parameters for the structure are summarized in Table 2-2.

Table 2-2: A418 Dike Key Design Parameters

Dike Feature	Detail
Type of Structure	Rockfill Embankment with Central Cutoff Wall
Maximum Height	32.0 m
Crest Elevation	+421.0 m
Crest Width	25.0 m
Crest Length	1,291 m
Upstream Slope Gradient	1.6H:1V
Downstream Slope Gradient	1.7H:1V
Containment Elevation	+417.5 m
Type of Containment	Composite Cutoff Wall (Plastic Concrete Diaphragm with Jet Grouting)
Fill Quantity	1,000,000 m^3
Dredge Quantity	114,000 m^3
Excavation of Unfrozen Overburden Material	39,000 m^3
Excavation of Frozen Overburden Material	4,000 m^3
Area of Cutoff Wall	18,000 m^2

Table adopted from Table 1.1 of Detailed Design of Dike A418 Final Design Report (NKSL 2004a).

The dike's embankment consists of a central core of 56 mm minus crushed aggregate (Zone 1) covered on the downstream side by a zone of 200 mm minus crushed rock (Zone 2) and on the upstream side by a zone of 900 mm minus rockfill (Zone 3). A filtering layer of 56 mm minus crushed rock was located between Zone 2 and the dike's foundation, which connects to the dike's central core. Toe berms, containing toe drains, were designed in various places along the dike's alignment and consists of a layer of Zone 1 material, overlain by the Zone 2 material, overlain by the Zone 3 material.

Containment for the A418 Dike is provided by a seepage cutoff wall consisting of a plastic concrete diaphragm with jet grout columns anchored into bedrock and a grout curtain. The plastic concrete diaphragm is located within the central zone of the embankment and extends from an elevation of +417.5 m into the dike's foundation soils. The cutoff wall is then continued into bedrock using jet grout columns, which contribute to reducing seepage and uplift pressures.

2.2.2 Construction Summary

Construction of the A418 Dike began in 2005 and was completed in 2006 (SLI 2021). The dike's construction generally consisted of the following tasks:

- Foundation preparation along the dike alignment, including dredging and removal of lakebed sediments as well as on-land excavations;
- Material placement of embankment fill materials in Lac de Gras to an elevation of +417.5 m;
- Vibro densification (compaction) of the central zone's embankment fill materials;
- Material placement of embankment fill materials to an elevation of +419.0 m;

- Installation of the central cutoff wall, including the plastic concrete diaphragm wall with jet grout columns and a grout curtain;
- Material placement of embankment fill materials to a final crest elevation of +421.0 m;
- Installation of thermosyphons at areas of contact between the central cutoff wall and the dike's abutments;
- Dewatering of the area inside the dike;
- Construction of the toe drains and berms; and
- Installation of the dike's instrumentation and pumping system.

The A418 Dike was largely constructed according to design with the exception of some modifications made to the dike's foundation design. Due to the subsurface conditions encountered during construction, the following modifications were made to the A418 Dike design:

- The dike's foundation was dredged prior to embankment placement to remove lakebed sediments and provide a competent foundation. Dredging on the upstream side of the dike was difficult as pockets of sediment continually flowed into the dredged areas. As a result, embankment fill placement was advanced from the downstream direction to "squeeze" the lakebed sediments away from the dike.
- Bedrock at the southwest abutment contained a highly transmissive, silt-filled decompression joint. Construction crews had difficulties sealing the joint and closing the grout curtain; however, a seal was eventually made using both single-fluid jet grouting and pressure grouting techniques.

Following foundation preparation and initial material placement, the central zone of the dike was compacted using vibro compaction methods. Jet grouting was completed beneath the diaphragm wall to a minimum depth of: 75% of the hydraulic head at the top of the grout column or 15 m, whichever was greater. The purpose of the jet grouting was to anchor the plastic concrete wall to the underlying bedrock and to fill joints within the bedrock below the anchored cutoff wall.

The dike's foundation soils under the lake were unfrozen, whereas on-land areas contained permafrost soils/rock. To mitigate against the potential for permafrost degradation on land, thermosyphons were installed in the abutments and island shores to artificially freeze the area of contact between the cutoff wall and the natural ground. Thermosyphons were installed in the following locations:

- North Abutment with the A154 Dike (near Station 0+80);
- Island C North Abutment (near Station 0+150);
- Island C South Abutment (near Station 0+350); and
- South Abutment with East Island (near Station 1+000).

2.2.3 Water Management

The A418 Dike separates the A418 mining works from a significant body of water (Lac de Gras) and, as such, several water management systems are in place to collect and dispose of seepage and runoff water from downstream of the structure. After initial dewatering of the mining area, perforated drains were installed along the toe of the dike and a Dike Pumping Station (DPS) was installed at a low elevation along the alignment. DPS-6 consists of an operating pump and standby pump that withdraw water from a heated sump located near

Station 0+880. It pumps water to the North Inlet Water Storage Facility (NIWSF) via a heat-traced pipeline installed along the toe berm of the dike. The system manages seepage and surface runoff from the A418 Dike including:

- Seepage through the dike is collected by the structure's toe drain and flows via pipes to DPS-6;
- Seepage beneath the dike, which reports to the surface between the toe of the structure and the open pit, is conveyed to the DPS-6 via open drainage ditches; and
- Surface runoff from the A154 Dike and the area between the structure and the open pit is conveyed to an downstream pond near Station 0+010 and pumped to DPS-6 via a surface pipeline.

The seepage and surface runoff generated from the A418 open pit and underground mining works are transferred to the NIWSF and eventually to the North Inlet Water Treatment Plant (NIWTP) for treatment prior to discharge to Lac de Gras. The A418 Dike's DPS-6 is designed to operate automatically and operations are monitored at the NIWTP for faults and high-level alarms. Flow rates from the DPS are monitored via flow meters at the NIWTP which are then recorded and tracked by DDMI.

The A418 pit dewatering systems are designed to handle maximum inflows from a 1/200-year return period. Ramp sumps are excavated and maintained with adequate freeboard to accommodate system breakdowns and maximum inflow events. In the unlikely event that in-pit sumps were overtopped or were inoperable for an extended period of time, the sump could overflow. Flooding within the A418 Open Pit would drain into the underground mine workings where it would be transferred to the surface using the underground pumping infrastructure.

In 2007, a series of 24 relief wells were installed within the embankment of the A418 Dike to reduce foundation porewater pressures. The relief wells were installed along the crest of the dike as well as the crest of the toe berm. Water collected by the relief wells is disposed by the DPS via the same methods described above. In 2010, groundwater flow into the A418 Open Pit reduced significantly as underground dewatering increased. Currently, no open pit dewatering is required in the A418 Open Pit.

During 2017, a series of four depressurization wells were installed along the south-east quadrant of the A418 mining works, between the open pit and the A418 Dike. Pumping commenced from these wells in December 2017. Drawdown from these depressurization wells has been recorded by all the piezometers associated with monitoring the A418 Dike.

3.0 ROLES AND RESPONSIBILITIES

The staff responsible for the A418 Dike's planning, operation, maintenance, and surveillance are identified in Diavik's *North Inlet (NI), A21, A154 & A418 Dikes OMS Manual* (DDMI 2022b). The Operations, Maintenance, and Surveillance (OMS) Manual outlines the various roles, responsibilities, and authority for the DDMI team involved with management of the A418 Dike.

DDMI is the Dam Owner of the A418 Dike and holds overall responsibility for the safety of the structure. Primary on-site responsibility for the dike resides with DDMI's Technical Services department, including instrumentation and performance monitoring as well as overall technical management. DDMI's Infrastructure department are responsible for operating and maintaining the A418 Dike's DPS, Relief Wells, Pump Wells, and surface water control structures as well as the dike's thermosyphons, power distribution, and access roads. DDMI's Surface Mining department provides support for dike repairs, as needed. DDMI's Health, Safety, and Environment department are responsible for operating the NIWTP and monitoring water quality in the NIWSF.

SNC-Lavalin Inc. (SLI), formerly Nishi-Khon/SNC-Lavalin Limited (NKSL), is the Designer of Record (DOR) for the A418 Dike and currently employs the Engineer of Record (EOR). In 2017, NKSL ceased to be a legal entity and the DOR responsibilities were transferred to SLI. SLI regularly reviews the performance of the A418 Dike with DDMI and conducts an annual inspection and performance evaluation of the structure.

Following a review of Table 2-1 in the OMS Manual as well as interactions with DDMI staff, Tetra Tech have identified the following roles and responsibilities for the A418 Dike as presented in Table 3-1.

Table 3-1: Roles and Responsibilities for A418 Dike

Role in OMS Manual	Person (Company)	Responsibilities in OMS Manual
President and Chief Operating Officer	Angela Bigg (DDMI)	▪ Provides support for overall dike stewardship; and ▪ Ensures appropriate resources are in place for operation, maintenance, and surveillance of dike.
General Manager	Matthew Breen (DDMI)	▪ Overall operational authority; ▪ Oversees day-to-day operations of the dike; and ▪ Notifies DDMI and external authorities of a potential, imminent, or actual dike emergency.
Technical Services Manager	Mufaro Chivasa (DDMI)	▪ Oversees all DSRC and geotechnical-related activities for the dike; and ▪ Implements dike stewardship in conformance with guidelines and adequate risk management.
Senior Dam Engineer (Surface Geotechnical)	Arthur Yeomans (DDMI)	▪ Provides geotechnical oversight of dike; ▪ Updates and implements DSRC; ▪ Monitors performance of dike; and ▪ Coordinates external inspections and review.
Senior Geotechnical Specialist (Surface Geotechnical)	Dan Guigon (DDMI)	▪ Ensures monitoring is carried out per DSRC; ▪ Coordinates instrumentation data collection; ▪ Identifies and coordinates dike maintenance; and ▪ Coordinates ongoing dike monitoring and maintenance.
NIWSF, A418, A154 Dike EOR	Benoit Mathieu (SLI)	▪ Reviews performance of dike and its related components; ▪ Conducts annual inspection of dike; and ▪ Updates DDMI on performance of dike.
Diavik Geotechnical Review Board	Paul Cicchini Richard Davidson Geoff Beale	▪ Provides external review, consultation, and opinion for dikes.

As a result of this DSR, including interactions with staff on site, Tetra Tech has the following comments regarding the Roles and Responsibilities for the A418 Dike:

- DDMI staff have a good understanding of their roles and responsibilities as they relate to the A418 Dike's DSRC;
- DDMI and SLI staff are well qualified to fulfill the roles and responsibilities as they relate to the A418 Dike's DSRC;
- DDMI have written agreements in place with SLI that identify the company as the DOR and Benoit Mathieu as the EOR for the A418 Dike; and

- In 2004, the Diavik Geotechnical Review Board (DGRB) was formed to provide independent external review and oversight during the design and construction of the A418 Dike. It consisted of three past members of the Diavik Dike Review Board, which was in place during the design and construction of the A154 Dike. The DGRB attends meetings, performs site inspections, and issues external review reports summarizing their findings and recommendations. Past members of the DGRB included Norbert Morgenstern, Andrew Robertson, and Zavis Zavodni and current members include Paul Cicchini, Richard Davidson, and Geoff Beale.

4.0 DOCUMENTATION REVIEW

The observations, conclusions, and recommendations provided in this DSR report are based on a review of the available documentation as well as the site inspection, staff engagement, and dam safety assessments undertaken. The A418 Dike documents provided to Tetra Tech by DDMI or accessed through the WLWB Public Registry for this DSR are listed below in Table 4-1.

Table 4-1: Documentation Reviewed for A418 Dike Dam Safety Review

Documentation Title	Date Issued	Reference	Key Information
Detailed Design of Dike A418 Final Design Report	November 2004	NKSL (2004a)	▪ Design Basis and Criteria ▪ Geotechnical, Geological, and Seismic Conditions ▪ Dike Design and Engineering Analysis ▪ Instrumentation ▪ Failure Modes and Response Analysis
Quality Assurance/Quality Control Plan for Construction of A418 Dike – Revision A	November 15, 2004	NKSL (2004b)	▪ Construction Methodology ▪ Construction Quality Assurance and Quality Control (QA/QC) ▪ Instrumentation Monitoring Procedures
Diavik Geotechnical Review Board Meeting June 28th to July 1st, 2004	November 10, 2004	DGRB (2004)	▪ Independent Technical Design Review
A418 Dam Safety Review DRAFT Report	November 2012	AMEC (2012)	▪ Past DSR Recommendations, Deficiencies, and Non-Conformances
A418 Dike Annual Inspection and Performance Evaluation	August 2015 to September 2021	NKSL (2015 to 2016); SLI (2017 to 2021)	▪ Dike Description ▪ Design Deviations ▪ Past Inspection Recommendations, Deficiencies, and Non-Conformances ▪ Instrumentation Monitoring Data and Analysis
2018 Dam Safety Review of the A418 Dike	October 29, 2018	Tetra Tech (2018)	▪ Past DSR Recommendations, Deficiencies, and Non-Conformances
Closure and Reclamation Plan – Version 4.1	December 2019	DDMI (2019)	▪ Dike Closure and Reclamation
Diavik Underground Mine – Inundation Plan Update	July 2020	DDMI (2020a)	▪ Inundation Scenarios ▪ Mine Pumping Systems and Scenarios
Business Resilience Management Plan – Revision 1	January 1, 2021	DDMI (2021a)	▪ Emergency Preparedness ▪ Risk Areas, Classifications, and Descriptions ▪ Incident Reporting Forms
Diavik Mine Site – Climate Analysis Update	May 21, 2021	Golder (2021)	▪ Climate Data

Table 4-1: Documentation Reviewed for A418 Dike Dam Safety Review

Documentation Title	Date Issued	Reference	Key Information
Type A Water Licence W2015L2-0001 (formerly W2007L2-0003, MV2005L2-0009, N7L2-1645)	June 8, 2021	WLWB (2021)	▪ Permits and Regulations Compliance ▪ Water Quality and Usage Criteria ▪ Water and Waste Management ▪ Aquatic Effects Monitoring ▪ Closure and Reclamation ▪ Engineering Standards
North Inlet (NI), A21, A154 & A418 Dykes Emergency Response Plan – Rev 1	September 2022	DDMI (2022a)	▪ Emergency Response Roles and Responsibilities ▪ Emergency Identification, Evaluation, and Classification ▪ Emergency Triggers, Actions, and Responses ▪ Emergency Notification Procedures and Contact Information
North Inlet (NI), A21, A154 & A418 Dikes OMS Manual – Rev 1	September 2022	DDMI (2022b)	▪ Dike Roles and Responsibilities ▪ Operational Procedures ▪ Maintenance Procedures ▪ Instrumentation and Monitoring ▪ Surveillance Requirements ▪ As-Built Drawings
Water Management Plan – Version 16	September 2022	DDMI (2022c)	▪ Dike Water Management System ▪ Site Water Balance ▪ Water Management Controls and Monitoring ▪ Water Management Contingency Measures

In addition to the documentation listed in Table 4-1, Tetra Tech was also provided with the following data files relevant to the A418 Dike:

- Diavik Large-Scale Failure Modes, Effects and Criticality Analysis on DDMI File *SHS FMEA 2020 Diavik_A21_A418_A154_Sept16_2020.xlsx* (DDMI 2020b);
- Diavik Qualitative Risk Analysis (Level 2) Workshop Record Sheet on DDMI File *RHMI-097-0812 R4 L2_Risk_Register_Geotech_20210922.xlsx* (DDMI 2021b);
- A418 Dike Inclinometers, Piezometers, and Thermistors Instrumentation Data on DDMI Files *A418 Inclos.zip*, *A418 Dike Piezo Grapher Plots.zip*, and *A418 Dike Thermistors.zip* (DDMI 2022d); and
- Diavik Aerodrome Weather Reports for August 8, 9, and 10, 2022.

5.0 SITE INSPECTION

A site inspection of the A418 Dike was undertaken by Nigel Goldup and Thomas Bradshaw of Tetra Tech on August 9 and 10, 2022. The scope of the visual assessment included inspecting the dike's abutments, crests, upstream slopes, downstream slopes, and downstream toe areas. Over the duration of the inspection, Nigel and Thomas were accompanied by DDMI's Dan Guignon (Senior Geotechnical Specialist) in the field. Weather conditions on August 9 were mainly sunny with light winds and air temperatures ranging from 19°C (high) to 11°C (low). Weather conditions on August 10 were mainly cloudy with short periods of light rain and temperatures ranging from 20°C (high) to 12°C (low).

Observations made during the site inspection of the A418 Dike are generally consistent with those described in the 2021 AIPE (SLI 2021). Appendix D presents photos and observations from Tetra Tech's site inspection. Tracked locations for the photos taken during the site inspection are shown in Figure 5-1.

Figure 5-1: Tracked Photo Locations from A418 Dike Site Inspection

Observations from the A418 Dike site inspection included:

- The dike structure was generally in good condition (Photos D1 to D8);
- Thermosyphon installations appear to be in good condition (Photos D9 to D12);
- DPS-6 appears to be working as intended (Photos D13 to D16). The DPS-6 downstream area appears to be a water management hub with water being discharged into the downstream pool from various sources. There is continued evidence of small sinkholes (up to 15 cm in diameter) at the base of the pond (Photo D14) which appear to represent the downward migration of fines into the coarser underlying material. No up flows of water

were observed during the site inspection which suggests they are not active sand boils. DDMI noted that these sinkholes have been monitored since 2009. DPS-6 was active and pumping during the site inspection;

- The infield pit depressurization wells appeared to be in good order and working (Photos D17 to D20);
- Downstream water collection appears to be well managed and is either diverted or pumped to DPS-6 (Photos D21 to D26). It was observed that:
  - There was sedimentation accumulation upstream of the ditch check dam near Station 0+450 (Photo D23) which has been monitored since 2016;
  - There were some small blisters of air and water found in the sediments at the base of ditch (Photo D25); and
  - There is a low point along the drainage channel, resulting in ponding near Station 0+650.
- A418 Dike instrumentation appears to be in good order and well maintained (Photos D27 to D40);
- It was noted that nine post construction in situ density evaluation test holes that were undertaken in 2016 along the upstream crest of the A418 Dike between Stations 0+550 and 0+850 (Photo D41);
- Two sections along the upstream slope were observed to be oversteepened due to wave erosion from Lac de Gras (Photo 42):
  - Between Stations 0+530 to 0+600, the bottom third of the upstream slope was oversteepened and near vertical as a result of wave erosion.
  - Between Stations 0+550 and 0+580, erosion protection material was not observed and appeared to be missing from the upstream slope; and
  - Between Stations 0+700 to 0+750, the bottom quarter of the upstream slope was oversteepened as a result of wave erosion.
- Thaw settlement was observed along upstream thermal berm near Station 0+100 (Photo D43); however, DDMI confirmed this feature has been observed and monitored since 2010;
- There is a partially blocked culvert along downstream water collection ditch near Station 0+800 (Photo D44);
- A downstream slope undulation was noted near Station 0+900 (Photo D45). Upon a review of historical photos, it was identified that this feature was present in 2007 (Photo D46) and appears to have not changed significantly over the last 15 years; and
- An area on the downstream slope appeared to have been regraded near Station 0+575 (Photo D47). Upon a review of historical photos, it was found that this feature was also noted in 2007 (Photo D48) and appears to have not changed significantly over the last 15 years.

6.0 STAFF ENGAGEMENT

6.1 Discussions with Site Staff

During and following the site inspection, Tetra Tech had valuable discussions and interactions with site staff from DDMI's Technical Services department. The following items were noted from past staff interviews and subsequent discussions with staff affiliated with the A418 Dike:

- DDMI has established a strong culture of safety and environmental protection and staff felt that there is good communication internally between the departments at Diavik;
- DDMI's Technical Services department is an experienced and knowledgeable geotechnical group involved with instrumentation and performance monitoring of the dike;
- DDMI's Technical Services department are familiar with the monitoring requirements of the dike, as outlined in Diavik's OMS Manual, and are able to adequately identify safety hazards, deficiencies, and non-conformances; and
- The A418 Dike's DOR and EOR both have long-standing involvement with Diavik's dikes and water management facilities.

6.2 Questionnaire

Tetra Tech prepared a questionnaire on various dam safety aspects of the A418 Dike and its associated infrastructure that was answered by DDMI staff involved in the operations, maintenance, and surveillance of the dike. The questions were prepared following guidance from the CDA including the *Dam Safety Guidelines* (CDA 2013) and *Technical Bulletin: Dam Safety Reviews* (CDA 2016). Tetra Tech's experience on dam safety and general understanding of the A418 Dike and its associated infrastructure were also used to prepare the questionnaire.

The intent of the questionnaire was to engage DDMI staff in the DSR process and document responses to questions on the A418 Dike's DSRC that were addressed during the site visit. The questionnaire was submitted to DDMI on October 7, 2022 and responses to the questions were received on October 25, 2022. The completed questionnaire is provided in Appendix E.

The responses to the questions and subsequent discussions demonstrated that the DDMI staff have an adequate understanding of the DSRC for the A418 Dike, with the following comments:

- Question 11. (Does DDMI maintain records of regular staff training? Is there an audit on current staff training?):
  - DDMI in response to Question 11 states that DDMI Technical Services department "job-specific training includes review of pertinent SOPs etc. there is no formal signoff"; however, a "more formal training program is currently under development". After submission of the questionnaire, Tetra Tech understands from follow-up discussions with DDMI that Dam Awareness Training has now been implemented for staff involved in the operations, maintenance, and surveillance of the A418 Dike;
- Question 24. (When did DDMI last test its ERP for the A418 Dike?):
  - DDMI noted that the exact date of the last ERP test for the A418 Dike is unknown as typically one emergency response test is conducted annually for one of Diavik's tailings or water management

structures; however, DDMI has not provided supporting documentation that a functional ERP test has been completed for the A418 Dike.

7.0 APPLICABLE DESIGN GUIDELINES

The CDA provides primary guidance for the design, construction, and monitoring of dams and dikes in Canada. Documents from the CDA that were referenced for this DSR of the A418 Dike are listed in Section 1.1 and the applicable design criteria is summarized in the following subsections.

7.1 Consequence Classification

A consequence classification system was developed by the CDA (2013) to categorize the consequences of a dam failure in terms of population at risk, loss of life, environmental and cultural values, and infrastructure and economic losses. The consequence classification of a dam is selected using the highest rating based on these types of loss. Consequences are considered incrementally to those that would have happened in the same event without failure of the dam. The CDA (2013) defines incremental consequence of failure as:

"The incremental consequences or damage that a dam failure might inflict on upstream areas, downstream areas, or on the dam itself, over and above any losses or damage that may have occurred in the same event or conditions had the dam not failed."

These consequence categories are applied to establish guidelines for some of the design parameters for a dam, such as the Inflow Design Flood (IDF) and Earthquake Design Ground Motion (EDGM), as well as the standard of care expected of owners. The CDA (2013) describes five consequence categories: Low, Significant, High, Very High, and Extreme as summarized in Table 7-1.

Table 7-1: Canadian Dam Association Consequence Classification Criteria

Consequence Classification	Population at Risk [1]	Loss of Life [2]	Environmental and Cultural Values Incremental Losses	Infrastructure and Economic Incremental Losses
Low	None	0	▪ Minimal short-term loss ▪ No long-term loss	▪ Low economic losses ▪ Area contains limited infrastructure or services
Significant	Temporary only	Unspecified	▪ No significant loss or deterioration of fish or wildlife habitat ▪ Loss of marginal habitat only ▪ Restoration or compensation in kind highly possible	▪ Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	≤ 10	▪ Significant loss or deterioration of *important* fish or wildlife habitat ▪ Restoration or compensation in kind highly possible	▪ High economic losses affecting infrastructure, public transportation, and commercial facilities
Very High	Permanent	≤ 100	▪ Significant loss or deterioration of *critical* fish or wildlife habitat ▪ Restoration or compensation in kind possible but impractical	▪ Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)

Table 7-1: Canadian Dam Association Consequence Classification Criteria

Consequence Classification	Population at Risk [1]	Loss of Life [2]	Environmental and Cultural Values Incremental Losses	Infrastructure and Economic Incremental Losses
Extreme	Permanent	> 100	▪ Major loss of *critical* fish or wildlife habitat ▪ Restoration or compensation in kind impossible	▪ Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Table adopted from Table 2-1 of Dam Safety Guidelines (CDA 2013).

[1] Definitions for Population at Risk:

None – There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary – People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent – The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (High, Very High, Extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

[2] Implications for Loss of Life:

Unspecified – The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

7.2 Failure Modes

Once a dam's hazards are identified and understood, the response of the dam must be assessed to identify the potential failure modes (PFM). Each PFM must be considered in the assessment of the consequences of dam failure because different failure modes can result in different consequences (CDA 2013).

A PFM of a dam describes how a component failure occurs to cause loss of system function. The CDA (2016) identifies three general categories that most PFMs fall within:

- *Overtopping* – dam fails by overtopping when inadequate freeboard leads to flow of water over the crest of the dam in an unintended manner;
- *Loss of Strength* – dam fails by loss of strength when there is inadequate internal resistance to hydraulic and other forces applied to the dam, foundations, and abutments; and
- *Contaminated Seepage* – release of contaminated seepage where impoundment or reservoir geochemistry is not compatible with the downstream environment.

Additionally, the CDA (2013) recommends that incremental losses from any PFMs should be evaluated for two scenarios:

1. *Sunny Day (i.e., fair weather, normal operations)* – sudden failure caused by internal erosion, piping, earthquake, operational error leading to overtopping, or another event; and
2. *Flood-Induced* – sudden failure caused by natural flooding of a greater magnitude than the dam can safely handle.

Typically for embankment dams, both overtopping and piping PFMs are considered when assigning a consequence classification. The simplest and most conservative procedures may be applied as a first approximation and more detailed analysis can be conducted, if necessary. The age of the dam also has an influence on the PFMs. After approximately the first five years following completion of final embankment geometry and filling, embankment dams are generally less likely to exhibit potentially serious problems (when also validated by performance monitoring measurement data); however, slow progressive processes, such as internal erosion, may occur, which can manifest themselves many years after initial impoundment.

7.3 Geotechnical Stability Criteria

CDA (2019) provides target levels related to minimum slope stability Factor of Safety (FS) for static and seismic loading conditions for dam analysis and assessment. The slope stability FS is the ratio of the forces resisting a slope failure to the forces driving a slope failure. A slope with a FS of 1.0 is at equilibrium (i.e., the forces causing slope movement are equal to the forces resisting slope movement). A FS of less than 1.0 indicates that the slope is marginally stable and likely deforming, and higher FS values indicate higher levels of stability. Minimum FS for dam slopes recommended by the CDA (2019) are provided in Table 7-2.

Table 7-2: Canadian Dam Association Target Factors of Safety for Geotechnical Stability

Loading Condition	Minimum Factor of Safety	Slope
During or at End of Construction	> 1.3	Typically Downstream
Long-Term (steady-state seepage, normal reservoir level)	1.5	Downstream
Full or Partial Rapid Drawdown	1.2 to 1.3	Upstream (where applicable)
Pseudo-Static	1.0	Upstream and Downstream
Post-Earthquake	1.2	Upstream and Downstream

Table adopted from Tables 3-4 and 3-5 of Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (CDA 2019).

7.4 Hydrological Criteria

Hydrological criteria for the design of mining dams and their associated facilities are provided by the CDA (2013) based on the dam's consequence classification. The IDF is the most severe inflow flood (peak, volume, shape, duration, timing) that mining dams must be designed for to ensure the integrity of the dam, either by storage and/or safe discharge (e.g., emergency spillway, pumping system). Applicable target levels for minimum AEP to be considered when developing design criteria for mining dam flood hazards are presented in Table 7-3.

Table 7-3: Canadian Dam Association Target Levels for Flood Hazards

Consequence Classification	Annual Exceedance Probability – Floods [1]	
	Construction, Operation, and Transition Phases (Active Care)	Closure Phase (Passive Care)
Low	1/100	1/1,000
Significant	Between 1/100 and 1/1,000 [2]	1/3 between 1/1,000 and PMF [3]
High	1/3 between 1/1,000 and PMF [3]	2/3 between 1/1,000 and PMF [3]
Very High	2/3 between 1/1,000 and PMF [3]	PMF [3]
Extreme	PMF [3]	PMF [3]

Table adopted from Tables 3-2 and 4-1 of Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (CDA 2019).
[1] Simple extrapolation of flood statistics beyond 10^{-3} AEP is not acceptable.
[2] Selected on basis of incremental flood analysis, exposure, and consequence of failure.
[3] Probable Maximum Flood (PMF) has no associated AEP.

7.5 Seismic Design Criteria

CDA (2019) provides target levels for seismic design criteria for mining dams based on the stage of the mine's life and the dam's consequence classification. The applicable target levels provide minimum AEP to be used when calculating earthquake hazards as presented in Table 7-4.

Table 7-4: Canadian Dam Association Target Levels for Earthquake Hazards

Consequence Classification	Annual Exceedance Probability – Earthquakes	
	Construction, Operation, and Transition Phases (Active Care)	Closure Phase (Passive Care)
Low	1/100	1/1,000
Significant	Between 1/100 and 1/1,000	1/2,475
High	1/2,475	½ Between 1/2,475 and 1/10,000 or MCE
Very High	½ Between 1/2,475 and 1/10,000 or MCE	1/10,000 or MCE
Extreme	1/10,000 or MCE	1/10,000 or MCE

Table adopted from Tables 3-3 and 4-2 of Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams (CDA 2019).
[1] Mean values of the estimated range in AEP levels for earthquakes should be used. The earthquake with the AEP as defined above is then input as the contributory earthquake to develop the Earthquake Design Ground Motion parameters as described in Section 6.5 of the Dam Safety Guidelines (CDA 2013).
[2] This level has been selected for consistency with seismic design levels given in the National Building Code of Canada (NRCC 2015).
[3] Maximum Credible Earthquake (MCE) has no associated AEP.

The CDA does not specify what proportion of the PGA should be considered as a horizontal seismic coefficient to represent the horizontal seismic load; however, it is standard industry practice to consider either:

- A proportion of the PGA, for which a FS of 1.0 in the pseudo-static analysis represents an acceptable level of displacement; or
- The full PGA, with an estimated magnitude of displacement that would occur, if the pseudo-static analysis indicates a FS less than 1.0.

8.0 DAM SAFETY ANALYSIS

Design criteria for the A418 Dike were listed in the 2004 detailed design report (NKSL 2004a), which noted the following objectives:

- *"Maintain adequate setback from the perimeter of the A418 open pit;*
- *Comply with state of the art design;*
- *Establish minimum required safety factors under various loading conditions according to all phases of mine development and operation;*
- *Minimize seepage consistent with cost-benefit analysis of foundation treatment; and*
- *Minimize environmental damage."*

As part of this DSR, Tetra Tech has reviewed the dam safety criteria for the A418 Dike, including design basis and design criteria, against current CDA guidelines. It should be noted that design of the dike was based on guidance from the 2000 *Canadian Dam Safety Guidelines*, which were current at the time. Findings from this DSR for the A418 Dike's dam safety criteria are outlined in the following subsections.

8.1 Dike Breach Analysis and Inundation Mapping Review

DDMI have prepared an inundation plan titled *Diavik Underground Mine – Inundation Plan Update* (DDMI 2020a) for all three dike structures at Diavik, including the A418 Dike. It defines a dike breach as "*a breach in the dike itself or its foundation, which results in direct connection to Lac de Gras, and very large or rapidly increasing uncontrolled releases of water from the lake through the dike into the pit*". It is understood from follow-up discussions with DDMI, that an updated inundation plan entitled *The Diavik D1.6 Inundation Management Plan* has recently been completed; however, this was not reviewed as part of this DSR.

A significant breach of the A418 Dike would flood the A418 open pit and underground mining works with inflowing water from Lac de Gras. Flows resulting from a breach in the dike have the potential to cause loss of life, equipment, and infrastructure as well as damage to DDMI's reputation.

Inundation mapping for breach scenarios of the A418 Dike are unnecessary as the A418 Open Pit is immediately downstream. In the event of a dike breach, Lac de Gras waters would flood into the A418 Open Pit as opposed to outwards into the surrounding environment; therefore, it is anticipated that the impacts would be limited to DDMI as no public or external stakeholders are located downstream.

8.2 Consequence Classification Review

The A418 Dike is currently assigned a CDA consequence classification of *Very High* based on the 2004 detailed design (NKSL 2004a), which used the consequence classification scheme from the 2000 *Canadian Dam Safety Guidelines*. Current CDA (2013) guidance on consequence classification is summarized in Section 7.2.1.

The consequence classification for the A418 Dike was reviewed during the 2012 DSR (AMEC 2012) and the 2018 DSR (Tetra Tech 2018). Both DSRs concluded that *Very High* is an appropriate consequence classification and found no need for revision. Tetra Tech reviewed the basis for this consequence classification and notes the following:

- **Population at Risk** – No permanent populations currently exist within the likely inundation areas downstream of the A418 Dike. Inundation mapping was not available for a possible breach of the structure; however, this would most likely flood the open pit and underground mining works as well as the surrounding infield area. Based on this, Tetra Tech would classify the Population at Risk as *Temporary only* which corresponds to a consequence classification of *Significant*.
- **Loss of Life** – As noted in the above Population at Risk assessment, no permanent populations exist within the inundation areas downstream of the A418 Dike; however, there are open pit and underground mining works that are expected to contain personnel and would be flooded in the event of a dike breach. Therefore, Tetra Tech estimates the Loss of Life to be between 10 and 100 personnel (i.e., ≤ *100*) which corresponds to a consequence classification of *Very High*.
- **Environmental and Cultural Losses** – The A418 Dike is the structural and hydraulic divide between the A418 Open Pit and Lac de Gras. A breach of the A418 Dike would likely allow waters from Lac de Gras to flood the open pit and underground mining works. On the basis that Lac de Gras would expand into the open pit area, the environmental impact on Lac de Gras will likely be low. Cultural losses would not be expected as the flooded area would only impact the existing mining works. Based on this, Tetra Tech would classify the Environmental and Cultural Losses as *Significant*.
- **Infrastructure and Economic Losses** – The A418 open pit and underground mine is an important resource for Diavik and consequences from breach of the A418 Dike would result in significant direct costs to DDMI for environmental restoration and other economic impacts (e.g., possible loss of the resource, delays in production, damage to infrastructure). Accordingly, Tetra Tech would assign a minimum classification of *High* for Infrastructure and Economic Losses.

In summary, Tetra Tech agrees with the overall CDA consequence classification of *Very High* that is currently assigned to the A418 Dike and found no need for revision. It should be noted that the consequence of dam failure and the consequence classification of a structure can change if it is raised, if there are substantial changes to the downstream environment, or if there are any other regulatory drivers (CDA 2019).

Tetra Tech understands that fine processed kimberlite (FPK) from Diavik's Process Plant will be deposited into the A418 mine workings (open pit and underground) starting in 2023 until the end of mine life in the first quarter of 2026, which represents a substantial change to the dike's downstream environment. Accordingly, it is recommended that DDMI, in consultation with the DOR, review the CDA Consequence Classification for the A418 Dike with respect to the planned change in downstream conditions.

8.3 Failure Modes Review

A failure modes and response analysis was undertaken for the A418 Dike as part of the 2004 detailed design (NKSL 2004a, Section 14). The analysis reviewed and identified PFMs for three phases of the dike's life: construction, initial dewatering, and operation. For each PFM scenario, the following information was identified:

- Trigger Events;
- Consequences;
- Remedial Measures; and
- Mitigative Measures.

More recently, DDMI has developed and maintained a site-wide Failure Modes and Effects Assessment (FMEA) for Diavik's dike facilities, which was last updated in September 2020 (DDMI 2020b). The FMEA identifies assumptions, stakeholders, objectives, success factors, and threats for each dike facility. The following PFMs were identified in the FMEA for the A418 Dike and its mining works:

- West Wedge;
- 210 Bench Contact Wall Failure;
- Contact Zone Failure;
- Unfavourable Metasediments (above and below haul ramp);
- High Porewater Pressures in Southeast Wall;
- MK1 and MK2 North Wall Wedge; and
- Lydon's Fault.

Tetra Tech reviewed the FMEA updated in 2020 and found it generally identifies and addresses the PFMs for the A418 mine workings; however, additional PFMs pertaining specifically to failure (breach) of the A418 Dike should be included. Operational PFMs identified in the 2004 final design should be incorporated into the current FMEA. Additionally, Tetra Tech has identified the following PFMs considered applicable to the A418 Dike:

- Overtopping:
  - Inadequate freeboard due to wind-wave dissipation (e.g., wave action exceeding dike crest); and
  - Inadequate freeboard due to excessive water levels in Lac de Gras (e.g., historical flood event).
- Loss of Strength:
  - Inadequate stability under applied loads due to mass movements:
    - Stability (e.g., increased slope movements inconsistent with expected trends);
    - Displacement (e.g., increased settlements inconsistent with expected trends);
    - Erosion (e.g., loss of dike structure due to erosion); and
    - Seismic Resistance.
  - Inadequate stability under applied loads due to loss of support:
    - Abutment failure (e.g., degradation of permafrost soils at abutments); and
    - Foundation failure (e.g., increased or rebounding porewater pressures in foundation).
  - Inadequate durability and cracking resistance due to instantaneous change of state:
    - Hydraulic fracturing (e.g., erosion of joint filling in bedrock); and
    - Seismic cracking or liquefaction.

- Inadequate durability and cracking resistance due to structural weakening:
  - Internal erosion (e.g., piping through dike core); and
  - Cutoff wall failure (e.g., cracking due to frost heave).
- Inadequate watertightness:
  - Through-dam seepage control failure (e.g., DPS failure); and
  - Seepage around interfaces (e.g., through abutments, cutoff wall, buried conduits or pipes).

Tetra Tech recommends that DDMI, in consultation with the EOR, review and update the FMEA to capture the PFMs identified in the 2004 final design (NKSL 2004a, Figure 14.1) as well as any recent changes to the A418 Dike's condition since the FMEA was last updated in September 2020. This recommendation has been carried forward to this DSR (see Section 13.1) and should consider the above PFMs.

8.4 Dike Performance Evaluation Based on Surveillance

Active instrumentation monitoring and visual performance inspections of the A418 Dike are undertaken by DDMI's Technical Services department and the DOR on a regular basis. The dike is equipped with a comprehensive instrumentation system that was installed as part of the original construction and includes:

- 85 vibrating wire piezometers (VWP) distributed at 20 locations along the dike;
- 20 relief wells to indicate porewater pressure levels, including 12 installed along the dike's crest and 8 along the toe berm;
- 4 Casagrande piezometers in the form of small diameter pump wells;
- 7 slope inclinometers, including 6 installed in the cutoff wall and 1 installed in the deepest part of the toe berm;
- 98 survey markers on the dike's crest and toe berm; and
- 52 thermistor strings, including 5 installed in the cutoff wall, 45 installed in the dike's fill and downstream foundation, and 2 installed near the dike toe.

Additionally, numerous visual inspections are undertaken as part of the performance monitoring of the A418 Dike and comprise:

- Weekly Visual Inspections;
- Detailed Walkover Inspections;
- Rapid Motorized Inspections;
- Annual Inspections and Performance Evaluations; and
- Third-Party Dam Safety Review Inspections.

The following subsections evaluate the performance of the A418 Dike based on the surveillance the instrumentation and performance monitoring items reviewed in this DSR.

8.4.1 Porewater Pressures

The original construction included the installation of 85 VWPs at 20 locations along the A418 Dike. The following is a short summary of the existing piezometric conditions based on the instrumentation data supplied to Tetra Tech (DDMI 2022d).

- **Station 0+075:**
  - The downstream VWP *V071* continues to show a gradually increasing water elevation which could be in question as the piezometer is reportedly frozen; and
  - The downstream VWP *V072* is also frozen and continues to show a decreasing water elevation.
- **Station 0+110:**
  - A significant increase in water elevation was recorded between July 2015 and July 2017 but since then the water elevations have since stabilized and both VWPs (*V101* and *V102*) are reported to be frozen.
- **Station 0+400, Station 0+450, and Station 0+500:**
  - The downstream piezometers along these sections are reported as being stable and dry.
- **Station 0+550**:
  - This section contains VWPs installed both upstream and downstream of the dike's cutoff wall;
  - Both the upstream and downstream VWPs show a downward hydraulic gradient with an approximate 12 m head difference across the cutoff wall;
  - The near cutoff wall downstream VWPs showed an increase in downstream hydraulic gradient after commencement of pumping from the pit edge depressurization wells in late 2017; and
  - The VWPs have remained stable after installation and pumping commenced from the pit edge depressurization wells in late 2017.
- **Station 0+600:**
  - The near cutoff wall downstream VWPs showed an increase in downstream hydraulic gradient after commencement of pumping from the pit edge depressurization wells in late 2017;
  - The downstream VWPs have remained stable after installation and pumping commenced from the pit edge depressurization wells in late 2017; and
  - All of the VWPs along this section are currently reported as being dry.
- **Station 0+650:**
  - The downstream VWPs have remained stable after installation and pumping from the pit edge depressurization wells commenced in late 2017; and
  - All of the VWPs along this section are currently reported as being dry and/or frozen.

- **Station 0+700:**
  - The near cutoff wall downstream VWPs showed an increase in downstream hydraulic gradient after commencement of pumping from the pit edge depressurization wells in late 2017;
  - Most of the downstream VWPs have remained stable after installation and pumping from the pit edge depressurization wells commenced in late 2017; and
  - The downstream VWPs *V705* and *V706* located close to the downstream drainage ditch have been behaving erratically since the Winter 2013 and it is reported that these piezometers are currently frozen.
- **Station 0+750:**
  - This section contains VWPs installed both upstream and downstream of the dike cutoff wall;
  - Both the upstream and downstream VWPs show a downward hydraulic gradient with an approximate 8 m head difference across the cutoff wall just above the bedrock;
  - The near cutoff wall downstream VWPs showed a marked increase in downstream hydraulic gradient after commencement of pumping from the pit edge depressurization wells in late 2017. Since this date the VWPs have remained stable with seasonal fluctuations; and
  - The downstream VWPs *V753* and *V754* located close to the downstream drainage ditch have been behaving erratically since the winter of 2013 and it is reported that these VWPs are permanently frozen.
- **Station 0+800:**
  - The near cutoff wall downstream VWPs showed an increase in downstream hydraulic gradient after commencement of pumping from the pit edge depressurization wells in late 2017 and have generally remained stable since this date; and
  - The downstream VWPs *V803* and *V804* located close to the downstream drainage ditch have been behaving erratically since July 2020 and June 2019 respectively. It is reported that these VWPs are permanently frozen.
- **Station 0+835:**
  - The downstream VWPs have remained stable after installation and pumping commenced from the pit edge depressurization wells which commenced in late 2017.
- **Station 0+845:**
  - The one downstream VWP is reported as being stable and dry.
- **Station 0+850:**
  - The downstream VWPs have remained generally stable after installation and pumping commenced from the pit edge depressurization wells in late 2017; and
  - Since 2019, seasonal increases in water elevation (approximately 2 m) appear to be associated with Spring Freshet.
- **Station 0+900:**
  - This section contains VWPs installed both upstream and downstream of the dike cutoff wall;

  - The upstream VWPs show a downward hydraulic gradient whereas the downstream VWPs show close to hydrostatic conditions, with an approximate 17 m head difference across the wall just above the bedrock; and
  - VWPs have remained mainly stable with seasonal fluctuations after installation and pumping commenced from the pit edge depressurization wells in late 2017.
- **Station 0+910:**
  - The downstream VWPs have remained generally stable with seasonal fluctuations after installation and pumping commenced from the pit edge depressurization wells in late 2017.
- **Station 0+925:**
  - The downstream VWPs have remained generally stable with seasonal fluctuations after installation and pumping commenced from the pit edge depressurization wells late 2017.
- **Station 0+935:**
  - This section contains VWPs installed both upstream and downstream of the dike cutoff wall;
  - Several of the upstream piezometers have been damaged including VWPs *V931*, *V932*, and *V933*; and
  - The near cutoff wall downstream VWPs showed an increase in downstream hydraulic gradient after commencement of pumping from the pit edge depressurization wells in late 2017. Since this date the VWPs have remained stable with seasonal fluctuations.
- **Station 0+950:**
  - The downstream VWPs have remained generally stable with seasonal fluctuations after installation and pumping commenced from the pit edge depressurization wells late 2017; and
  - VWP *V952* is dry.

In general, the following can be drawn from the provided piezometric monitoring data:

- VWPs are performing as expected apart from some of the shallow VWPs which are either frozen and/or dry;
- A clear hydraulic gradient increase was noted in a number of the dike's cross-sections, both upstream and downstream of the cutoff wall, due to pit edge depressurization pumping which began in December 2017; and
- Piezometric levels appear to be generally stabilizing since the pit edge depressurization pumping program began.

It should be noted that the influence of the open pit depressurization wells has resulted in a general lowering of the piezometric elevation in many of the VWPs installed upstream and downstream of the dike cutoff wall. As would be expected, the greatest influence has been recorded by the VWPs downstream of the cutoff wall. Accordingly, this has increased the hydraulic gradient (water head difference) across the cutoff wall, which increases the potential for seepage and seepage-related erosion. Therefore, it is critical that regular seepage monitoring continue to be undertaken in the dike's relief wells to identify any changes in seepage composition as recommended in the 2020 AIPE (SLI 2020).

It understood that the A418 mine workings will be used as a tailings storage facility (TSF) for FPK starting in 2023. Accordingly, when operating as a TSF it will be very important to continue to monitor the piezometric conditions. In fact, heightened monitoring may be required during this operational period as the tailings supernatant water may influence the existing piezometric regime. Also, stopping the operation of the depressurization wells could result in a sudden increase in hydraulic head in the dike's foundation. The next operational phase of converting the A418 mine workings into a TSF needs careful planning, design, and monitoring to ensure the facility "*continues to operate within the design parameters*" and should involve the DOR for the A418 Dike.

8.4.2 Inflows

Seepage inflows and surface runoff for the A418 Dike are collected, discharged, and monitored from DPS-6. The dike's toe drains which flow into the pumping station are not equipped with flow meters to track inflows. As a result, inflow rates are approximated from the DPS-6 pumping cycles which have been monitored since May 2013 (SLI 2021). Further details on the A418 Dike's seepage and surface water management system are provided in Section 2.2.3.

Tetra Tech reviewed weekly average pumped inflow rates from DPS-6 from the past five years, as provided in the 2021 AIPE (SLI 2021), and noted the following:

- High inflows during Spring Freshet (mid to late May) ranged from 5.1 L/s (2019) to 10.3 L/s (2021) over the past five years. Inflows were notably higher in 2020 and 2021 which corresponds to higher snowmelt and rainfall amounts during this period resulting in higher lake levels in Lac de Gras;
- Low inflows during End of Winter (mid to late April) can be up to 1.2 L/s; however, inflows have been too low to assess accurately in the past four years; and
- A418 Pit Depressurization Wells came online in December 2017 and one of the wells discharge directly into DPS-6. This lead to increased inflows in DPS-6, particularly during Spring Freshet; however, the discharge rates appear stable and have not increased over time.

The 2021 AIPE (SLI 2021) states that "the seepage reporting to DPS-6 is well within the pump capacity and design objectives of the pumping station". Tetra Tech concurs with this assessment and notes that weekly monitoring of the pumping rates from DPS-6 should continue to promote early detection of increased seepage inflows from the A418 Dike.

8.4.3 Deformations

Deformations in the A418 Dike are measured by inclinometers and survey markers installed along the dike's crest and toe berm. Recent data from the instruments was reviewed and is summarized in the following subsections.

8.4.3.1 Inclinometers

Six inclinometers were installed in the cutoff wall and anchored into the bedrock, and one was installed in the toe berm, to measure the magnitude and rate of vertical and horizontal deformation. Readings have been recorded once per year, typically in the summer.

Tetra Tech reviewed the latest instrumentation data provided for the inclinometers (DDMI 2022d). In general, the greatest deflections measured in the cutoff wall occurred during initial dewatering toward the downstream side. All inclinometers within the cutoff wall also display a reversal in movement, toward the upstream side, in an isolated segment typically between 5 m and 10 m depth. This may be attributed to the formation of ice in the downstream embankment pushing against the cutoff wall, as suggested in the 2021 AIPE (SLI 2021), and installation of thermistors in this area may provide a better understanding of the extent of the ice formations. In general, all inclinometers reviewed appear to be within the historic range of values and similar to past observations.

Observations of each inclinometer data set reviewed are summarized below:

- **Inclinometer *IN560* (Station 0+540):**
  - A maximum deformation of about 50 mm toward the downstream is observed at the crest;
  - A relative deformation of about 20 mm back toward the upstream direction is seen at about 7.5 m to 8.5 m depth. A relative deformation of about 10 mm toward the upstream is also seen at about 5.5 m depth;
  - Currently the profile appears to be consistent and comparable to past observations; and
  - Deformations appear to be negligible in the parallel axis.
- **Inclinometer *IN650* (Station 0+650):**
  - A deformation of about 40 mm toward the downstream is observed at the crest;
  - A maximum deformation of about 55 mm is seen at about 3.0 m depth from 2014, which has reduced by about 10 mm in the most recent reading;
  - A relative deformation of about 15 mm back toward the upstream direction is seen at about 6.5 m to 9.0 m depth;
  - Currently the profile appears to be consistent and comparable to past observations; and
  - A maximum deformation of about 15 mm is seen at about 2.5 m depth in the parallel axis, which is appears stable otherwise.
- **Inclinometer *IN720* (Station 0+725):**
  - A maximum deformation of about 110 mm toward the downstream is observed at the crest from the most recent reading;
  - A relative deformation of about 15 mm back toward the upstream direction is seen between 6.0 m to 9.0 m depth;
  - Currently the profile appears to be consistent and comparable to past observations; and
  - Deformations appear to be negligible in the parallel axis.
- **Inclinometer *IN820* (Station 0+825):**
  - The most recent data shows a deformation of about 75 mm toward the downstream at the crest;
  - A maximum deformation of about 87 mm toward the downstream is seen at about 3.0 m depth;
  - A relative deformation of about 20 mm back toward the upstream direction is seen between 5.0 m to 9.0 m depth;
  - Currently the profile appears to be consistent and comparable to past observations; and

  - A maximum deformation of about 30 mm is seen at the crest to about 2.0 m depth in the parallel axis, which is appears stable otherwise.

- **Inclinometer *IN890* (Station 0+888):**
  - The most recent data shows a deformation of about 127 mm toward the downstream at the crest;
  - A maximum deformation of about 135 mm toward the downstream is seen at about 3.0 m depth in the most recent reading;
  - A relative deformation of about 25 mm back toward the upstream direction is seen between 5.0 m to 8.0 m depth;
  - Currently the profile appears to be consistent and comparable to past observations;
  - Deformations appear to be negligible in the parallel axis.
- **Inclinometer *IN930* (Station 0+925):**
  - The most recent data shows a deformation of about 28 mm toward the downstream at the crest;
  - A maximum deformation of about 50 mm toward the downstream is seen at about 7.0 m depth, typically projected toward the upstream in all other inclinometers;
  - A relative deformation of about 15 mm back toward the upstream direction is seen between 8.0 m to 10.0 m depth;
  - Currently the profile appears to be consistent and comparable to past observations; and
  - A maximum deformation of about 25 mm is seen at the crest in the parallel axis, which is appears stable otherwise.

Data was not provided for Inclinometer *IN890B*, the inclinometer installed deep within the toe berm; however, the 2021 AIPE states that a bad telescopic joint, possibly pulled apart by frost heave, was discovered at a depth of 10.0 m, which had been causing swings in data of up to 50 mm in several directions (SLI 2021). A method to correct the situation was implemented by DDMI; however, while the data seemed to be reliable up to 2015, results were no longer plausible in 2016. Readings since August 2017 have stabilized to less than 30 mm the parallel and perpendicular axis.

8.4.3.2 Survey Markers

A total of 98 survey markers are installed along the A418 Dike including 35 along the downstream crest, 36 along the upstream crest, and 27 are installed along the downstream toe berm. Readings are taken annually with an automated system. Tetra Tech reviewed the survey data that was included in the 2021 AIPE (SLI 2021) and a summary is provided below:

- **Downstream Crest Survey Markers:**
  - Vertical Deformations:
    - The largest vertical deformations appear to have occurred during the initial dike dewatering;
    - The largest cumulative vertical deformation is approximately 160 mm at Station 0+872;

        - Slight upward movements are shown in the data between Stations 0+300 to 0+350 and Stations 0+975 to 1+200;
        - Data appears to be missing for Survey Marker *M0202* (Station 0+200) in 2021;
        - Data is not displayed for Survey Marker *M0102* (Station 0+100) in the dike profile graph; and
        - Data is not displayed for Survey Marker *M0972* in the individual survey marker graph.
    - Horizontal Deformations:
        - A maximum horizontal deformation of approximately 200 mm is shown at Station 0+872; and
        - A spike in all horizontal deformation measurements is seen in 2021, which appears to be due to a survey error.
- **Upstream Crest Survey Markers:**
    - Vertical Deformations:
        - The largest cumulative vertical deformation is approximately 87 mm at Station 0+721; and
        - Slight upward movements are shown in the data between Stations 0+200 to 0+400, Stations 0+975 to 1+000, and Stations 1+150 to 1+200.
    - Horizontal Deformations:
        - Horizontal deformation data for the upstream crest survey markers was not included in the 2021 AIPE, however, it was stated that the largest cumulative horizontal deformation is approximately 102 mm at Station 0+751; and
        - 2019 data appears to be erroneous, possibly due to survey error as data in 2020 and 2021 align with previous values.

Monitoring data for the survey markers installed along the A418 Dike's toe berm was not included or discussed in the 2021 AIPE; therefore, Tetra Tech was unable to review data for the survey markers installed along the toe berm.

8.4.4 Ground Temperatures

Ground temperatures for the A418 Dike are monitored through 52 thermistor strings, including 5 installed in the cutoff wall, 45 installed in the dike's fill and downstream foundation, and 2 installed near the dike toe. The monitoring goals for the thermistors include:

- Tracking the aggradation/degradation of permafrost;
- Evaluating the performance and efficiency of the thermosyphons;
- Providing advanced warning of potential seepage zones and instability due to thawing of frozen materials; and
- Validating the thermal analyses done for various areas of the dike.

Ground temperature readings have been generally collected once per month since the start of 2021. In previous years readings were recorded two to four times per month, and more frequently in the months following construction. Tetra Tech noted the following during review of the A418 Dike thermistor data:

- **North Abutment Thermistors:**
  - Frozen ground conditions have been achieved and maintained in the areas within and outside of the influence of the thermosyphons;
  - The temperature cycles contain both active and passive cooling periods and the effect of the thermosyphons is clearly visibly in the displayed data. A warming trend observed from 2014 to 2018 was ceased with active cooling from thermosyphons in the summer of 2018;
  - Warming trends are visible for some years but, overall, a general cooling trend since construction is observed; and
  - Some thermistor readings appear to be excluded as anomalous, including June 2016 (T080-1865, T0731-1863), October 2017 (T0831-1866), August 2019 (T0832-1867), and January 2021 (T0831-1866, T058-1896), among others.
- **Island C North and South Shore Thermistors:**
  - Frozen ground conditions have been achieved and maintained in the areas within and outside of the influence of the thermosyphons. Temperatures remain well below freezing for the length of the cables;
  - The temperature cycles contain both active and passive cooling periods and the effect of the thermosyphons is clearly visibly in the displayed data. A warming trend observed from 2014 to 2018 was ceased with active cooling from thermosyphons in the summer of 2018;
  - Some North Island C thermistor readings appear to be excluded as anomalous, including January 2016 (T183-1898), June 2021 (T1682-1874, T1681-1873, T170-1890, T1592-1871, T1591-1870, T162-1872, T155-1869), and April 2022 (T1682-1874, T1681-1873, T170-1890, T1592-1871, T1591-1870, T162-1872, T155-1869), among others; and
  - Some South Island C thermistor readings appear to be excluded as anomalous, including February 2016 (T329-1846), August 2017 (T341-1880), August 2019 (T3382-1879, T3282-1876), February 2020 (T3382-1879, T3282-1876), August 2020 (T329-1846), May 2020 (T341-1880), August 2021 (T314-1839, T308-1903), and April 2022 (T341-1880), among others.
- **South Abutment Thermistors:**
  - Frozen ground conditions have been achieved and maintained in the areas within and outside of the influence of the thermosyphons, though, lower beads on average are warmer than at the other abutments;
  - The temperature cycles contain both active and passive cooling periods and the effect of the thermosyphons is clearly visibly in the displayed data. A warming trend observed from 2014 to 2018 was ceased with active cooling from thermosyphons in the summer of 2018;
  - Since 2019, a slight warming trend is observed in the lower beads while a slight cooling trend is observed in the upper beads;
  - One bead (Bead #5 at +408.0 m) on Thermistor *T974-1881* at Station 0+998 appears to be defective and no readings have been recorded since installation; and
  - Some thermistor readings appear to be excluded as anomalous, including December 2015 (T978-1883), April 2016 (T1007-1908), July 2018 (T1017-1909, T1007-1908), June 2021 (T1007-1908, T1002-1907), November 2021 (T1002-1907), January 2022 (T988-1893, T978-1883), and February 2022 (T1017-1909).

- **Remaining Dike Thermistors:**
  - Bead #1 (at +416.0 m) on Thermistor *T1100-1912* at Station 1+100 appears to be defective and no readings have been included since November 2018;
  - Some thermistor readings appear to be excluded as anomalous, including in January 2017 (T775-1888), July 2018 (T1125-1913, T1100-1912, T1050-1910, and T900-1906), September 2018 (T1075-1718), October 2020 (T700-1905 and T560-1892), January 2022 (T900-1906), and February 2022 (T700-1905 and T560-1892), among others;
  - A sudden increase of temperatures is seen from July 2017 to June 2018 in Beads #4 through #11 (+398.0 m to +412.0 m) in Thermistor *T845-1842* at Station 0+845. These beads then show a cooling trend starting in June 2018;
  - A steady cooling trend is observed in Thermistor *T100-1897*, located in the channel between the North Abutment and Island C. Frozen conditions reached the deepest bead at +386.0 m and have remained frozen since July 2012;
  - Gradual cooling trends are observed in the lower beads of Thermistors *T775-1888* and *T525-1887* along the toe berm suggesting the ingress of freezing in the glacial till foundation is expanding at the toe of the dike;
  - Unfrozen conditions remain below approximately +410.0 m at Thermistors *T900-1906*, *T845-1842*, and *T700-1905*, located in the dike crest downstream of the cutoff wall. Beads above this elevation appear to fluctuate seasonally and a slight cooling trend is observed in the data over time; and
  - Unfrozen conditions remain below approximately +414.0 m at Thermistor *T560-1892*, located within the cutoff wall. Beads above this elevation appear to fluctuate seasonally and a slight cooling trend is observed in the data over time.

Monthly readings appear to be a suitable frequency for displaying current trends in ground temperatures. Ground temperature thresholds outlined in the ERP state that thermistor readings within thermosyphon groups above -2°C for a single bead or above -5°C for a group of beads should trigger action by DDMI and possible engagement of the EOR. Ground temperature thresholds would trigger responses on most existing reading sets. It is recommended that thresholds should be reviewed and updated to reflect current design and performance requirements for the A418 Dike.

9.0 GEOTECHNICAL ASSESSMENT

Tetra Tech completed a geotechnical assessment as part of this DSR which included a review of the A418 Dike's geotechnical investigations, foundation conditions, slope stability analyses, thermal analyses, and internal erosion potential. Geotechnical information on the dike's material properties and geotechnical design parameters as well as the ongoing instrumentation and performance monitoring were reviewed from the available documentation (see Section 4.0).

Findings from the geotechnical assessment undertaken for the A418 Dike DSR are summarized in the following subsections.

9.1 Geotechnical Investigations

Several geotechnical investigations, including laboratory and in situ testing as well as geophysical surveys, were completed between 1996 and 2004 in support of the A418 Dike's design (NKSL 2004a). The foundation conditions along the dike alignment were established using the following methods:

- Sonic Drilling (72 boreholes);
- Diamond Drilling (24 boreholes);
- Piezocone Soundings (22 soundings);
- Testpitting in the nearby A154 Dike (3 testpits); and
- Ground Penetrating Radar.

The 2012 DSR (AMEC 2012) states that *"geotechnical and hydrogeological site investigations, design criteria, and design analyses are clearly spelled out and meet or exceed state of practice"*. Tetra Tech concurs with this assessment and found the level of geotechnical investigations to be adequate for the A418 Dike's design.

9.2 Foundation Conditions

The geotechnical and hydrogeological investigations undertaken for the A418 Dike (see Section 9.1) established the anticipated subsurface conditions along the dike alignment. Prior to construction, the subsurface conditions within the A418 Dike's footprint generally consisted of the following layers:

- **Lacustrine (Lakebed) Sediments** – fine-grained soils ranging from silt with some sand and clay to sandy silt with occasional gravels. Lakebed sediments were up to 5.5 m thick but generally had a thickness between 1 m and 2 m. The soils were typically non-plastic, soft to dense, and had low organic content. Sediments were present along the majority of the lakebed except in shallow waters along the shoreline where cobble and boulder fields were located.
- **Glacial (Ablation) Till** – unsorted deposits of ablation till with grain sizes ranging from clay to boulders. The thickness of the till layer in offshore locations was up to 14.7 m while thicknesses on the East Island and Island C ranged from 1.6 m to 10.0 m. Tills predominantly consisted of two different units: an upper layer of sands and gravels containing occasional cobbles and a lower layer of well-graded gravels with varying portions of sand, silt, and cobbles.
- **Granitic Bedrock** – granite and granodiorite rock generally of good quality with an average rock quality designation value of 85.4%. Bedrock was typically competent as no continuous layers of weathered rock were encountered at the bedrock surface, only slight to moderate weathering was encountered in select boreholes.

Foundation preparation during construction typically consisted of removing snow, ice, organics, boulders, ice-rich soils, soft lake sediments, and other deleterious materials along the A418 Dike alignment. Dredging and on-land excavations were undertaken to provide a competent foundation for the dike on either dense or frozen glacial till or competent bedrock.

9.3 Stability Analyses

Tetra Tech reviewed the original material properties and stability criteria used for design of the A418 Dike. The material properties selected for geotechnical analysis and design of the dike appear reasonable and representative of the structure's construction materials and foundation conditions. Upstream and downstream slopes of the A418 Dike were evaluated for stability based on the 2000 *Canadian Dam Safety Guidelines*, which were current at the time of design. Required and calculated FS from the 2004 detailed design (NKSL 2004a) are summarized in Table 9-1.

Table 9-1: Required and Calculated Factors of Safety for A418 Dike Stability from 2004 Design

Stability Analysis Scenario	Upstream		Downstream	
	Required	Calculated	Required	Calculated
End of Construction, Before Dewatering (end of fill placement to elevation +421.0 m)	1.3	1.43	1.3	1.53
Partial Dewatering, Downstream (downstream only)	-	-	1.3	1.51 [1]
Full Dewatering, Downstream (after partial porewater pressure dissipation)	-	-	1.3	1.64 [1]
Steady State Case, Upstream (upstream lake level at elevation +415.8 m)	1.5	1.52	-	-
Steady State Case, Downstream (upstream lake level at elevation +417.0 m)	-	-	1.5	1.65
Pseudo-Static Case with Horizontal Seismic (upstream lake level at elevation +415.8 m, k = 0.023 g)	1.1	1.39	1.1	1.57
Pseudo-Static Case with Horizontal Seismic (upstream lake level at elevation +415.8 m, k = 0.053 g)	1.1	1.25	1.1	1.46
Pseudo-Static Case with Horizontal Seismic (upstream lake level at elevation +415.8 m, k = 0.080 g)	1.1	1.13	1.1	1.38

Table adopted from Tables 5.3 and 5.4 in Detailed Design of Dike A418 Final Design Report (NKSL 2004a).
[1] Assumed porewater pressure drawdown rate will be adjusted during initial dewatering to maintain the required FS of 1.3.

Tetra Tech reviewed the original geotechnical stability criteria and results for design of the A418 Dike against the current CDA (2019) guidelines (see Section 7.3). Accordingly, the following DSR comments are provided for the geotechnical stability analyses undertaken for the A418 Dike:

- The minimum calculated FS for the structure's slope stability generally met or exceeded the static assessment criteria specified by the CDA (2019);
- Pseudo-Static loading conditions were evaluated using PGA values of 0.023 g, 0.053 g, and 0.080 g; however, the EDGM should be reviewed and updated based on more recent seismic hazard information from Earthquakes Canada (i.e., 2020 National Building Code of Canada Seismic Hazard Tool); and
- Post-Earthquake (Post-Seismic) loading conditions were not evaluated for the A418 Dike; however, it appears that the 2004 final design (NKSL 2004a) references the liquefaction and post-seismic assessments that were done for the A154 Dike. Based on the range of post-seismic stability analyses completed for the A154 Dike, it appears that a dike height of greater than 17.5 m would not meet the target FS of 1.2 recommended by the CDA (2019). It is recommended that a dike-specific post-earthquake analysis be conducted for the A418 Dike.

Overall, geotechnical design of the dike considered seepage, slope stability, stress/deformation, and thermal effects using appropriate engineering methods of analysis; however, the seismic stability assessments should be reviewed and updated based on current seismic hazard information and to ensure conformance with the CDA (2019) guidelines. Accordingly, it is recommended that the post-seismic stability of the dike be assessed using post-earthquake strengths, as recommended by the CDA (2019).

9.4 Thermal Analyses

The A418 Dike was constructed in an area containing permafrost, and several factors were considered to ensure satisfactory performance of the dike in this unique environment. The main objectives of the design were to prevent degradation of the permafrost, prevent frost-heaving of the till foundation and disruption of the embedded seepage barrier, and achieve a suitable interface at the abutments between the frozen ground and the constructed cutoff wall.

Several detailed thermal analyses were performed during the design of the adjacent A154 Dike. These analyses were used to evaluate the freeze-thaw depth and the risk of frost heave in the till foundation, determine the thermal protection required for the foundation soils and the pattern of thermosyphons at the abutments, and evaluate the impact of dike construction and seepage on the underlying permafrost. The thermal performance of the A154 Dike was observed to be satisfactory, and so most of the same features were incorporated into the design of the A418 Dike.

The thermal considerations and features implemented are summarized below for each designated zone:

- **Abutments:** Frozen ground conditions are to be maintained by artificial cooling using thermosyphons. Thermosyphon clusters are used in the same pattern adopted for the A154 Dike (seven pairs), with the addition of one extra pair at the cold (abutment side of the permafrost boundary) end of the thermosyphon cluster. This additional pair of thermosyphons was added to provide better protection for the first few metres onshore, as a slight degradation of permafrost was observed at the A154 Dike. Both passive and active cooling are used to maintain frozen ground conditions as necessary.
- **Shallow Water Zone Between South Peninsula (A154 Dike) and Island C:** The existence of permafrost within this shallow channel was initially suggested by early temperature records in an exploration borehole, inviting the possibility of an alternate design. However, additional thermistor cable readings showed no frozen conditions in the first 30 m below lakebed in the middle of the narrow channel. Therefore, a standard plastic concrete cutoff wall connected into artificially frozen ground was constructed, with thermosyphon groups used at each abutment.
- **Unfrozen Till Foundation Near Shoreline:** The submerged till foundation on the warm (lake) side of the permafrost boundary is to be maintained as much as possible to prevent frost heave and potential dislocation of the cutoff wall. From the thermal simulations performed during the design of the A154 Dike, it was determined that synthetic insulation was required to prevent significant frost-heave when till was encountered above elevation +409.5 m. The same measures were adopted for A418 Dike, and the insulation (extruded-expanded polystyrene) thickness requirements implemented on the warm side of the thermosyphon clusters are summarized below:
  - Till elevation above +412.0 m – 300 mm of insulation;
  - Till elevation between +410.0 m +412.0 m – 200 mm of insulation;
  - Till elevation between +409.0 m +410.0 m – 100 mm of insulation; and
  - Till elevation below +409.0 m – no insulation required.
- **Freeboard Dike on Permafrost:** Frozen conditions are to be maintained. Disturbance of underlying permafrost was to be minimized during foundation preparation on Island C and on the main island. Freeze-back of materials

was allowed prior to completion of foundation to ensure no thawed soil was trapped beneath the dike. New thaw cycles were to be prevented using temporary synthetic insulation if necessary due to any delays of embankment construction.

Thermistor cables are installed along the dike to monitor performance of the thermosyphons, aggradation/ degradation of frozen soils, and validate the thermal analyses. The thermal performance of the A418 Dike is detailed further in Section 8.4.4 where review of the instrumentation data is discussed.

10.0 HYDROTECHNICAL ASSESSMENT

Tetra Tech performed a hydrotechnical assessment of the A418 Dike. This section presents our assessment of the previous NKSL and AMEC hydrotechnical design work, Tetra Tech's independent review of hydrologic data, IDF estimates, and Lac de Gras water levels review for the A418 Dike system, as well as the Golder Climate Analysis Update.

The Hydrotechnical Assessment includes five components:

1. Design Basis Review including assessing the design criteria followed by the original 1999 dike design and subsequent 2014 design update;
2. Review of the CDA Hydrotechnical Guidelines and Regulations which govern current dam safety in Canada;
3. Hydrologic Review including the estimation of the following events:
    a. Maximum Annual 24-hour Rainfall for the 2 to 10,000-Year Return Period;
    b. Maximum Annual Snowfall Accumulation for the 2 to 5,000-Year Return Period;
    c. Annual and Spring Probable Maximum Precipitation (PMP); and
    d. Review of wind data including intensity, direction, and return period.
4. Review and analysis of the applicable PMF and IDF events and subsequent Lac de Gras water levels; and
5. A freeboard assessment including review of the dam crest elevation, wave set up, and wave run up.

10.1 Design Basis Review

A primary hydrotechnical concern to the integrity of the A418 Dike is the maximum instantaneous water levels expected in Lac De Gras during the IDF event. The A418 Dike's design criteria were developed by NKSL and is presented in the Diavik Diamond Mines Water Retention Dikes Final Design Report (1999). These criteria were further developed by AMEC and BGC in the 2014 A21 Dike Design Report which incorporated location-specific wave set up and wave run up calculations, applicable to the A418 Dike system. Table 10-1 below presents the Design Criteria which were used for the design and construction of the A418 Dike.

Table 10-1: A418 Dike Hydrotechnical Design Criteria

Component	Hydrotechnical Design Criteria	Originator
Lake Characteristics	Drainage Basin Lac de Gras: **3,980 km^2**	NKSL
	Lake Area: **580 km^2**	NKSL
	Average Lake Depth: **15 m**	NKSL
	Typical lake level fluctuation: **El. +415.5 m to +416.0 m**	NKSL
	Maximum Normal Water Level (MNWL): +**415.85 m**, corresponding to a return period of 2 years	NKSL
	MNWL for 1 in 10,000 year return period: +**416.70 m**	NKSL
	Maximum Design Water Level (MDWL): MNWL$_{(1\ in\ 10,000)}$ + wind set up for return period of 100 years. +**416.88 m**	AMEC
	Maximum Instantaneous Water Level (MIWL): MDWL + wind set up and wave run up for return period of 100 years. +**420.10 m**	AMEC
Wind Data	10 year return period: 89 km/hr wind speed, set up = **0.26 m**	AMEC
	100-year return period: 95 km/hr wind speed, set up = **0.33 m**	AMEC
	1,000-year return period: 114 km/hr wind speed, set up = **0.42 m**	AMEC
Wave Characteristics	100-year wave set up and wave run up: **0.18 m and 3.19 m***	AMEC
	1000-year wave set up and wave run up: **0.25 m and 3.79 m***	AMEC

** Wave set up and run up taken from the northeast direction as this yields the worst combined effect when wave set up and run up are added together compared to the west-northwest direction.*

In determining the Maximum Design Water Level (MDWL) and Maximum Instantaneous Water Level (MIWL) water levels for Lac de Gras, the Final Design Report (NKSL1999) and A21 Design Report Update (BGC 2014) do not reference a specific PMF or IDF event. Instead, determination of inflow design parameters for Lac de Gras was performed using a SSARR model (Streamflow Analysis and Reservoir Regulation). Developed by the US Army Corps of Engineers, SSARR is a conceptual model that simulates snow accumulation, snowmelt, and evapotranspiration over a selected watershed based on precipitation and air temperature data.

Stream gauge data is a required input in order to calibrate SSARR models; however, no direct stream gauge data is available for rivers or creeks flowing into Lac de Gras. To overcome this NKSL utilized the Thonokied River and the Tree River watersheds as regional proxy stations to develop a synthetic period of record extending from 1968 to 1995. Although the original SSARR model was not reviewed, Tetra Tech looked at the recent period of record for the Tree River (Thonokied River period of record ends in 1990) to determine if any major changes have been observed that would revise the modelling inputs. This analysis is presented in Figure 10-1 below. As detailed-, two larger events occurred following the initial 1999 analysis (shown in orange). Based on the more recent data, an update of the original SSARR model should be considered as the recent observations will likely increase the inflows predicted by the model.

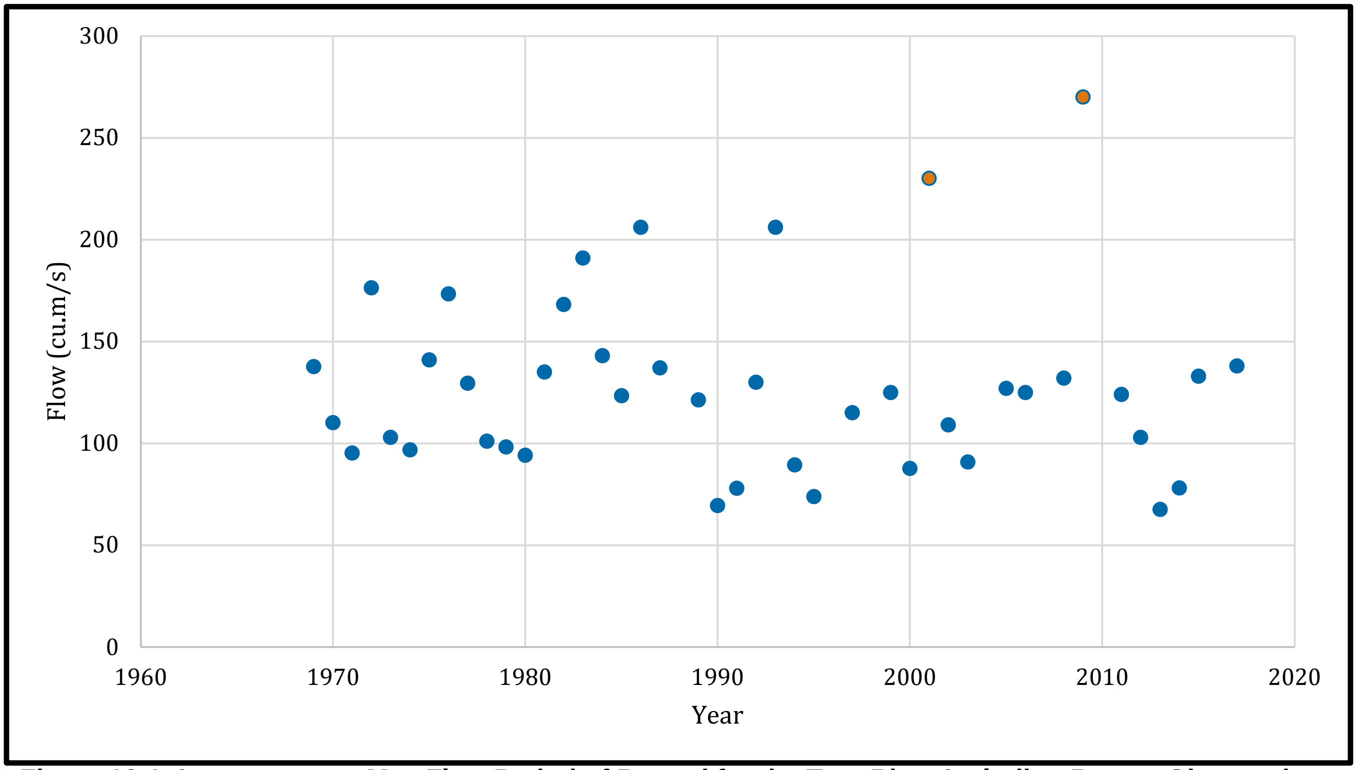


Figure 10-1: Instantaneous Max Flow Period of Record for the Tree River Including Recent Observations up to 2016

10.2 Hydrotechnical Regulations and Guidelines

This hydrotechnical assessment follows the guidance from the CDA (2007). The current practice for the selection of the flood that a dam should be able to withstand, the IDF, is based on the consequence classification that would result from the failure of the dam. During the IDF, the maximum normal operating level should be maintained at all times below the top of the impervious core of the dam, unless analysis can demonstrate that temporary exceedance of this level does not endanger the dam. Freeboard should be provided which exceeds the minimum required to minimize the probability of dam overtopping by waves, considering wind setup, and the wave runup against the embankment.

The dam consequence classification is applied to establish guidelines for selecting the IDF. Accepted practice in Canada uses the CDA (2013) guidelines to determine the IDF for a particular dam from its consequence classification (see Section 7.4). The A418 Dike has been assigned a consequence classification of *Very High* and, based on this, the IDF considered targets a flood hazard which is 2/3 between the 1/1,000-year event and the PMF.

Further to the CDA regulations, the British Columbia Dam Safety Regulation (HSCR 2016) states that, for dams containing the full IDF, 72-hour duration rainfall events are to be considered. Although the A418 Dike relies on Lac de Gras containing the entire IDF, it is Tetra Tech's opinion that the 72-hour event statistics are not applicable to this system due to the lake's natural estuary. Therefore, Golder's Climate Analysis Update (Golder 2021) analysing the 72-hour rainfall event will not be included in this DSR.

10.3 Hydrology Assessment

Tetra Tech performed a comparison between the recent A21 Dike DSR hydrology assessment completed by Tetra Tech in 2022 and Golder's 2021 *Diavik Mine Site – Climate Analysis Update*. Both documents are current reports covering the site's climate data. The conclusion of the comparison suggests that the Golder-reported results are equivalent and/or more conservative than the Tetra Tech values. Moreover, the Golder (2021) results include the analysis of the 72-hour rainfall events which is deemed not applicable to the Diavik A418 Dike site, as explained in Section 10.2. Both Golder and Tetra Tech calculations did not take into consideration the effects of the natural overflow of the Lac de Gras at the outlet, and are, therefore, conservative.

Also, the Golder (2021) report does not include the analysis of the wave set-up and run-up. This analysis was performed by Tetra Tech, augmented by the data provided in the AMEC 2007 report.

In summary, the adopted Golder results are presented in Sections 10.3.1 through 10.3.3, and a combination of the AMEC 2007 and the Tetra Tech 2022 results are presented in Section 10.3.4.

10.3.1 Maximum 24-Hour Rainfall

Table 10-2 provides the resulting frequency analysis quantities for maximum annual and spring 24-hour rainfall.

Table 10-2: Diavik Maximum 24-hour Adjusted Rainfall Return Periods

Return Period (years)	Max Annual 24-hour Rainfall (mm)	Max Spring 24-hour Rainfall (mm)
5,000	129.9	111.0
1,000	100.9	81.1
500	89.6	70.2
200	75.8	57.3
100	66.0	48.6
50	56.9	40.7
20	45.6	31.3
10	37.6	24.9
5	29.9	18.9
2	19.7	10.9

10.3.2 Snowfall Accumulation and Potential Snowmelt Depth

The snowfall accumulation (SWE) for Diavik is presented in Table 10-3.

Table 10-3: Diavik Annual Snowfall Accumulation and Potential Snowmelt Return Periods

Return Period (years)	Annual Snowfall Accumulation (SWE mm)	Annual Potential Snowmelt (SWE mm)
PMP*	N/A	183
5,000	573	153
1,000	480	144
500	444	141
200	399	137
100	368	135
50	338	100
20	300	98
10	272	96
5	244	95
2	205	93

** Golder did not provide methodology for the estimation of the Probable Maximum Snowmelt.*

10.3.3 Probable Maximum Precipitation

Table 10-4 presents the Golder (2021) PMP estimates for Diavik.

Table 10-4: Diavik 24-hour Seasonal and Annual Probable Maximum Precipitation Estimates

Season	24-hour PMP (mm)
Spring	217
Annual	238

10.3.4 Wind Data Review

Hourly wind data collected at the CS located in the Diavik site between 1997 to 2019 were analyzed to determine the wind speed return period in the area. Figure 10-2 presents the wind roses for winds at the mine site with the left panel representing all-season period (all data included) and the right panel representing the ice-free period (only data collected between the months of May and October included).

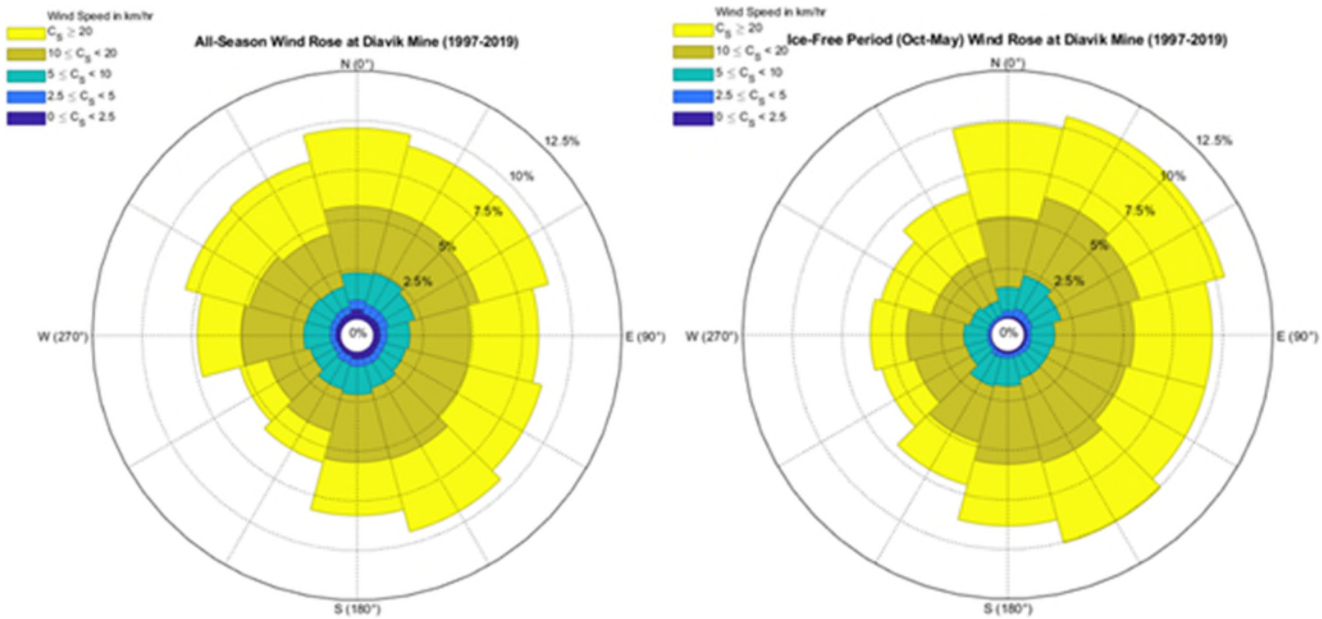


Figure 10-2: 3-Parameter Lognormal Distribution for 24-hour Reported Rainfall

The extreme event return period analysis was completed using the method of Goda (1988). The CS at Diavik where wind measurements were made was located on-land; however, winds that generated waves in a waterbody tend to be faster than winds over land during the same event; as such, a conservative increase of 20% was applied to account for the wind-over-water effect for strong wind (Sayah and Mai 2007; NOAA: Buoy Station 46060 and Land-based Station BLIA2 - https://www.ndbc.noaa.gov/educate/windspeed_ans.shtml).

Table 10-5 below details the design extreme event return-period wind speed over water for both all-season and ice-free period. The **bolded black** values are compared to the values presented by AMEC in 2007. Unfortunately, the 2007 AMEC document did not state the date range of the wind data set that was analyzed, nor did it specify whether or not the wind data collected during ice-free period were analyzed to determine the design wind speed for wave-run-up calculation. However, it would not be unreasonable to assume the data set analyzed by AMEC was collected between 1997 and 2003 for the ice-free period, thus the comparison is made in Table 10-5 below based on this assumption.

Table 10-5: Design Extreme Event Return-Period Wind Speed For Wave Run-up at A418 Dike

Return Period (Years)	West-Northwest Wind Speed (km/hr)			Northeast Wind Speed (km/hr)		
	All-Season	Ice Free Period	2007 AMEC	All-Season	Ice Free Period	2007 AMEC
	(1997 to 2019)	(1997 to 2019)	(unknown)	(1997 to 2019)	(1997 to 2019)	(unknown)
1	70.0	58.1	-	69.1	63.7	-
5	77.2	73.8	-	86.2	80.8	-
10	80.0	79.4	-	92.9	87.6	-
50	86.1	91.1	-	107.3	102.6	-
100	88.6	**95.9**	**95**	113.2	**108.9**	**110**
1,000	96.5	**110.9**	**114**	132.0	**129.4**	**130**

Comparison of the **bolded black** values appears to indicate that the two sets of results are similar and do not represent a significant change to the design wind speed over the last 14 years since the completion of the 2007 AMEC document, provided that the aforementioned assumptions made are valid.

10.3.5 Probable Maximum Flood

This section describes the development of the A418 Dike PMF. The PMF is defined as the most severe flood that may reasonably be expected to occur at a particular location. It is generated by the PMP, which is the maximum precipitation that may be reasonably expected, plus possible snowmelt contributions. These values were taken from the Golder 2021 climate report. The 24-hour duration-event values were used, as explained in Section 10.2. Two PMF scenarios were considered:

- Summer-autumn PMF generated by the summer-autumn PMP.
- Spring PMF, which is defined as the maximum of two cases:
  - PMF calculated as a combination of the spring PMP and a snow accumulation with a frequency of 1/100-year.
  - PMF calculated as a combination of the Probable Maximum Snow Accumulation with a rainstorm frequency of 1/100-year.

These scenarios yield the following estimated PMF events.

Table 10-6: Estimated Probable Maximum Flood Events

Parameter	Sumer-Autumn PMF		Spring PMF (Rainfall Governed)		Spring PMF (Snowmelt Governed)	
	Event	Amount	Event	Amount	Event	Amount
Rainfall (mm)	Annual PMP	238	Spring PMP	217	100-Year	48.6
Snowmelt (mm)	N/A	0	100-Year	135	PMP	183
	Total	**238 mm**	**Total**	**352 mm**	**Total**	**231.6 mm**

As shown, the rainfall governed spring PMF yields the highest estimated lake level increase and was therefore assumed to be the governing PMF event carried forward into the IDF calculations.

10.3.6 1/1,000-Year Flood

This section describes the development of the A418 Dike 1/1,000-Year flood, needed in combination with the above PMF to estimate the IDF for "*Very High*" Consequence dams.

Estimates of the 1/1,000-year flood were made following guidance in *Guidelines On Extreme Flood Analysis* (Alberta Transportation 2004). Two combinations of rainfall and snowmelt were considered:

- A 1/1,000-year winter-spring rainfall event combined with average snowpack/snowmelt; and
- A 1/1,000-year snowpack/snowmelt combined with an average winter-spring rainfall event.

The resulting inputs for the two rain and snow combinations, taken from Golder (2021), are summarized in Table 10-7. The 24-hour duration-event values were used, as explained in Section 10.2.

Table 10-7: Summary of Precipitation and Snowmelt Inputs for the 1/1,000-Year Event

Scenario	Case 1 (Rainfall Governed)		Case 2 (Snowmelt Governed)	
	Event	**Amount (mm)**	**Event**	**Amount (mm)**
Rainfall	1/1,000-year 24-Hour Spring Rainfall	81.1	Average 24-Hour Spring Rainfall	10.9
Snowmelt	Average Snowmelt	93	1/1,000-year Snowmelt	144
	Total	**174.1**	**Total**	**154.9**

The controlling case with the greatest combined rain and snowmelt is the 1/1,000-year 72-Hour spring rainfall event.

10.3.7 Inflow Design Flood

The Diavik A418 Dike has been determined by this DSR to be a "*Very High*" consequence facility. The CDA (2013) recommends an IDF with AEP of 2/3 between the 1/1,000-year flood and the PMF for this classification. The 24-hour duration-event values were used, as explained in Section 10.2.

As discussed in Section 10.1 the original SSARR model was not reviewed by Tetra Tech. As an independent assessment, Tetra Tech chose to assess the lake levels developed by NKSL and BGC by leveraging the hydrologic estimates established in the preceding sections and applying the following high-level runoff analysis:

- Pixel analysis of the Lac de Gras watershed indicates that lakes cover approximately 20%, and dry land covers approximately 80% of the total watershed area.
  - Assume rain or snowmelt over lakes correlates to a 1:1 depth increase of lake water level.
  - Assume a 0.75 runoff coefficient for rainfall and snowmelt on dry land.
- The above assumptions are highly conservative and allow for the following inferences:
  - Rainfall depth over the **catchment** results in a 4:1 increase in lake level (i.e., 100 mm in rain results in a 400 mm increase in lake level).
  - Snowmelt depth over the catchment is assumed to result in a 4:1 increase in lake level (i.e., 100 mm of SWE snowmelt results in a 400 mm increase in lake level).

The resulting IDF Lake levels are presented in Table 10-8 below.

Table 10-8: Summary of Inflow Design Flood Lac de Gras Elevations

Flood Event	Antecedent Lake Level	Combined Rain and Snow Depth (m)	Associated Lake Level Increase (m)	IDF Lake Level (m)
1,000-Year (Case 2)	MNWL - 415.85 m	0.174	0.696	+416.546
Spring PMF (Rainfall Governed)	MNWL - 415.85 m	0.352	1.408	+417.258
IDF – High Consequence (2/3 between the 1/1,000-year flood and the PMF)	MNWL - 415.85 m	**0.293**	**1.173**	**+417.023**

10.4 Wave Run-up and Wind Set-up Review

10.4.1 Methodology Review

This section presents Tetra Tech's opinion on the methodology used and presented in *Appendix J – AMEC (2007) Hydrologic Analyses* (hereinafter referred to as the '2007 AMEC document') that was appended as part of the main report, *A21 Dike - 2014 Design Report Update*, by BGC in which design wave run-up was calculated. The opinion presented below is categorized into several aspects, each of which have contributed to various degrees of calculated design values. Please note that the opinion pertains to the methodology only; the arithmetic of the calculations were not reviewed or checked.

10.4.2 Design Criteria

There was no clear indication in the 2007 AMEC document regarding the location of the station from which wind data were extracted for the analysis AMEC undertook. It is noted that this 2007 AMEC document was appended as part of BGC's main report, in which wind climate was described based on the wind data collected at the mine site. However, Tetra Tech is unable to independently confirm if AMEC used the data collected at the mine site.

There was no indication if AMEC has scaled up the wind speed collected at the land-based wind station to determine the design wind speed for wave generation in Lac de Gras. The scaling up of land-based wind speed is necessary to estimate the wind speed over water for wave generation due to the lower friction of winds over water than on land.

10.4.3 Calculation of Design Wind Set-Up

AMEC used analytical/empirical equations utilized in the NKSL design report for the A154 Dike and it is very likely that the approach is not sufficient, especially when associated to the lack of observed wave data to validate the applicability and accuracy of the equations. The methodology used by AMEC was not (at the time of the study) and still is not the best methodology that one could use to determine the design wind-set up, wave climate conditions, and hence wave-run-up at the project site. The best approach to determine these important design parameters would be a numerical modelling study.

10.4.4 Calculation of Design Wave Climate

AMEC in 2007 used the Automated Coastal Engineering System (ACES), developed in 1992, to determine a representative wind fetch, which was then utilized in the empirical wave height equations used in the 1999 NKSL design report. While this approach might have been sufficient in 1999, it was almost certainly not the best approach in 2007 when design wave climate was determined by AMEC because at that time numerical wave modelling software was already operational and publicly available for use.

A418 Dike appears to be protected from the wave attack from the west-northwest by the landmass to the west; the analytical equations used in the 2007 AMEC document, unlike a numerical model, could not have taken that fact into full account when calculating the design wave height. Use of analytical equations, as opposed to a detailed model, is likely to produce a conservative estimate in this context.

10.4.5 Calculation of Design Wave Run-Up

AMEC in 2007 used ACES to determine wave run-up. While the 2007 AMEC document stated that the design slope of 1.6L:1V was used, the document did not indicate whether the roughness of the sloping dike face has been taken into account when calculating the wave run-up. Ignoring roughness would lead to a more conservative estimate of run-up.

The AMEC 2007 methodology did not and could not have taken into account the wave approach angle in relation to the dike face. In addition to the dike material, the wave approach angle further affects the resulting wave run-up. Ignoring the wave approach angle should lead to a more conservative estimate of run-up.

At the time of the AMEC work in 2007, an internationally recognized wave-run-up manual, the European Wave Overtopping Manual (EurOtop) was available. The latest version was published 2018 and included the most recent equations and methodology based on the latest research and experimental works on wave run-up and overtopping.

10.4.6 Wave Run-Up Summary

On the basis of the above review it appears that the AMEC 2007 wave run-up design is likely conservative in several aspects. Accordingly, Tetra Tech is of the opinion that the A418 Dike wave run-up design is appropriate for the current structure.

10.5 Freeboard Assessment

The CDA defines the freeboard as the vertical distance between the reservoir level and the crest of the containing structure. For “*Very High*” consequence dams, the crest of the embankment structure should be set such that the structure is protected against the following scenarios:

- No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/1,000-year when the reservoir is at its maximum normal elevation.
- No overtopping by 95% of the waves caused by the most critical wind with a frequency of 1/2-year when reservoir is at its maximum extreme level during the passage of the IDF.

As wave set-up and wave run-up estimates for the 2-year wind event were not provided in BGC’s design update report. Tetra Tech conservatively adopted the 1 in 10-year wind event for the second scenario above.

The crest elevation of the A418 Dike was designed to be +421.0 m in elevation. Based on the Design Update Report this provides a 0.5 m freeboard above Lac de Gras MIWL calculated to be +420.1 m (BGC 2014).

A dike COW acting as the seepage reduction element within the dike tops at an elevation of +417.5 m. Based on the Design Update Report this provides a 0.5 m freeboard above Lac de Gras MDWL calculated to be +416.88 m (BGC 2014).

Computed values for wind setup and wave runup are included in the freeboard assessment summary presented in Table 10-9.

Table 10-9: Summary of the Freeboard Assessment

Parameter	A418 Dike – Lac de Gras	
Consequence Class	**-**	**CDA "*Very High*" Consequence**
Scenario	**Lake Level at Maximum Normal Elevation**	**Lake Level During IDF**
Wind Frequency (years)	1/1,000	1/10
Max Lake Elevation (m)	+415.85	+417.02
Wind Setup (m)	0.25	0.18
Wave Runup (m)	3.79	3.19
Required Freeboard for Wind Setup + Wave Runup (m)	4.04	3.37
Combined Elevation (m)	+419.89	+420.39
Remaining Freeboard (m)(2)	**1.11**	**0.61**

(1) *The crest of the embankment is overtopped at 421.0 m.*

(2) *The available freeboard is taken as the difference between the combined elevation and the crest of the embankment. Zero or negative freeboard indicates overtopping.*

The freeboard analysis, as well as the lake level values, do not take into consideration the effects of the natural overflow of the Lac de Gras at the outlet, and are, therefore, conservative. Tetra Tech is of the opinion that the A418 Dike provides adequate freeboard when Lac de Gras is at its maximum normal elevation. The freeboard also appears to be sufficient during the IDF passage based on a "*Very High*" consequence classification for the A418 Dike.

11.0 DAM SAFETY RISK CONTROLS REVIEW

The DSRC for the A418 Dike comprises the facility owner's Dam Safety Management System (DSMS), operating plans and procedures, maintenance and testing of critical equipment, surveillance plans, performance evaluations, and emergency management. The A418 Dike is currently an operating structure and is considered to be in the *Operation Phase* of its lifecycle, meaning Section 3.0 is of CDA (2019) is applicable. At this stage of the dike's lifecycle, conditions can be reasonably predicted, surveillance is conducted by staff on site, and emergency response is possible.

Tetra Tech was provided with copies of Diavik's Emergency Response Plan (DDMI 2022a), Emergency Preparedness Plan (DDMI 2021a), OMS Manual (DDMI 2022b), Water Management Plan (DDMI 2022c), and past inspection and monitoring reports. Specific comments on the reviewed DSRC documentation are provided in the following subsections.

11.1 Emergency Response Plan

An Emergency Response Plan (ERP) is an internal, dam-specific document that should identify actions the dam owner will take in response to unusual or emergency conditions (CDA 2013). The ERP should outline the key emergency response roles and responsibilities as well as required notifications and contact information. Key content to be included in an ERP is detailed by the CDA in Section 4.2.3 of the *Dam Safety Guidelines* (CDA 2013) and Section 3.5 of the *Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams* (CDA 2019).

Diavik's current ERP was last updated in September 2022 and covers emergency response for the NIWSF, A21, A154, and A418 Dikes (DDMI 2022a). It presents emergency response plans for three levels of urgency:

- **Imminent or Actual Dam Emergency:** Dam failure is occurring or about to occur that could result in large or rapidly increasing uncontrolled release that requires widespread downstream evacuation as it cannot reasonably be prevented.
- **Potential Dam Emergency:** Situation may lead to a dam failure but is not an immediate threat of dam failure and downstream activities may need to take steps to mitigate damage and prepare to evacuate.
- **Hazardous Condition or Incident:** The situation is not normal; does not pose an immediate danger but could develop into one.

Tetra Tech reviewed the ERP, in relation to the A418 Dike, and found that the document largely meets the requirements of the CDA (2013) guidelines. While emergency management for the A418 Dike is relatively robust, Tetra Tech has the following comments and suggestions for further improvement of the ERP:

- The ERP is recommended to be updated on an annual basis to ensure that emergency contact information and links with other DSMS documents remain current;
- Emergency contact information for the DOR as well as indigenous, government, and regulatory agencies that would need to be contacted in the event of an emergency are provided in Appendix A;
- Other editorial discrepancies were noted throughout the ERP, including:
  - Section 3.1 (Categorization of Emergency Level) has two broken table reference links and it is unclear which tables were intended to be referenced; and
  - Section 3.6.2 (Action by Discoverer) has a broken table reference link and should reference Table 3-1.

11.2 Emergency Preparedness Plan

An Emergency Preparedness Plan (EPP) is an external, dam-specific document developed by the dam owner that the defines the hazards posed by the dam, the roles and responsibilities of all parties, and notifications to be made (CDA 2013). The EPP is not a response document, but it should contain essential information so that external agencies can develop their own response plan. It should also detail an effective emergency management process to ensure that site personnel can adequately respond to a dam emergency (e.g., adequate training, plan testing). Key content to be included in an EPP is detailed in Section 4.3.2 of the 2013 *Dam Safety Guidelines* (CDA 2013).

Diavik's current EPP was updated in January 2021 and is titled *Business Resilience Management Plan – Revision 1* (DDMI 2021b). The document was prepared to apply to Diavik's overall operations and is not dike-specific. The scope of the EPP is *"the overarching plan for business resilience and recovery programme. All members of DDMI staff and its management are to abide by the provisions of this plan and to participate in the plan's ongoing* *development and administration"*. It provides *"a specially formed management structure in support of our local resources and the activation of procedures to deal with the subsequent recovery process"*.

Tetra Tech reviewed Diavik's EPP, in relation to the A418 Dike, and has the following comments and suggestions for further improvement:

- The document identifies 12 risk areas including incidents resulting from injury, environmental and man-made disasters, disruptions to the supply chain, as well as loss of regulatory or community support; however, many of the risk areas are not considered applicable to the A418 Dike;
- The risk areas identified in the EPP are largely not related to the ERP; however, the risk areas which are applicable to the ERP should be linked and updated accordingly;
- The document does not address the emergency management process and procedures to guide site personnel through the process of responding to a dike emergency; and
- There is no supporting documentation showing that the EPP has been implemented. The document included a *Situation Report Template (Alternate)* dated April 6, 2020, which included a list of attendees but the form was not completed to provide a record of any discussions. It is assumed that the form is considered a template and the information provided should have been deleted.

11.3 Operations, Maintenance, and Surveillance Manual

An OMS Manual is a living document that describes the means and methods of operating and maintaining a water retaining structure. The CDA (2019) recommends developing an OMS Manual to document the requirements and procedures for the safe operation, maintenance, and surveillance of a dike. Operational and maintenance procedures as well as the appropriate level of surveillance can change during different phases of a dike's life and, as such, OMS manuals should be revised or updated annually. The CDA (2013) recommends that an OMS manual includes the following contents:

1. Project Description, including an overview of the facility and supporting infrastructure;
2. Operation, including roles and responsibilities, operating criteria and constraints, data requirements, operating procedures, and water management systems;
3. Maintenance, including maintenance programs for embankments and supporting infrastructure; and
4. Surveillance, including visual inspections, dam instrumentation, documentation, and follow-up.

Tetra Tech reviewed the OMS Manual (DDMI 2022b) prepared for Diavik, which was last updated in September 2022. The manual is a site-wide document and applies to the A418 Dike as well as the NIWSF, A154 Dike, and A21 Dike. It includes figures as well as a detailed description of Diavik's facilities and structures. Additionally, the OMS Manual provides details on personnel roles and responsibilities, Emergency and Trigger Action Response Plans (TARPs), and instrumentation as well as operations, maintenance, and surveillance requirements for each facility.

After reviewing the OMS Manual as it pertains to the A418 Dike, Tetra Tech concluded that overall the dike is being maintained and operated in accordance with the manual's requirements. The document provides a monitoring plan and quantitative performance objectives for the structure which are tracked and verified regularly. Tetra Tech has the following comments and suggestions on the OMS Manual for further improvement:

- Section 2 (Roles, Responsibilities, and Authority):
  - The level of required knowledge for roles is clearly outlined and there are training modules in place for responsible staff; however, details on how competencies will be met is unclear and how change management, transitions plans, and succession planning and handover procedures are considered.
- Section 8 (Operation):
  - Sections 8.1 (General) and 8.2 (A21, A154, A418 Dike Water Management) primarily speak to operations that only pertain to the A21 Dike rather than all three dike structures at Diavik, as intended;
  - Section 8.2.3 (A418 Pump Station Operation) does not include or reference details on the *"pre-selected levels"* that start and stop the DPS-6 pumping system, unlike the details provided for the A21 Dike in Section 8.2.1 (A21 Pump Stations (DPS) Operation);
  - Section 8.2.6 (A418 & A154 Relief Wells) does not include or reference details on the locations and elevations of the A418 Dike's relief wells, unlike the details provided for the A21 Dike in Section 8.2.5 (A21 Relief Wells); and
  - Section 8.5 (Thermosyphons) largely speaks to thermosyphons that pertain to the A21 Dike rather than all three dike structures at Diavik, as intended.
- Section 9 (Maintenance):
  - Table 9-1 (Planned Maintenance) outlines the minimum frequency of various maintenance activities. A list of regular maintenance items for each component is recommended to be included or referenced.
- Section 11 (Emergency and Trigger Action Response Plan) references TARPs which are provided in the ERP; however, it is not clear whether these are all located within the ERP or a separate TARP plan. The section should direct the reader to Section 3.3 of the ERP where the TARPs are located.
- Other editorial discrepancies were noted throughout the OMS Manual, including:
  - Table of Contents includes numerous broken reference links to subsections in Section 11 (Emergency and Trigger Action Response Plan) which no longer exist (e.g., Subsections 11.1 to 11.5);
  - List of Tables includes several broken reference links to tables in Section 11 (Emergency and Trigger Action Response Plan) which no longer exist (e.g., Tables 11-1 to 11-8); and
  - Section 10.2 (Monitoring Frequency, Interpretation, and Records) contains a broken reference link to a section on ERP response levels.

11.4 Water Management Plan

A Water Management Plan (WMP) is a site-specific plan that must be developed and implemented for operation of all water management structures at Diavik. The purpose of the plan is to detail site water management practices and outline the life-of-mine water balance. The WMP is a requirement of Diavik's Water Licence granted by the WLWB (2021).

Diavik's current WMP was updated in September 2022 and is titled *Water Management Plan – Version 16* (DDMI 2022c). The plan is well structured and presents sufficient detail on the water management associated with the A418 Dike. It includes a water balance that reviews and predicts the base case inflows for both the A418 open pit and underground operations.

Tetra Tech reviewed Diavik's WMP, in relation to the A418 Dike, and has the following comments and suggestions for further improvement:

- The WMP should be updated and submitted to the WLWB on an annual basis, per Part G of Diavik's Water Licence;
- Section 1.3 (Water Management Responsibilities) is recommended to be linked to Section 2 (Roles, Responsibilities, and Authority) of the OMS Manual where detailed roles and responsibilities are identified; and
- Appendix A (Summary of Climate Data) should be updated using the recent climate analysis update for Diavik (Golder 2021).

11.5 Instrumentation and Performance Monitoring Frequency

Active instrumentation monitoring and visual performance inspections of the A418 Dike are undertaken by DDMI's Technical Services department and the DOR as part of the dike's DSRC. The frequency and nature of instrumentation and performance monitoring for the A418 Dike are detailed in Diavik's OMS Manual (DDMI 2022b).

The following subsections outline the instrumentation and performance monitoring items reviewed in this DSR.

11.5.1 Instrumentation

Instrumentation monitoring for the A418 Dike is undertaken based on the performance of the dike and the monitoring frequency is subject to change should the conditions justify (e.g., seismic event, climatic event, change in operating conditions). The A418 Dike's instrumentation during normal conditions should be monitored at the minimum frequencies outlined in Table 11-1.

Table 11-1: Minimum Instrumentation Reading Frequency for A418 Dike

<table>
<tr><th>Instrumentation Type</th><th>Monitoring Frequency</th><th>Monitored By</th><th>Reported To</th></tr>
<tr><td>Vibrating Wire Piezometers</td><td>Twice Weekly</td><td rowspan="7">DDMI Technical Services</td><td rowspan="8">Senior Dam Engineer
or
Senior Geotechnical Specialist</td></tr>
<tr><td>DPS Cycles</td><td rowspan="2">Weekly</td></tr>
<tr><td>Flow Meters</td></tr>
<tr><td>Thermistors</td><td>Monthly</td></tr>
<tr><td>Crackmeters</td><td rowspan="2">Quarterly</td></tr>
<tr><td>Inclinometers</td></tr>
<tr><td>Relief Wells</td><td>Biannually</td></tr>
<tr><td>Survey Markers</td><td>Annually</td><td>Survey Subcontractor</td></tr>
</table>

Table adopted from Table 10-1 of Diavik Diamond Mines North Inlet (NI), A21, A154 & A418 Dikes OMS Manual (Rio Tinto 2022b).

Tetra Tech was not provided with detailed instrumentation data for the A418 Dike's DPS Cycles, Flow Meters, Crackmeters, and Survey Markers; however, a summary of the instrumentation monitoring results was provided in the 2021 AIPE (SLI 2021). Upon reviewing the provided instrumentation data, Tetra Tech noted the following:

- Instrumentation monitoring data is reviewed and evaluated by the EOR on an annual basis during the AIPEs to verify conformance with the dike's design intent;
- VWPs for the A418 Dike appear to be monitored in accordance with the minimum frequency specified in the OMS Manual over the last five years;

- Several VWPs are inactive or have limited readings, likely due to freezing of water in the instrumentation; however, the EOR does not consider these piezometers to be critical to the safe operation of the dike and they have not been recommended for repair/replacement;
- Thermistors for the A418 Dike appear to be monitored in accordance with the minimum frequency specified in the OMS Manual over the last five years, except Dike Crest Thermistors *T900-1906* (short two monthly readings) and *T525-1887* (short three readings);
- Four South Island C thermistors (*T337-1840*, *T329-1846*, *T314-1839*, and *T308-1903*) are currently inaccessible as the thermistors were buried during road construction in July 2022; and
- Inclinometers for the A418 Dike appear to be monitored in accordance with the minimum reading frequency specified in the OMS Manual over the last five years.

Overall, the instrumentation monitoring program for the A418 Dike appears comprehensive and is aligned with the failure modes identified for the structure.

11.5.2 Visual Performance Inspections

Visual performance inspections of the A418 Dike, in combination with the instrumentation monitoring, are conducted on a regular basis to monitor the dike's overall performance and identify potential hazards. Inspections are also required after unusual or extreme events including rapid snowmelt, heavy rainfall, high winds, or significant changes in piezometric levels. The types and frequency of visual performance inspections to be undertaken for the A418 Dike are summarized in Table 11-2.

Table 11-2: Visual Performance Inspection Types and Frequency for A418 Dike

Inspection Type	Inspection Frequency	Conducted By	Reported Up To
Weekly Visual Inspection	Weekly	DDMI Technical Services	Senior Dam Engineer or Senior Geotechnical Specialist
Rapid Motorized Inspection			
Detailed Walkover Inspection	Biannually		
Review Board Inspection	Annually	DGRB	Technical Services Manager
Annual EOR Inspection		EOR	General Manager Operations and Regulatory Authorities
Third-Party Dam Safety Reviews	Quinquennially	Third-Party	

Table adopted from Tables 12-3 and 12-4 of Diavik Diamond Mines North Inlet (NI), A21, A154 & A418 Dikes OMS Manual (Rio Tinto 2022b).

Diavik's Water Licence (WLWB 2021, Section 25 g) requires that an AIPE of the A418 Dike be undertaken by a Geotechnical Engineer as per the below text:

"g) an inspection of the Water Retention Dikes shall be carried out annually between June and September, by a Geotechnical Engineer. The Engineer's report shall be submitted to the Board within ninety (90) days of completing the on-site inspection, including a covering letter from the Licensee outlining an Implementation Plan for addressing each of the Engineer's recommendations."

Tetra Tech reviewed the AIPE reports for the A418 Dike from 2015 to 2021 (NKSL 2015 to 2016; SLI 2017 to 2021). Each report describes the findings of an annual site inspection undertaken by the EOR as well as an evaluation of the dike's performance based on the past year's instrumentation monitoring and weekly visual inspections. Additionally, Tetra Tech reviewed both previous DSRs conducted in 2012 (AMEC 2012) and 2018 (Tetra Tech

2018) for the A418 Dike. The reports conclude with recommendations for the A418 Dike to address deficiencies and non-conformances, which are reviewed and described further in Section 13.1 of this DSR.

Tetra Tech was not provided with copies of the A418 Dike's Weekly Visual Inspections, Rapid Motorized Inspections, and Detailed Walkover Inspections; however, a review of results from the Weekly Visual Inspections is provided in the 2021 AIPE (SLI 2021). Based on a review of the above-mentioned inspection reports, Tetra Tech has the following comments:

- It is understood that DDMI's Technical Services department is in regular communication with the EOR regarding findings and deficiencies observed from the routine performance inspections; however, it is not clear how any abnormal observations, if identified, are reported to SLI;
- Dike inspections and reporting by the Senior Dam Engineer (i.e., Weekly Visual Inspections) meet the frequency specified in the OMS Manual and are reviewed annually by the EOR as part of the AIPEs;
- It is understood that rapid motorized inspections conducted on site by the DGRB on an annual basis did not occur from 2019 to 2021 due to the COVID-19 pandemic; however, DDMI provided the DGRB with annual updates on the status of each dike structure during this period and on-site inspections recommenced in 2022;
- Dike inspections and reporting by the EOR (i.e., AIPEs) meet the frequencies specified in the OMS Manual and Diavik's Water Licence (i.e., annually) and include a detailed review of the structure's instrumentation monitoring data;
- The AIPEs appear to review operational documentation and provide written confirmation that the dike is conforming to the intent of its original design;
- Recommendations from the AIPEs are updated and summarized in Table 2 at the beginning of each report, including comments and recommended actions from DDMI, indicating that each action is being tracked and acted upon; and
- Third-party DSRs for the A418 Dike are being conducted in accordance with the scope and frequency required by the CDA (2013), the OMS Manual, and Diavik's Water Licence.

In summary, the visual performance inspection program for the A418 Dike is robust and aligns with the OMS Manual and regulatory requirements for the structure.

12.0 REGULATORY CONFORMANCE REVIEW

Diavik is regulated under the *Mackenzie Valley Resource Management Act and Regulations* for which the WLWB has primary regulatory authority. The WLWB has granted DDMI a site-specific Type A Water Licence which permits a maximum of 1.28 Mm^3/year of water to be extracted from Lac de Gras during Diavik's operational phase, for diamond mining and milling purposes. The Water Licence requires submission of various documentation including dike safety reports, emergency preparedness plans, dam designs, tailings designs and management plans, closure and reclamation plans, and an OMS Manual. Details on Diavik's current Water Licence are provided in Table 12-1.

Table 12-1: Diavik's Type A Water Licence Reference Information

Water Licence Detail	Reference Information
Licence Number	W2015L2-0001 (formerly W2007L2-0003, MV2005L2-0009, N7L2-1645)
Licence Type	A
Water Management Area	Northwest Territories 05
Location	Lac de Gras, NT
Purpose	Water Use and Waste Disposal
Description	Diamond Mining and Milling
Effective Date of Licence	October 19, 2015
Amendment Date of Licence	June 8, 2021
Term of Licence	10 Years
Expiry Date of Licence	December 31, 2025

Diavik's Water Licence contains several conditions applicable to the A418 Dike that must be met to maintain regulatory conformance. Below is a summary of the Water Licence conditions applicable to the dike's operations, maintenance, and surveillance:

- *Part G: Conditions Applying to Water and Waste Management*
  - *Condition 25: The Licensee shall operate and maintain the Water Retention Dikes to engineering standards such that at a minimum they comply with the Dam Safety Guidelines, and in accordance with the following:*
    - *a) The lowest point on the upper edge of the Diaphragm Wall shall not be lower than +419.0 metres above mean sea level, or as recommended by a Geotechnical Engineer and as approved by the WLWB;*
    - *b) The Licensee shall install and maintain geotechnical instrumentation in the Water Retention Dikes as described in each of the Dike Design Reports;*
    - *c) The Licensee shall carry out the instrumentation reading schedule as provided by the WLWB;*
    - *d) Weekly inspections of the Water Retention Dikes shall be conducted and the records of these inspections and all monitoring records shall be made available to the WLWB or an Inspector upon request;*
    - *f) Any deterioration or erosion of any Engineered Structures associated with the Water Retention Dikes shall be reported to an Inspector and repaired immediately; and*
    - *g) An inspection of the Water Retention Dikes shall be carried out annually between June and September, by a Geotechnical Engineer. The Engineer's report shall be submitted to the WLWB within ninety (90) days of completing the on-site inspection, including a covering letter from the Licensee outlining an Implementation Plan for addressing each of the Engineer's recommendations.*
  - *Condition 30: The Licensee shall conduct DSRs of the following:*
    - *b) The A418 Dike in 2017 and every five (5) years thereafter, or at a frequency approved by the WLWB.*

      The DSRs shall be conducted in accordance with the Dam Safety Guidelines by a Professional Engineer. The timing of the DSR inspection will be at the discretion of the Review Engineer conducting the inspection.

- *Condition 31: Within ninety (90) days after completing a DSR inspection, the Licensee shall submit to the WLWB:*

  a) The Engineer's DSR Report; and

  b) An Implementation Plan outlining how the Licensee will respond to each recommendation in the Engineer's DSR Report, including a rationale for any decisions that deviate from the Engineer's recommendations.

Tetra Tech reviewed and confirmed that the A418 Dike is currently in regulatory conformance with the above Water Licence conditions. It should be noted that a DSR for the dike was not conducted in 2017 as required by Condition 30, Item b; however, DDMI obtained a frequency variance from the WLWB to complete the DSR in 2018.

13.0 DAM SAFETY ISSUES

Tetra Tech's DSR of the A418 Dike reviewed past dam safety issues and identified new dam safety issues that should be addressed in a timely manner to improve and maintain dam safety. These issues were classified into two separate categories based on guidance from the CDA (2016), defined as:

- **Deficiency (D)** – *An inadequacy, or uncertainty in the adequacy, of the dam system to meet its performance goals in accordance with good dam safety practices.*
- **Non-Conformance (NC)** – *An inadequacy in the non-physical controls (procedures, processes, and management systems) necessary to maintain the safety of the dam.*

Dam safety issues for the A418 Dike were rated in terms of actionable importance (from 1 to 4) following the priority rankings utilized in the AIPEs, defined as:

- **Priority 1** – a high probability or actual dam safety issue considered immediately dangerous to life, health, or the environment, or a significant risk of regulatory enforcement;
- **Priority 2 –** a deficiency which, if not corrected, could likely lead to injury, environmental impact, or significant regulatory enforcement; or a repetitive deficiency that demonstrates a systematic breakdown of procedures;
- **Priority 3 –** a single occurrence of a deficiency or non-conformance that alone would not be expected to result in a dam safety issue; and
- **Priority 4 –** a best management practice recommended where further improvements are necessary to meet industry best practices or reduce potential risks.

The following subsections outline the past and new dam safety issues identified for the A418 Dike by Tetra Tech over the course of this DSR.

13.1 Past Dam Safety Recommendations

Tetra Tech reviewed the dam safety recommendations identified in past AIPEs and DSRs conducted for the A418 Dike, including:

- 2021 AIPE conducted by SLI (2021);
- 2020 AIPE conducted by SLI (2020);
- 2019 AIPE conducted by SLI (2019);
- 2018 DSR conducted by Tetra Tech (2018); and
- 2018 AIPE conducted by SLI (2018).

As part of this DSR, Tetra Tech updated the status and assigned priority rankings (see Section 13.0) for each past dam safety recommendation. A total of nine past dam safety recommendations were identified, as detailed in Table 13-1.

Table 13-1: Past Dam Safety Recommendations for the A418 Dike

Past Dam Safety Recommendation Number	Past Dam Safety Recommendation Description	Reference Documentation	Current Dam Safety Review Update	
			Status	Priority Ranking
2020-AIPE-A418-R1	Erosion Protection between Stations 0+500 to 0+600 and Stations 0+700 to 0+750 ▪ Upstream protection eroded or missing between Stations 0+500 to 0+600 and Stations 0+700 to 0+750 of the A418 Dike. Continue monitoring and repair with additional rockfill only, where necessary.	SLI (2020)	Deficiency (revised and added to current DSR)	3
2020-AIPE-A418-R2	Thermistor String Installation to Supplement Inclinometer Data ▪ Reversal of relative incremental movement between Stations 0+560 and 0+930, at depths of 4 m to 10 m was noted for the A418 Dike. Suggested cause could be from the formation of ice in the downstream embankment pushing against the plastic concrete cutoff wall. Installation of thermistor strings with closely spaced beads is suggested in the embankment immediately upstream and downstream of one or more inclinometers to determine the extent of ice and its seasonal variation.	SLI (2020)	Resolved	3
2020-AIPE-A418-R3	DPS-6 and Pit Depressurization Well A418-DP17-01A Seepage Analysis ▪ Since 2018, water from Pit Depressurization Well A418-DP17-01A has been flowing into the DPS-6 Catch Basin. Continue to perform chemical analysis on inflows and seepage reporting to the DPS-6 Catch Basin to determine if flow is transiting through cementitious dike materials or a naturally occurring mineral from the bedrock.	SLI (2020)	Resolved	3
2020-AIPE-A418-R4	Relief Well Sampling and Testing ▪ Continue to sample and test water from surrounding A418 Dike relief wells that are discharging, even if not located in the DPS-6 area, to identify any change in the chemical composition of seepage.	SLI (2020)	Resolved	3
2020-AIPE-A418-R5	2020 OMS Manual Updates ▪ Include relevant recommendations to the OMS Manual.	SLI (2020)	Resolved	3
2019-AIPE-A418-R1	Granular Filter Material (Zone 1A) Reserve Piles ▪ In the event that piping is encountered on A418 Dike, there are currently no reserve piles of granular filter material easily accessible for dike repairs. It is understood that reserve piles of Zone 1A material produced for the A21 Dike are available on site. Regardless, it should be ensured that equipment can mobilize rapidly and access DPS-6, if required.	SLI (2019)	Pending	3
2018-AIPE-A418-R1	Relief Well RW6 Cleaning ▪ Clean Relief Well RW6 at Station 0+725 of the A418 Dike where sand has accumulated due to a probable suction of surrounding sand into the well when direction of flow was changed from being upward to downward.	SLI (2018)	Pending	3
2018-DSR-A418-R1	2018 ERP Updates ▪ Update and convert the ERP into a “live” document.	Tetra Tech (2018)	Resolved	4
2018-DSR-A418-R2	DPS-6 Summary Report ▪ Create an internal report on the details of the pumping rates per well and the effects on piezometer readings in the vicinity of DPS-6.	Tetra Tech (2018)	Resolved	4

13.2 Past Dam Monitoring Recommendations

Tetra Tech reviewed the dam monitoring recommendations identified in past AIPEs and DSRs conducted for the A418 Dike, including:

- 2021 AIPE conducted by SLI (2021);
- 2020 AIPE conducted by SLI (2020);
- 2019 AIPE conducted by SLI (2019);
- 2018 DSR conducted by Tetra Tech (2018); and
- 2018 AIPE conducted by SLI (2018).

As part of this DSR, Tetra Tech updated the status and assigned priority rankings (see Section 13.0) for each past dam safety monitoring recommendation. A total of six past monitoring recommendations were identified, as detailed in Table 13-2.

Table 13-2: Past Dam Monitoring Recommendations for the A418 Dike

Past Dam Monitoring Recommendation Number	Past Dam Monitoring Recommendation Description	Reference Documentation	Current Dam Safety Review Update	
			Status	Priority Ranking
2021-AIPE-A418-M1	<u>2019/2020 Survey Marker Data Discontinuities</u> ▪ The 2019 and 2020 survey marker data show a discontinuity in deformations that is not considered representative of actual deformation increments. The survey team should be asked to provide a likely explanation for this and means to avoid such discontinuities in the future.	SLI (2021)	Pending	4
2020-AIPE-A418-M1	<u>DPS-6 Pump Flows</u> ▪ Assess the DPS-6 pump flows throughout the year, particularly at the noise-free period of late winter, as these will be indicative of a leak path that may have been opened.	SLI (2020)	Ongoing	3
2019-AIPE-A418-M1	<u>Thermosyphon Compressor Units</u> ▪ Two compressor units were removed from the A418 Dike's north abutment and north of Island C to be used at the A21 Dike. Thermosyphons in this area are now only working in passive mode. Continue to assess the need to prolong thermosyphon compressor usage on a case by case basis.	SLI (2019)	Ongoing	3
2019-AIPE-A418-M2	<u>Manual Instrumentation Readings</u> ▪ Continue to redo questionable instrumentation readings manually to validate the results or correct any erroneous interpretations. This applies particularly to the inclinometers and Casagrande piezometers.	SLI (2019)	Ongoing	3
2019-AIPE-A418-M3	<u>Minor Cracking at Station 0+910</u> ▪ Minor cracking was observed on the crest of the A418 Dike near Station 0+910 during the 2013 inspection and now appears to have closed. Continue to monitor and record any displacements. Continue to grade the top of dike to enhance the ability to conduct visual inspections.	SLI (2019)	Ongoing	3
2018-DSR-A418-M1	<u>Thermosyphon Condition Assessments</u> ▪ Implement condition assessments for the A418 Dike's thermosyphons. A condition assessment of the thermosyphon radiators is normally completed in the early winter when air temperatures are between -10°C and -15°C and ground temperatures are warm from the previous summer.	Tetra Tech (2018)	Ongoing	3

13.3 New Dam Safety Issues

Tetra Tech has identified new dam safety issues for the A418 Dike as a result of this DSR, including deficiencies and non-conformances. These new dam safety issues were categorized and assigned priority rankings based on the definitions provided in Section 13.0.

A total of six new dam safety issues, including one deficiency and five non-conformances, were identified during this DSR. Table 13-3 provides a list of new dam safety issues along with Tetra Tech's recommended actions and priority rankings.

Table 13-3: New Dam Safety Issues for the A418 Dike

Dam Safety Issue Number	Dam Safety Issue Description	Dam Safety Issue Type	Recommendation	Current DSR Report Section	Priority Ranking
		Deficiencies			
2022-DSR-A418-D1	Erosion Protection between Stations 0+530 to 0+600 and Stations 0+700 to 0+750 ▪ Erosion protection was not observed and appeared to be missing from the upstream slope between Stations 0+550 and 0+580. ▪ Upstream erosion protection is oversteepened and near vertical along the upstream slope between Stations 0+530 to 0+600 and Stations 0+700 to 0+750.	Deficiency	▪ Reassess the areas of erosion protection along the A418 Dike's upstream slope between Stations 0+530 to 0+600 and Stations 0+700 to 0+750. ▪ It is recommended that DDMI, in consultation with the EOR, provide confirmation that the upstream slopes of the A418 Dike remain "fit for purpose" and meet the structure's design intent, despite the wave erosion and oversteepening that has occurred in the areas identified.	5.0	3
		Non-Conformances			
2022-DSR-A418-NC1	Emergency Response Test ▪ It is unknown when the last ERP Test was conducted for the A418 Dike.	Non-Conformance	▪ Conduct a formal ERP Test for the A418 Dike to conform with the CDA (2013) guidelines.	6.2	3
2022-DSR-A418-NC2	Failure Modes and Effects Assessment ▪ The current FMEA for the A418 Dike does not include any PFMs that were identified in the 2004 final design (NKSL 2004a, Figure 14.1) as well as several other PFMs identified in by the CDA (2016). ▪ The current FMEA was last updated in September 2020.	Non-Conformance	▪ Review and update the FMEA, in consultation with the EOR to capture the A418 Dike PFMs identified in the 2004 final design (NKSL 2004a, Figure 14.1) as well as those identified in Section 8.3 of this DSR.	8.3	4
2022-DSR-A418-NC3	Thermosyphon Group Ground Temperature Thresholds ▪ Most ground temperatures measured from thermistors in thermosyphon groups exceeded the current TARP Levels outlined in the ERP (i.e., single beads exceeding -2°C, group of beads exceeding -5°C).	Non-Conformance	▪ Review and revise, where necessary, the Ground Temperature TARP Levels for the thermistors in thermosyphon groups to reflect current design and performance requirements.	8.4.4	3
2022-DSR-A418-NC4	Seismic Stability Assessment Updates ▪ Seismic stability assessments for the A418 Dike are not based on the current seismic hazard values available from Earthquakes Canada. ▪ Post-seismic stability (i.e., post-earthquake loading conditions) has not been assessed for the A418 Dike, as recommended by the CDA (2019).	Non-Conformance	▪ Review and update seismic stability assessments for the A418 Dike with the current 2020 National Building Code of Canada seismic hazard values available from Earthquakes Canada. ▪ Assess the post-seismic stability of the A418 Dike using post-earthquake strengths to conform with the CDA (2019) guidelines.	9.3	3
2022-DSR-A418-NC5	Dike Safety Management System Documentation Revisions ▪ Revisions were identified following review of the DSMS documentation and should be completed during the next annual update.	Non-Conformance	▪ Recommended revisions to the DSMS documentation, pertaining to the A418 Dike, are listed in the following subsections of this report: – Section 11.1 (Emergency Response Plan); – Section 11.2 (Emergency Preparedness Plan); – Section 11.3 (Operations, Maintenance, and Surveillance Manual); and – Section 11.4 (Water Management Plan).	11.1 11.2 11.3 11.4	4

14.0 CONCLUSIONS

A DSR is considered to be a "snapshot in time" and the observations, reviews, assessments, and conclusions provided for the A418 Dike in this report are valid at the time of review. As the dike conditions change, the findings of this DSR may no longer be valid and a reassessment may be required. Conclusions from Tetra Tech's DSR for the A418 Dike are provided in the following subsections.

14.1 Summary of Findings

Tetra Tech completed a detailed DSR for the A418 Dike including a documentation review, site inspection, staff engagement, dam safety analysis, geotechnical and hydrotechnical assessments, DSRC review, and regulatory conformance review. Below is a summary of the findings from this DSR of the A418 Dike:

- DDMI staff and the EOR have a good understanding and are well qualified to fulfill their roles and responsibilities as they relate to the A418 Dike's DSRC;
- A site inspection of the A418 Dike observed that the structure was generally in good condition and consistent with those described in the 2021 AIPE (SLI 2021); however, two areas of erosion protection along the upstream slope of the dike were observed to have deficiencies and are recommended to be assessed;
- It is unknown when the last ERP Test was conducted and it is recommended that a formal test be completed for the A418 Dike;
- The CDA Consequence Classification of *Very High* that is currently assigned to the A418 Dike is appropriate for the structure;
- The current FMEA generally identifies and addresses the PFMs for the A418 mine workings; however, several PFMs related to failure of the A418 Dike are not included. Accordingly, it is recommended that the FMEA be updated, in consultation with the EOR, to capture the PFMs identified in the 2004 final design as well as those identified in this DSR;
- The instrumentation and performance monitoring program for the A418 Dike is comprehensive and aligns with the PFMs identified for the structure; however, several ground temperatures measured from thermistors in thermosyphon groups exceed the current TARP Levels outlined in the ERP. Accordingly, it is recommended that the Ground Temperature TARP Levels for the thermistors in thermosyphon groups be reviewed and updated to reflect current design and performance requirements;
- The overall level of geotechnical design for the A418 Dike is adequate, including the design basis and criteria selected as well as the geotechnical investigations and analyses performed; however, seismic stability assessments for the dike are not based on current seismic hazard values and post-seismic stability (i.e., post-earthquake loading conditions) has not been evaluated. Accordingly, it is recommended that the seismic stability assessments for the A418 Dike be reviewed and updated based on current seismic hazard values and CDA (2019) guidance;
- The A418 Dike is currently in regulatory conformance with Diavik's Water Licence conditions;
- This DSR of the A418 Dike has identified six new dam safety issues, including one deficiency and five non-conformances, that should be addressed in a timely manner to improve and maintain dam safety;
- It is understood that FPK from Diavik's Process Plant will be deposited into the A418 mine workings (open pit and underground) starting in 2023 until the end of mine life in the first quarter of 2026, which represents a substantial change to the downstream environment of the structure. Accordingly, it is recommended that the

A418 Dike's design, roles and responsibilities, consequence classifications, FMEA, and DSRCs be reviewed and updated to ensure that the requirements for a TSF are met as the pit converts to the A418 TSF.

Based on the DSR completed, the A418 Dike is operating safely and performing as intended. Current operation of the dike largely conforms to the CDA guidelines; however, there are some identified dam safety issues that are recommended to be addressed, as detailed in Section 13.0.

14.2 Next Dam Safety Review

This DSR conducted by Tetra Tech is the third review undertaken for A418 Dike. Per Diavik's Water Licence (Part G, Condition 30. b), DDMI are to conduct DSRs for "the A418 dike in 2017 and every five (5) years thereafter, or at a frequency approved by the Board" (WLWB 2021). This aligns with the DSR frequency suggested by the CDA for dikes with a consequence classification of *Very High* (CDA 2013, Table 5-1). Therefore, the next DSR for the A418 Dike is recommended be conducted in the summer of 2027.

Tetra Tech understands that FPK from Diavik's Process Plant will be deposited into the A418 mine workings (open pit and underground) starting in 2023 until the end of mine life in the first quarter of 2026, which represents a significant change to the dike's downstream environment. Accordingly, the CDA (2013) recommends that any significant change that may affect a dam's safety, including those due to "new developments downstream of the dam", should trigger a DSR or appropriate investigation. Therefore, the next DSR for the A418 Dike may be required before 2027.

15.0 CLOSURE

We trust this document meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
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PERMIT TO PRACTICE TETRA TECH CANADA INC.
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Date 9 NOVEMBER 2022
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APPENDIX A

TETRA TECH'S LIMITATIONS ON USE OF THIS DOCUMENT

LIMITATIONS ON USE OF THIS DOCUMENT

DAM SAFETY REVIEW REPORT

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the “Professional Document”).

The Professional Document is intended for the sole use of TETRA TECH’s Client (the “Client”) as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the “Contract” herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

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Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an “Authorized Party”), consideration for such authorization is the Authorized Party’s acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the “Limitations on Liability”). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party’s express acceptance of, and agreement to, the Limitations on Liability.

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Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH’s “Instruments of Professional Service”), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH’s Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH’s Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client’s current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. The content of this report represents the best judgment of TETRA TECH based on the available information. The observations, conclusions, and recommendations developed for this report are deemed to be valid as of the date of the site inspection. If any conditions change (e.g., loading, reservoir level, etc.), however, the dam performance may be altered and a reassessment is required. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by third parties other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this document, at or on the development proposed as of the date of the Professional Document requires a supplementary exploration, investigation, and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to explore, address or consider and has not explored, addressed or considered any environmental or regulatory issues associated with development on the subject site.

1.8 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems, methods and standards employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. TETRA TECH does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

1.9 APPLICABLE CODES, STANDARDS, GUIDELINES & BEST PRACTICE

This document has been prepared based on the applicable codes, standards, guidelines or best practice as identified in the report. Some mandated codes, standards and guidelines (such as Canadian Dam Association's Dam Safety Guidelines, ASTM, AASHTO Bridge Design/Construction Codes, Canadian Highway Bridge Design Code, National/Provincial Building Codes) are routinely updated and corrections made. TETRA TECH cannot predict nor be held liable for any such future changes, amendments, errors or omissions in these documents that may have a bearing on the assessment, design or analyses included in this report.

APPENDIX B

DIAVIK SEISMIC HAZARD VALUES

2020 National Building Code of Canada Seismic Hazard Tool

This application provides seismic values for the design of buildings in Canada under Part 4 of the National Building Code of Canada (NBC) 2020 as prescribed in Article 1.1.3.1. of Division B of the NBC 2020.

Seismic Hazard Values

User requested values

Code edition	NBC 2020
Site designation X_S	X_C
Latitude (°)	64.489
Longitude (°)	-116.239

Please select one of the tabs below.

NBC 2020 Additional Values Plots API

Background Information

The 5%-damped spectral acceleration ($S_a(T,X)$, where T is the period, in s, and X is the site designation) and peak ground acceleration (PGA(X)) values are given in units of acceleration due to gravity (g, 9.81 m/s^2). Peak ground velocity (PGV(X)) values are given in m/s. Probability is expressed in terms of percent exceedance in 50 years. Further information on the calculation of seismic hazard is provided under the *Background Information* tab.

The 2%-in-50-year seismic hazard values are provided in accordance with Article 4.1.8.4. of the NBC 2020. The 5%- and 10%-in-50-year values are provided for additional performance checks in accordance with Article 4.1.8.23. of the NBC 2020.

See the *Additional Values* tab for additional seismic hazard values, including values for other site designations, periods, and probabilities not defined in the NBC 2020.

NBC 2020 - 2%/50 years (0.000404 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.0832	0.0567	0.0336	0.0188	0.00609	0.00246	0.0409	0.0405

The log-log interpolated 2%/50 year $S_a(4.0, X_C)$ value is : **0.0080**

▼ Tables for 5% and 10% in 50 year values

NBC 2020 - 5%/50 years (0.001 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.0436	0.0315	0.0188	0.00976	0.00262	0.000906	0.0205	0.0206

The log-log interpolated 5%/50 year $S_a(4.0, X_C)$ value is : **0.0036**

NBC 2020 - 10%/50 years (0.0021 per annum) probability

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$

$S_a(0.2, X_C)$	$S_a(0.5, X_C)$	$S_a(1.0, X_C)$	$S_a(2.0, X_C)$	$S_a(5.0, X_C)$	$S_a(10.0, X_C)$	$PGA(X_C)$	$PGV(X_C)$
0.0247	0.019	0.0112	0.00541	0.00126	0.000398	0.0113	0.0114

The log-log interpolated 10%/50 year $S_a(4.0, X_C)$ value is : **0.0018**

Download CSV

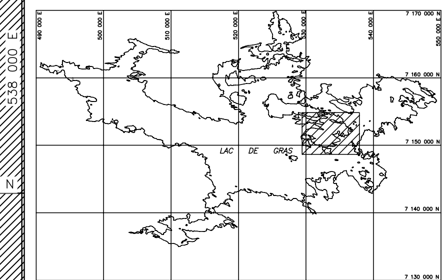
Go back to the seismic hazard calculator form

Date modified: 2021-04-06

APPENDIX C

A418 DIKE AS-BUILT DRAWINGS

PLATE 3



LOCATION PLAN

LEGEND:

- - - - - DREDGED SLURRY PIPELINE CORRIDOR

NKSL AS-BUILT

1 : 12 500   0 125 250 375 500 625 m

ENGINEERS STAMP: PROFESSIONAL ENGINEER — FEB.10, 2005 — D. A. RATTUE — LICENSEE — NWT

015803-3120-41DD-0003-01

NISHI-KHON/ SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

SITE LOCATION
A418 DIKE
GENERAL ARRANGEMENT

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
1	GENERAL REVISION	10 FEB. 2005	
0	ISSUED FOR CONSTRUCTION	03 NOV. 2004	
A	PRELIMINARY – 100%	30 JUL. 2004	

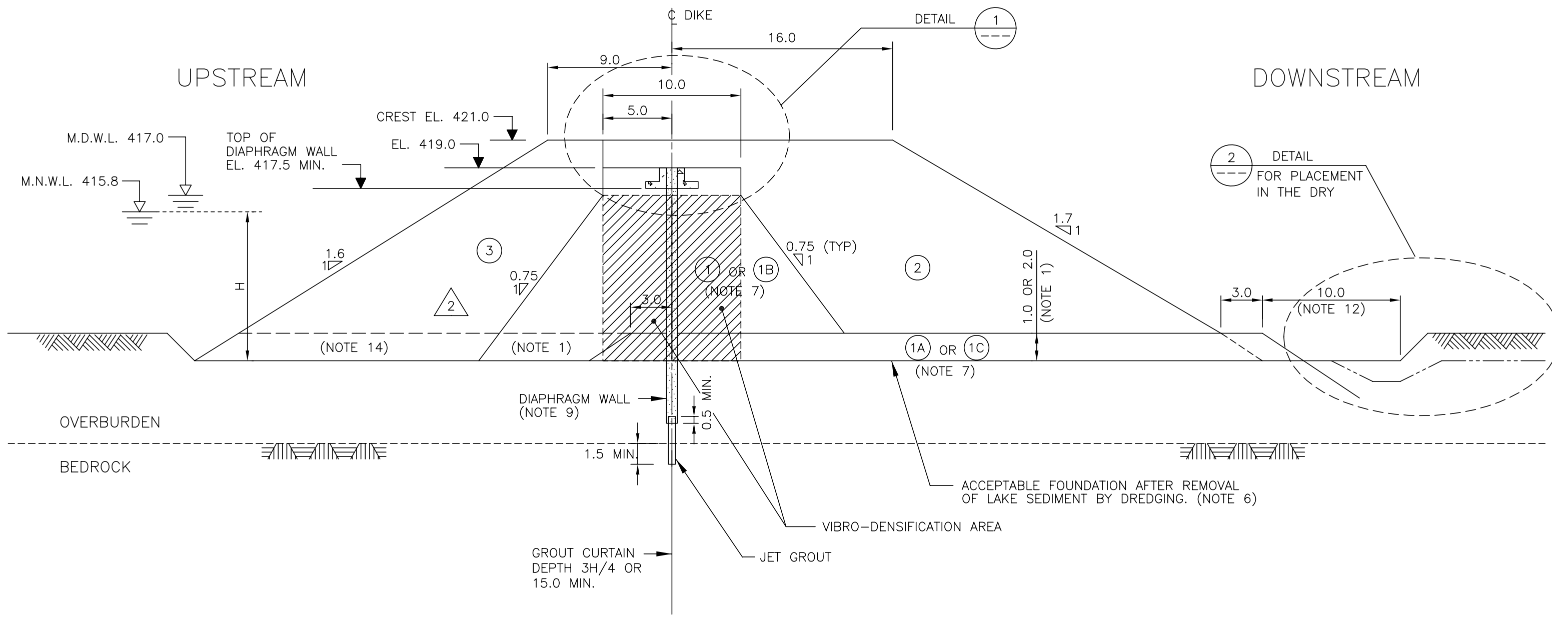
REFERENCE DRAWINGS (DWG. NO. / DESCRIPTION) — REVISIONS (NO. / DESCRIPTION / DATE / BY / CLIENT / PROJECT ENGINEER / COORD. / ENGINEER/DESIGNER / CHECK)

SECTION:
SCALE: 1:12 500
DESIGNED: G.Blanchette
DRAWN: D.Ouzelet
CHECKED: S.Zhou
APPROVED: A. RATTUE

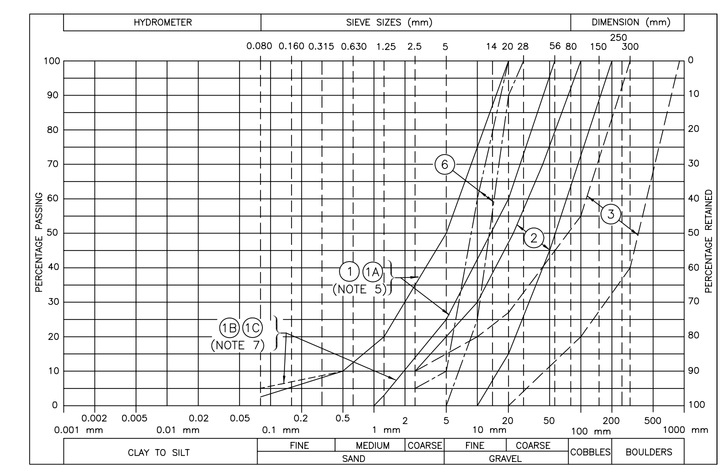
DIAVIK DIAMOND MINES INC.

FORMAT SIZE: A1
DRAWING NUMBER: 2140-41D2-1003
REV.: F

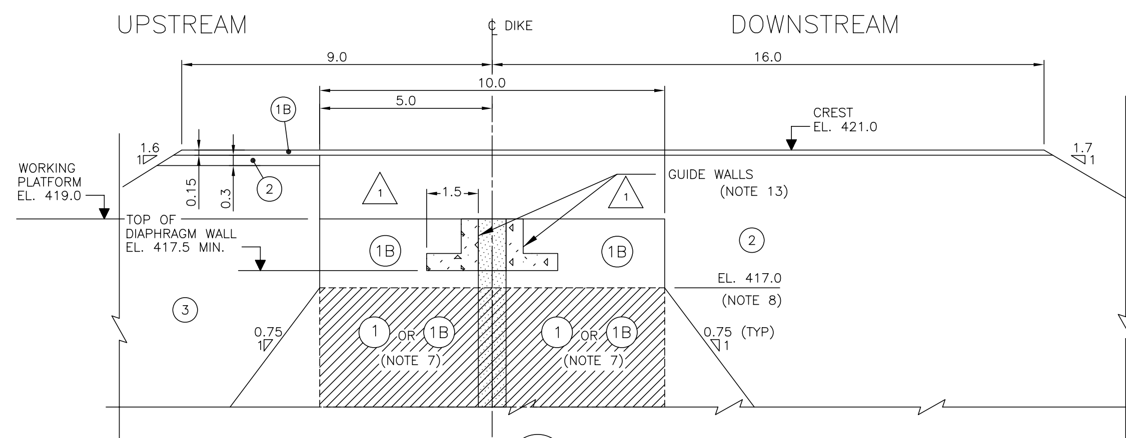
PLATE 6



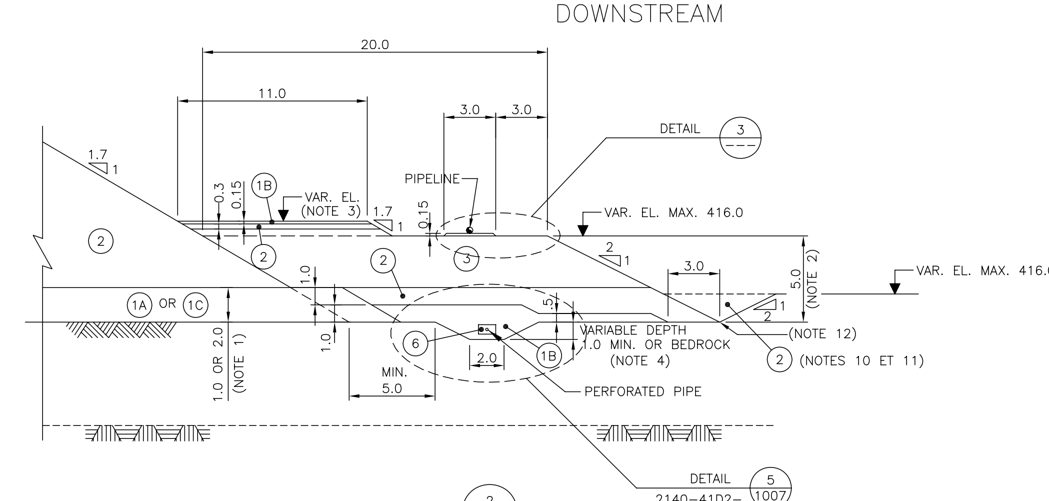
A418 DIKE – TYPICAL CROSS-SECTION "A"
IN THE LAKE
PLACEMENT IN THE WET
1 : 250



GRADATION CURVES

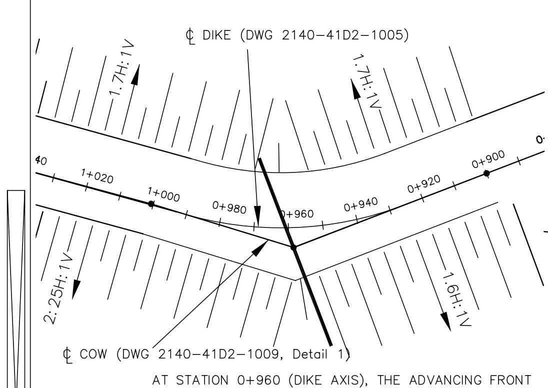


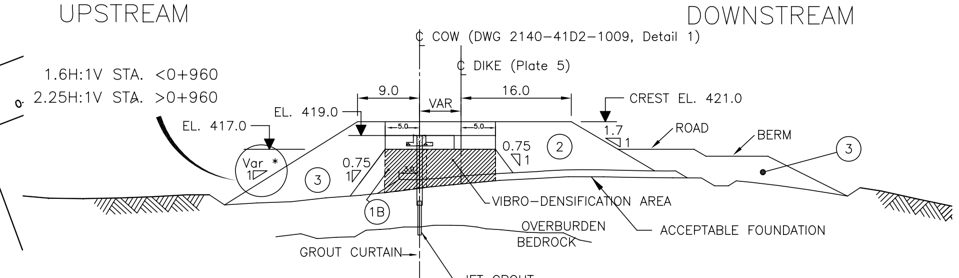
DETAIL 1
1 : 100



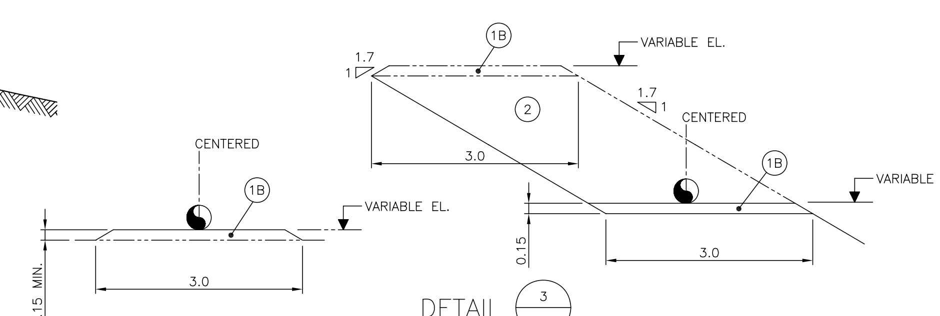
DETAIL 2
PLACEMENT IN THE DRY
1 : 200

REFERENCE RFI'S:
RFI CD0019-652 (TOE BERMS-BLANKET CONNECTION DET.)
RFI CD0019-657 (TOE BERMS-PROPOSED ZONE 3 FINAL ELEVATION)
RFI CD0019-657 REV1(TOE BERMS-PROPOSED ZONE 3 FINAL ELEVATION REVISED)
RFI CD0019-692 (TOE BERMS-INTERSECTION DPS-6 PAD AND TOE BERM CROSS-SECTION)





MODIFIED CROSS SECTION
NEAR STATION 0+960



DETAIL 3
1 : 50

NOTES:

1. ABOVE FOUNDATION LEVEL 410.0, THICKNESS OF FILTER BLANKET IS 1.0 m. BELOW FOUNDATION LEVEL 410.0, THICKNESS OF FILTER BLANKET IS 2.0 m. ADDITIONAL MATERIAL PLACED BY CLAMSHELL BETWEEN STATIONS 0+870 AND 0+950 TO REDUCE ABUTMENT SLOPE AND FILL LOW SPOT (SEE ALSO NOTE 14)
2. BERM THICKNESS IS 5m EXCEPT WHERE THE BERM ELEVATION IS SPECIFIED IN PLAN VIEWS.
3. ELEVATION AS REQUIRED TO BUILD THE ACCESS ROAD AND RAMPS.
4. TOE DRAINAGE TRENCH NOT REQUIRED WHEN FOUNDATION LEVEL EXCEEDS 415.0.
5. FOR CONSTRUCTION IN THE WET, ZONE 1 OR 1B MATERIAL PLACED BY DUMPING ON THE ADVANCING FILL AND PUSHING INTO WATER BY DOZER. ZONE 1A OR 1C PLACED BY CLAMSHELL DIRECTLY ONTO LAKEBED. FOR CONSTRUCTION IN THE DRY, ZONE 1B MATERIAL PLACED IN LAYERS.
6. PREPARATION OF ACCEPTABLE FOUNDATION FOR ZONES 1, 1A, 1B AND 1C INCLUDES THE REMOVAL OF BOULDER NESTS. SEDIMENT REMOVAL IS REQUIRED FOR THE ENTIRE FOOTPRINT.
7. ZONES 1B AND 1C REPLACE ZONES 1 AND 1A MATERIALS RESPECTIVELY WHERE THE DIKE FOUNDATION IS ABOVE LEVEL 410
8. THE LIMITS INDICATE THE MINIMUM ZONE DENSIFIED. THE PLATFORM AT THE TIME OF THE WORK MAY BE BETWEEN ELEVATIONS 416.5 AND 417.5.
9. THE MINIMUM EXCAVATION CRITERIA IS 3 m INTO TILL OR 0.25 H MEASURED RELATIVE TO DIKE AXIS, WHICHEVER IS THE GREATER, DISCOUNTING THE PRESENCE OF ANY GRANULAR MATERIAL WHICH MAY OVERLY TILL.
10. BACKFILL AS REQUIRED TO SUIT OVERALL DRAINAGE PATTERN.
11. BACKFILL AS DIRECTED BY MANAGER'S REPRESENTATIVE AT INSTRUMENT LOCATIONS.
12. REMOVAL OF LAKE SEDIMENT FROM 10.0 m POINT OUT TO FINAL TOE CARRIED OUT AFTER DEWATERING.
13. THE REAL DIMENSION OF GUIDE WALLS DETERMINED BY CUT OFF SUBCONTRACTOR
14. BETWEEN STATIONS 0+870 AND 0+950 ZONE 2 MATERIAL PLACED FROM A BARGE TO REPROFILE THE ABUTMENT SLOPE (2H:1V) AND FILL THE DEPRESSION TO ELEVATION 395 PRIOR TO THE ADVANCE OF ZONE 3 EMBANKMENT.
15. CONTRACTORS AS-BUILT CROSS-SECTIONS SHOWN ON DRAWINGS SK-LDG-AB-004 SHEETS 1 TO 11.

LEGEND:

(hatch)	GROUND LEVEL
(hatch)	ASSUMED BEDROCK LEVEL
M.N.W.L.	MAXIMUM NORMAL WATER LEVEL (1:2 YEARS)
M.D.W.L.	MAXIMUM DESIGN WATER LEVEL (1:10 000 YEARS)
RFI	CONTRACTOR'S REQUEST FOR INFORMATION/CLARIFICATION

ZONES:

- (1) 0–56 mm CRUSHED STONE (DUMPED OR PLACED)
- (1A) 0–56 mm CRUSHED STONE (CLAMSHELL)
- (1B) 0–56 mm CRUSHED STONE (DUMPED OR PLACED)
- (1C) 0–56 mm CRUSHED STONE (CLAMSHELL)
- (2) 0–200 mm CRUSHED STONE
- (3) 0–900 mm QUARRY ROCK
- (6) DRAIN MATERIAL

NKSL AS-BUILT

1 : 50	0	0.5	1	1.5	2	2.5 m
1 : 100	0	1	2	3	4	5 m
1 : 200	0	2	4	6	8	10 m
1 : 250	0	2.5	5	7.5	10	12.5 m

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

ENGINEERS STAMP: REGISTERED PROFESSIONAL ENGINEER, JUN.23, 2005, D. A. RATTUE, LICENSEE, NWT

NKSL DRAWING NUMBER 015803-3120-41DD-0006-01

NISHI-KHON/SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

A418 DIKE
TYPICAL CROSS-SECTIONS
SHEET 1 OF 2

DWG. NO.	DESCRIPTION
41D2-1022	VIBRO-DENSIFICATION – DETAILS
41D2-1021	CUTOFF WALL AND GROUT CURTAIN

REFERENCE DRAWINGS

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	

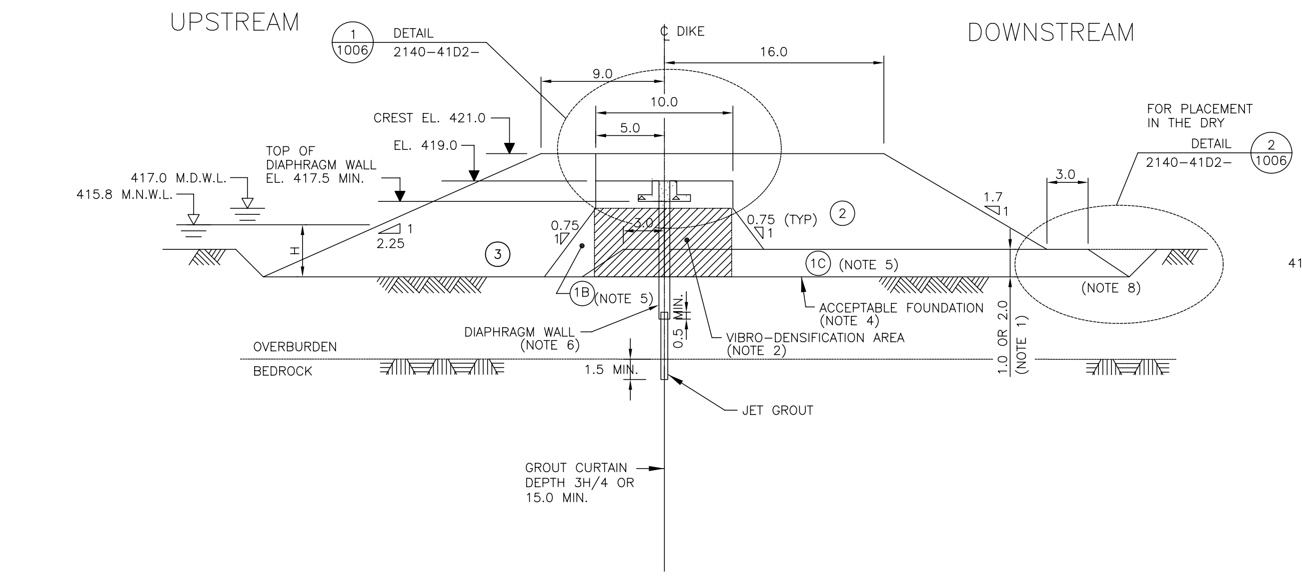
NO.	DESCRIPTION	DATE	BY
2	REVISION TO CLAMSHELL PLACING	23 JUN. 2005	
1	REVISED AS SHOWN	10 FEB. 2005	
0	ISSUED FOR CONSTRUCTION	03 NOV. 2004	
A	PRELIMINARY – 100%	30 JUL. 2004	

REVISIONS

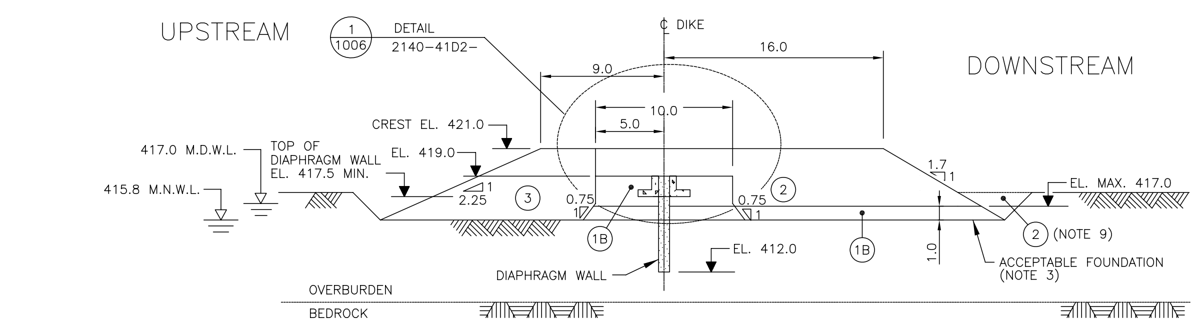
SECTION:
SCALE: AS SHOWN
DESIGNED: A.Rattue
DRAWN: D.Ouzelet
CHECKED: D.Lemelin
APPROVED: A. RATTUE

DIAVIK DIAMOND MINES INC.

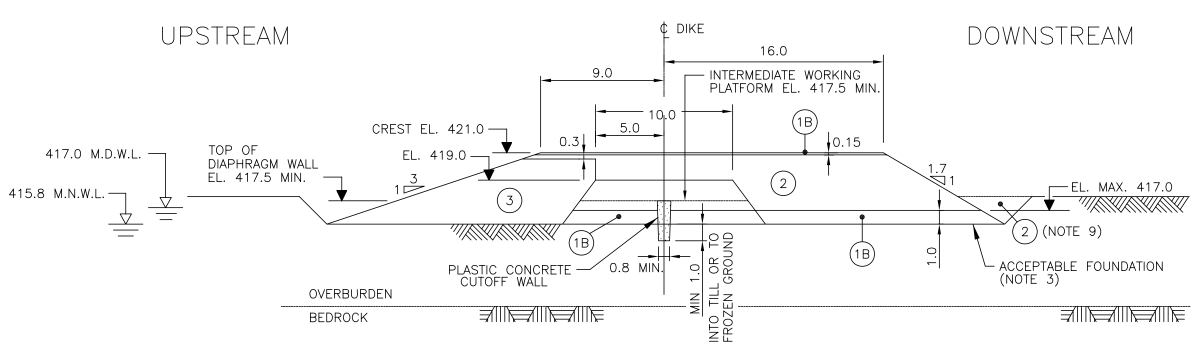
FORMAT SIZE: A1
DRAWING NUMBER: 2140-41D2-1006
REV.: F



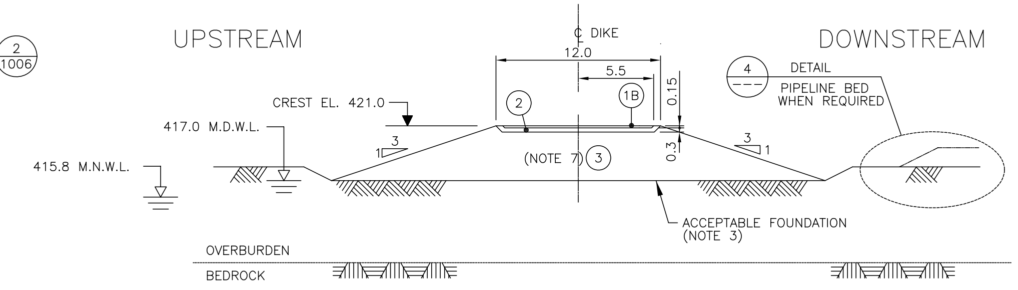
A418 DIKE – TYPICAL CROSS-SECTION "B"
NEAR SHORELINE (NOTE 10)
1 : 250



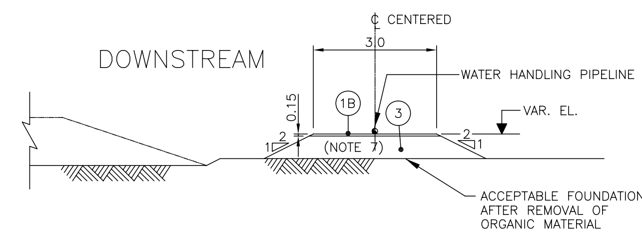
A418 DIKE – TYPICAL CROSS-SECTION "C"
BELOW EL. 417.0 (NOTE 10)
1 : 250



A418 DIKE – TYPICAL CROSS-SECTION "D"
ON ABUTMENTS (NOTES 10 AND 12)
1 : 250



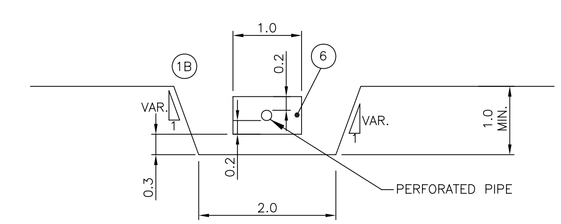
A418 DIKE – TYPICAL ON LAND CROSS-SECTION "E"
1 : 250



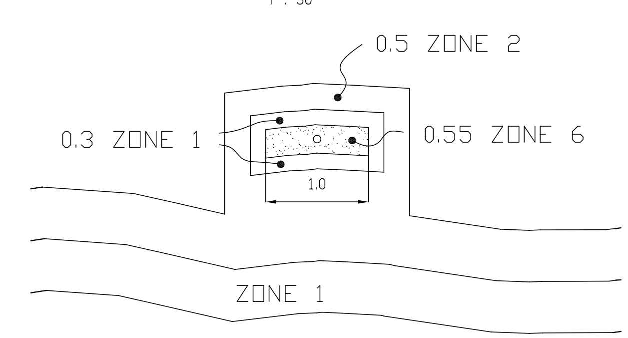
DETAIL 4 REF. RFI CD0019-680 (TOE-BERM ACCESS ROAD AND PIPE BENCH AT ISLAND "C")

PIPELINE BED REF. RFI CD0019-688 (THE PIPE BENCH FROM STA. 0+160 TO 0+280 IS 3 m OPPOSED TO 9 M)

1 : 250



DETAIL 5
1 : 50



ALTERNATE DETAIL USED NEAR DPS-6
N.T.S

PLATE 7

NOTES:

1. ABOVE FOUNDATION LEVEL 410.0, THICKNESS OF FILTER BLANKET IS 1.0 m
   BELOW FOUNDATION LEVEL 410.0, THICKNESS OF FILTER BLANKET IS 2.0 m
2. VIBRO-DENSIFICATION CARRIED OUT WHERE FOUNDATION LEVEL IS BELOW 414 m.
3. EXCAVATION OF BOULDERS, ACTIVE LAYER AND ORGANIC MATERIAL TO ACCEPTABLE FOUNDATION AS DIRECTED BY MANAGER'S REPRESENTATIVE.
4. PREPARATION OF ACCEPTABLE FOUNDATION FOR ZONES 1, 1A, 1B AND 1C INCLUDES THE REMOVAL OF BOULDER NESTS. SEDIMENT REMOVAL IS REQUIRED FOR THE ENTIRE FOOTPRINT.
5. NOT USED
6. THE MINIMUM EXCAVATION CRITERIA IS 3 m INTO TILL OR 0.25 H MEASURED RELATIVE TO DIKE AXIS, WHICHEVER IS THE GREATER DISCOUNTING THE PRESENCE OF ANY GRANULAR MATERIAL WHICH MAY OVERLY TILL.
7. WHEN EMBANKMENT HEIGHT DOES NOT ALLOW PLACEMENT OF ZONE 3 MATERIAL, THIS ZONE REPLACED BY ZONE 2.
8. REMOVAL OF LAKE SEDIMENT FROM 10.0 m POINT OUT TO FINAL TOE CARRIED OUT AFTER DEWATERING.
9. BACKFILL AS DIRECTED BY MANAGER'S REPRESENTATIVE.
10. DIKE CUTOFF COMPRISES A DIAPHRAGM WALL AND/OR JET GROUT AS INDICATED ON 2140-41D2-1011 AND 2140-41D2-1012
11. CONTRACTORS AS-BUILT CROSS-SECTIONS SHOWN ON DRAWINGS SK-LDGC-AB-004 SHEETS 1 TO 11.
12. REF. LETTER #NKSL-LDG-CD0019-0210

LEGEND:

GROUND LEVEL
ASSUMED BEDROCK LEVEL
M.N.W.L. MAXIMUM NORMAL WATER LEVEL (1:2 YEARS)
M.D.W.L. MAXIMUM DESIGN WATER LEVEL (1:10 000 YEARS)
RFI CONTRACTOR'S REQUEST FOR INFORMATION/CLARIFICATION

ZONES:

(1) 0-56 mm CRUSHED STONE (DUMPED OR PLACED)
(1A) 0-56 mm CRUSHED STONE (CLAMSHELL)
(1B) 0-56 mm CRUSHED STONE (DUMPED OR PLACED)
(1C) 0-56 mm CRUSHED STONE (CLAMSHELL)
(2) 0-200 mm CRUSHED STONE
(3) 0-900 mm QUARRY ROCK
(6) DRAIN MATERIAL

NKSL AS-BUILT

1 : 50 0 0.5 1 1.5 2 2.5 m
1 : 250 0 2.5 5 7.5 10 12.5m

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

ENGINEERS STAMP — REGISTERED PROFESSIONAL ENGINEER, DEC.21, 2005, D. A. RATTUE, LICENSEE, NWT

NKSL DRAWING NUMBER 015803-3120-41DD-0007-01

NISHI-KHON/SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

A418 DIKE
TYPICAL CROSS-SECTIONS
SHEET 2 OF 2

DWG. NO.	DESCRIPTION
41D2-1022	VIBRO-DENSIFICATION – DETAILS
41D2-1021	CUTOFF WALL AND GROUT CURTAIN
41D2-1006	TYPICAL CROSS-SECTIONS 1/2
41D2-1005	EXCAVATION – PLAN

REFERENCE DRAWINGS

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	

REVISIONS

NO.	DESCRIPTION	DATE	BY
2	REVISED AS SHOWN	21 DEC. 2005	
1	REVISED AS SHOWN	10 FEB. 2005	
0	ISSUED FOR CONSTRUCTION	03 NOV. 2004	
A	PRELIMINARY – 100%	30 JUL. 2004	

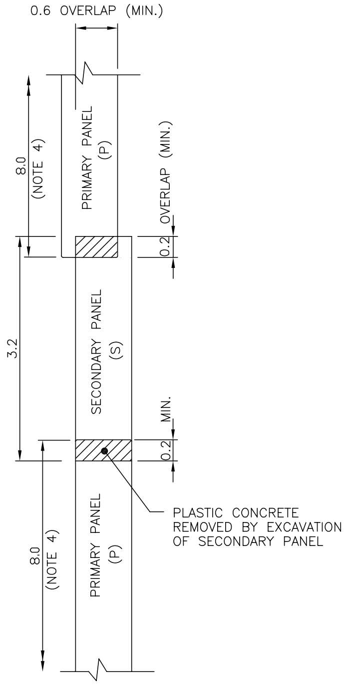
REVISIONS

SECTION:
SCALE: AS SHOWN
DESIGNED: A.Rattue
DRAWN: D.Ouzelet
CHECKED: D.Lemelin
APPROVED: A. RATTUE

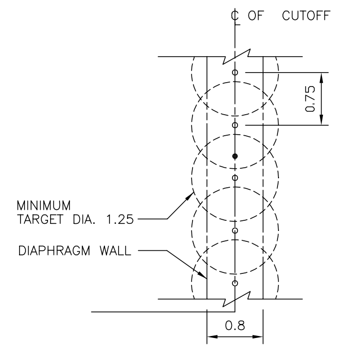
DIAVIK DIAMOND MINES INC.

FORMAT SIZE A1
DRAWING NUMBER 2140-41D2-1007
REV. F

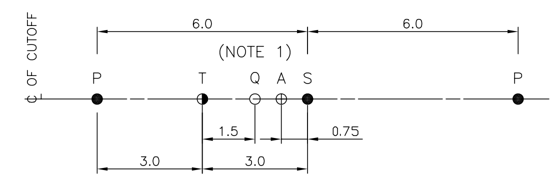
PLATE 21



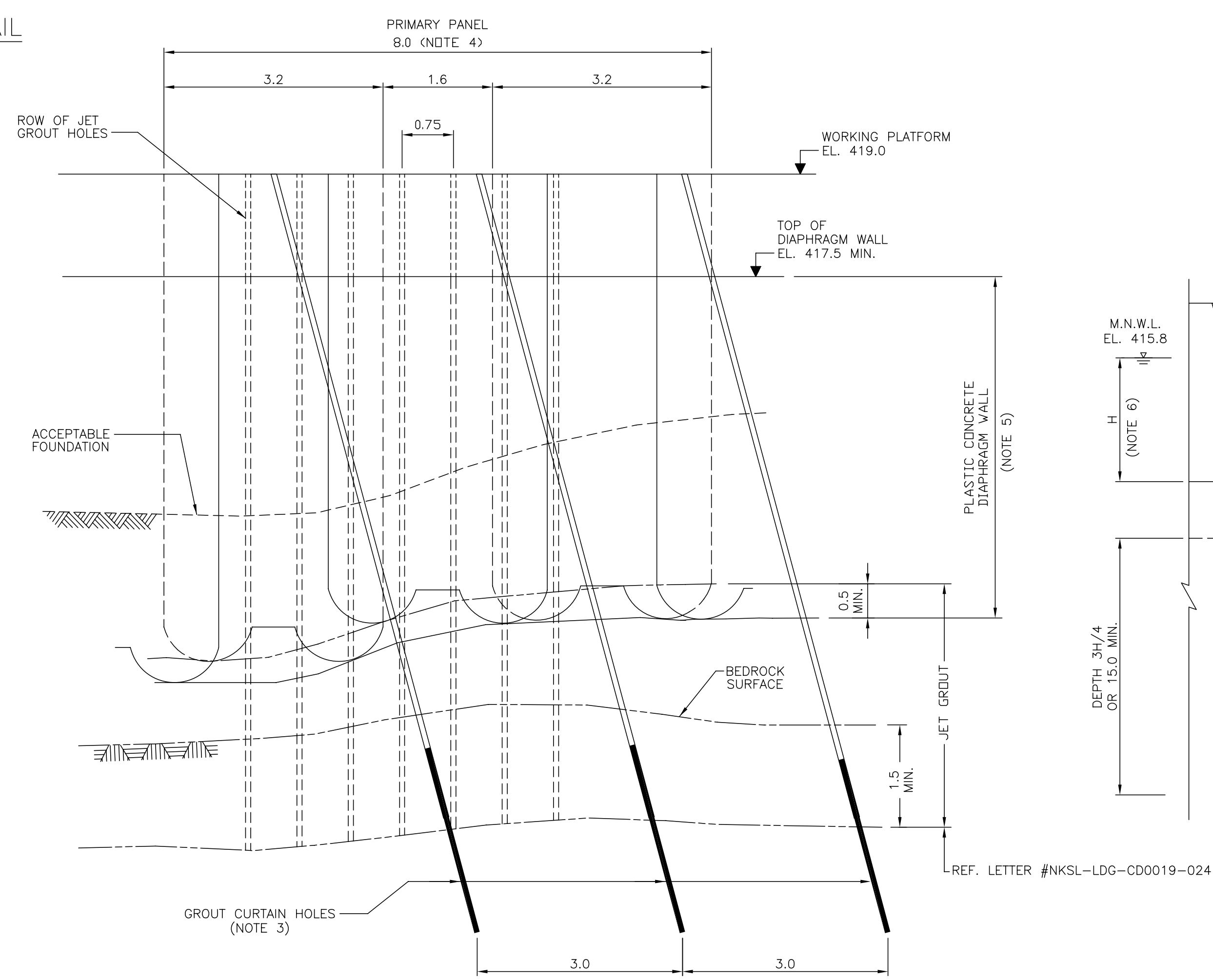
DIAPHRAGM WALL DETAIL
PLAN
1 : 50



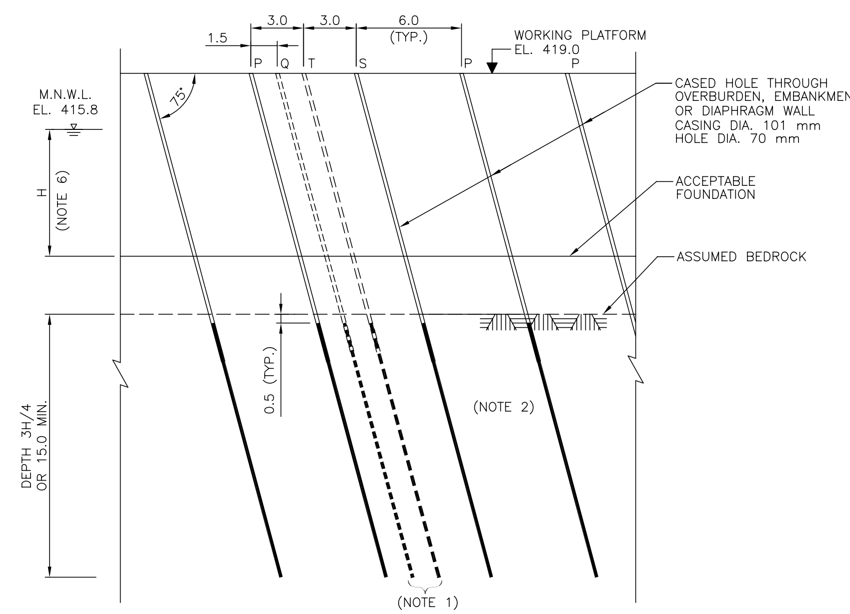
JET GROUT
CUTOFF DETAIL
PLAN
1 : 50



GROUT CURTAIN DETAIL
PLAN
1 : 100



JET GROUT DETAIL
SECTION
1 : 50



GROUT CURTAIN DETAIL
SECTION
1 : 200

NOTES:

1. QUATERNARY AND ADDITIONAL GROUT HOLES WHERE REQUIRED.
2. AZIMUTH AND INCLINATION OF GROUT HOLES ADJUSTED AS REQUIRED AT PERMAFROST BOUNDARIES TO COVER REQUIRED SURFACE AREA.
3. CURTAIN GROUT HOLES GENERALLY DIPPING 75° TO NORTH EXCEPT IN CURVED ALIGNMENT AND AS REQUIRED TO GROUT BELOW ABUTMENTS.
4. PANEL LENGTHS FOR ILLUSTRATION ONLY. SUBJECT TO ADJUSTMENT AS NECESSARY TO SUIT EQUIPMENT AND FOR REASONS OF TRENCH STABILITY.
5. DIAPHRAGM WALL TO ROCK OR IN TILL TO 0.25H OR 3 m MIN.
6. H IS MEASURED ON DIKE AXIS.
7. REF. LETTER #NKSL-LDG-CD0019-0199
REF. LETTER #NKSL-LDG-CD0019-0241
REF. LETTER #NKSL-LDG-CD0019-0259

LEGEND:

- P ● PRIMARY HOLE
- S ● SECONDARY HOLE
- T ◑ TERTIARY HOLE
- Q ○ QUARTERNARY HOLE
- A ⊕ ADDITIONAL HOLE

M.N.W.L. MAXIMUM NORMAL WATER LEVEL (1:2 YEARS)

NKSL AS-BUILT

1 : 50 0 0.5 1 1.5 2 2.5 m
1 : 100 0 1 2 3 4 5 m
1 : 200 0 2 4 6 8 10 m

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

ENGINEERS STAMP: REGISTERED PROFESSIONAL ENGINEER, FEB.10, 2005, D. A. RATTUE, LICENSEE, NWT

NKSL DRAWING NUMBER 015803-3130-4GDD-0001-01

NISHI-KHON/SNC ◆ LAVALIN

DIAVIK DIAMOND MINE
A418 DIKE
CUTOFF WALL AND GROUT CURTAIN DETAILS

FORMAT SIZE: A1 | DRAWING NUMBER: 2140-41D2-1021 | REV.: F

DWG. NO.	DESCRIPTION
41D2-1022	VIBRO-DENSIFICATION - DETAILS
41D2-1006	TYPICAL CROSS-SECTIONS 1/2

REFERENCE DRAWINGS

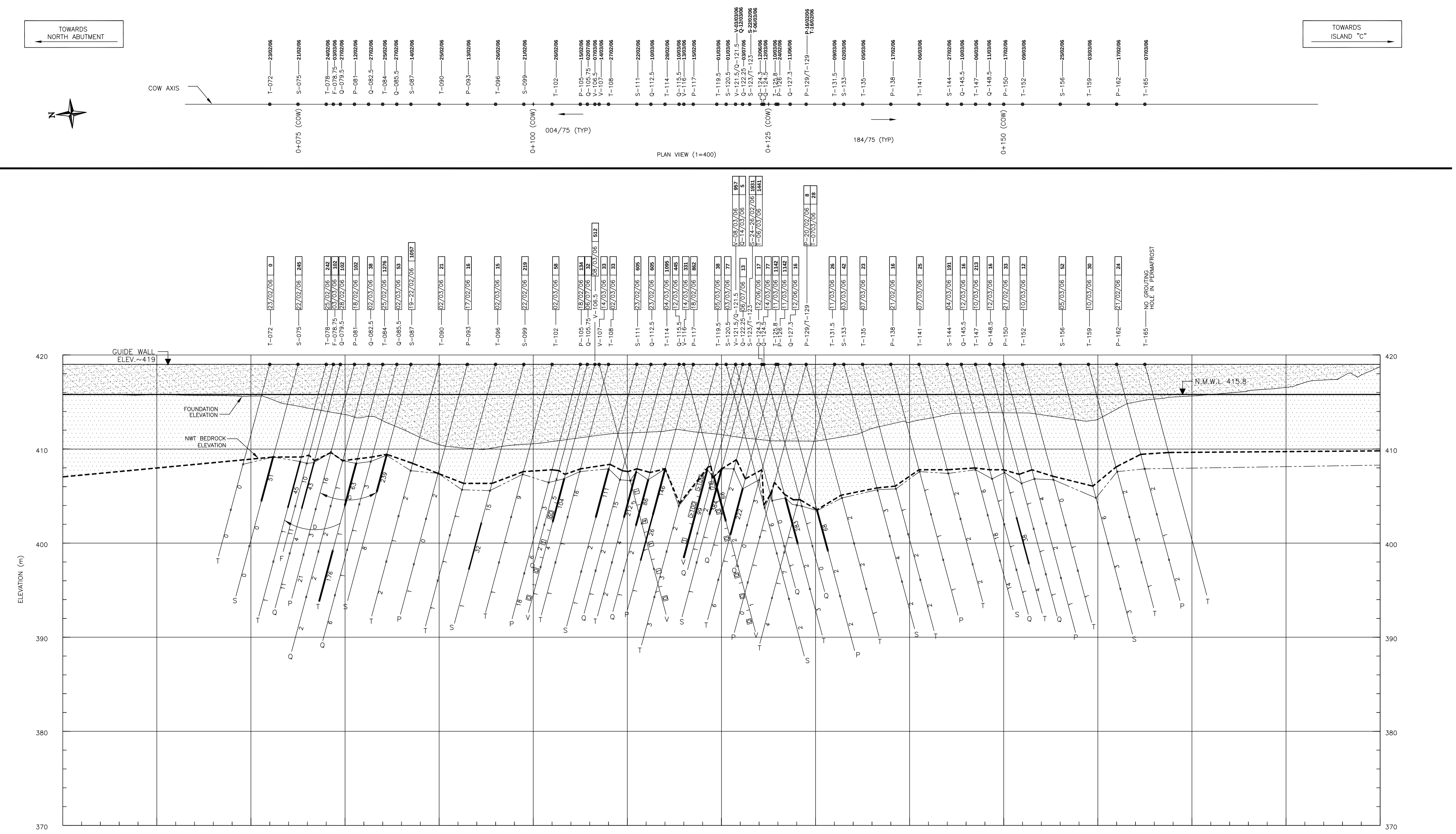
NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
1	REVISED AS SHOWN	10 FEB. 2005	
0	ISSUED FOR CONSTRUCTION	03 NOV. 2004	
A	PRELIMINARY - 100%	30 JUL. 2004	

REVISIONS

		DATE
SECTION:		
SCALE:	AS SHOWN	
DESIGNED:	D.Lemelin	MAY 2004
DRAWN:	D.Ouzelet	MAY 2004
CHECKED:	D.Lemelin	MAY 2004
APPROVED:	A. RATTUE	MAY 2004

DIAVIK DIAMOND MINES INC.

PLATE 21A



ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- 23/02/06 DRILLING DATE
- T-072 HOLE AND STATION NUMBER
- 23/02/06 | 230 GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G COMMUNICATION DURING GROUTING
- D COMMUNICATION DURING DRILLING
- LUGEON VALUE (FROM WATER TEST)
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- * PACKER SETTING

STATION (COW)

LONGITUDINAL PROFILE ALONG COW AXIS: FORMAT A1 (1=200)

NOTES:
- LOST DRILLING BIT AT 0+141 (26.1 m DEEP)
- LOST CASING AT STA. 0+153 (4 m)

NKSL AS-BUILT

DWG. NO.	DESCRIPTION
REFERENCE DRAWINGS	

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	

SECTION:
SCALE: AS SHOWN
DESIGNED: GB
DRAWN: DL
CHECKED: GB
APPROVED: SA

DIAVIK DIAMOND MINES INC.

ENGINEERS STAMP

NKSL DRAWING NUMBER 015803–3xxx–xxxx–xxxx–00

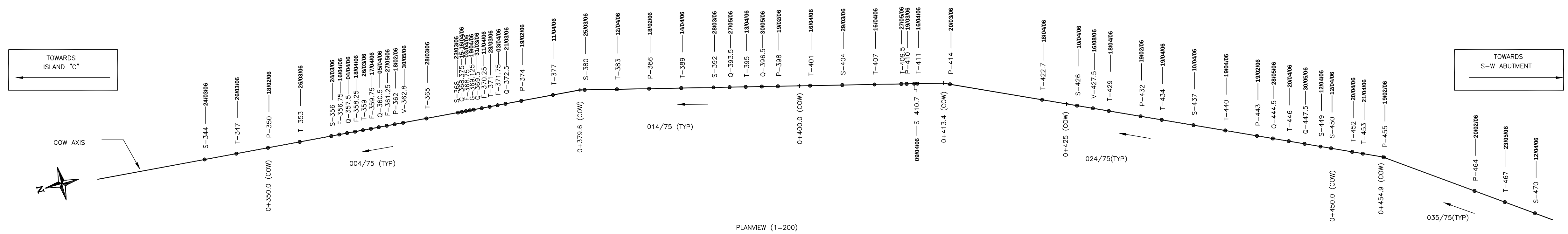
NISHI–KHON/ SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

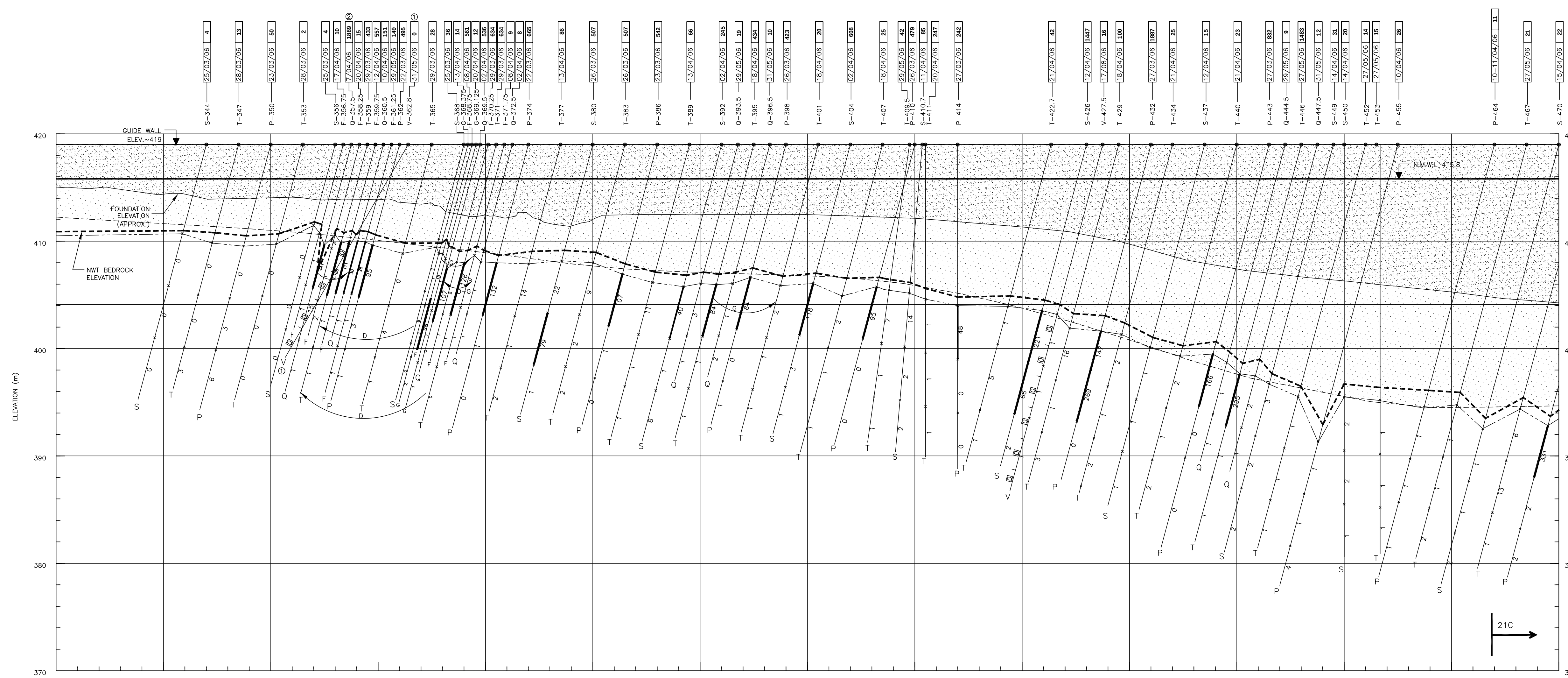
A418 DIKE – CURTAIN GROUTING
GROUT HOLE LAYOUT
FROM STA. 0+075(COW) TO 0+165(COW)

FORMAT SIZE: A1
DRAWING NUMBER: 2140–41D2–1021A
REV.: F

PLATE 21B



PLANVIEW (1=200)



STATION (COW)
LONGITUDINAL PROFILE ALONG COW AXIS (1=200)

LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- **23/02/06** DRILLING DATE
- T–072 HOLE AND STATION NUMBER
- 23/02/06 | 230 GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G COMMUNICATION DURING GROUTING
- D COMMUNICATION DURING DRILLING
- [0] LUGEON VALUE (FROM WATER TEST)
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- × PACKER SETTING

NOTE:

- LOST CASINGS AT 0+383 (2 m), 0+401 (4 m), 0+410.7 (2 m), 0+449 (6 m), 0+467 (2 m) & 0+470 (4 m).
- LOST STEEL CROWN BIT AT 0+423,
- LOST HAMMER AT 0+410.3 (13.7 m DEEP)
- HIT STEEL AT 0+430 (15.8 m DEEP)

① VERIFICATION HOLE V–362.8: LUGEON VALUE < 3, HOLE BACKFILLED.

② CASING SET TOO DEEP IN BEDROCK. REMOVED CASING OF 3 m FOR GROUTING UPPER STAGE AND TO OVERLAP THE JET GROUT IN THAT AREA.

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

NKSL AS-BUILT

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
2	REVISED HOLE LAYOUT	MAR 06 2006	
1	TERTIARY HOLES ADDED	FEB 18 2006	

REVISIONS

REFERENCE DRAWINGS (DWG. NO. / DESCRIPTION)

SECTION:
SCALE: AS SHOWN
DESIGNED: GB
DRAWN: DL
CHECKED: CB
APPROVED: SA

DIAVIK DIAMOND MINES INC.

ENGINEERS STAMP

NKSL DRAWING NUMBER 015803–xxxx–xxxx–xxxx–xx

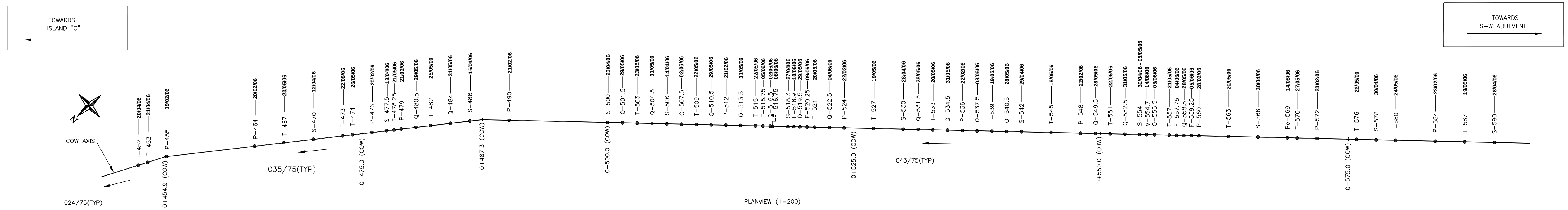
NISHI–KHON/ SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

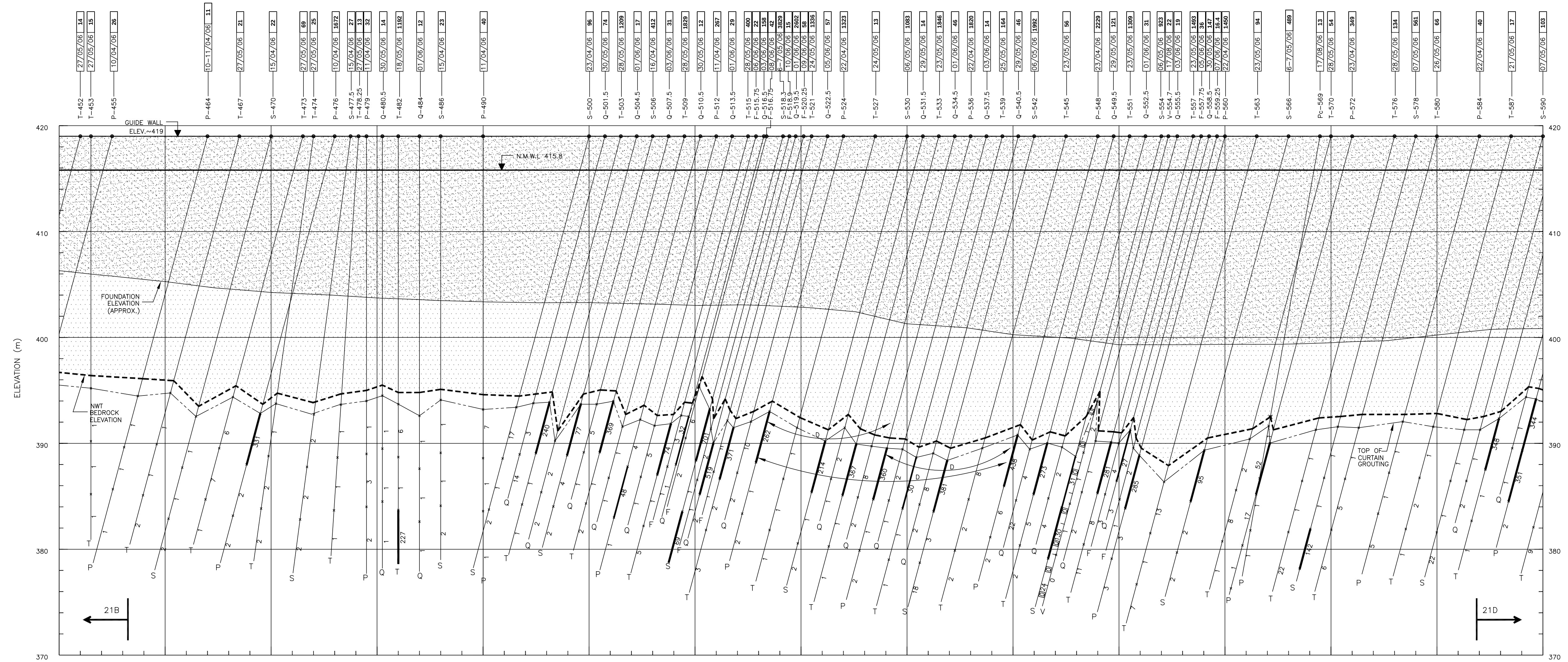
A418 DIKE – CURTAIN GROUTING GROUT HOLE LAYOUT FROM STA. 0+340(COW) TO 0+460(COW)

FORMAT SIZE: A1
DRAWING NUMBER: 2140–41D2–1021B
REV.: F

PLATE 21C



PLANVIEW (1=200)



LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- 23/02/06 — DRILLING DATE
- T–072 — HOLE AND STATION NUMBER
- 23/02/06 | 230 — GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G — COMMUNICATION DURING GROUTING
- D — COMMUNICATION DURING DRILLING
- LUGEON VALUE (FROM WATER TEST)
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- × PACKER SETTING

LONGITUDINAL PROFILE ALONG COW AXIS (1=200)

NOTES:

LOST CASINGS AT 0+467 (2 m), 0+470 (4 m), 0+476.75 (6 m), 0+516.75 (8 m), 0+518 (0.15 m)
0+539 (4 m), 0+569 (2 m), 0+575 (2 m), 0+582 (4 m) & 0+587 (26 m).
LOST DRILLING BIT AT STA. 0+483 & 0+581

NKSL AS-BUILT

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
2	REVISED HOLE LAYOUT	MAR 06 2006	
1	TERTIARY HOLES SHOWN	FEB 18 2006	

REVISIONS

REFERENCE DRAWINGS (DWG. NO. | DESCRIPTION)

SECTION:
SCALE: AS SHOWN
DESIGNED: GB
DRAWN: DL
CHECKED: GB
APPROVED: SA

DIAVIK DIAMOND MINES INC.

ENGINEERS STAMP

NKSL DRAWING NUMBER 015803–xxxx–xxxx–xxxx–xx

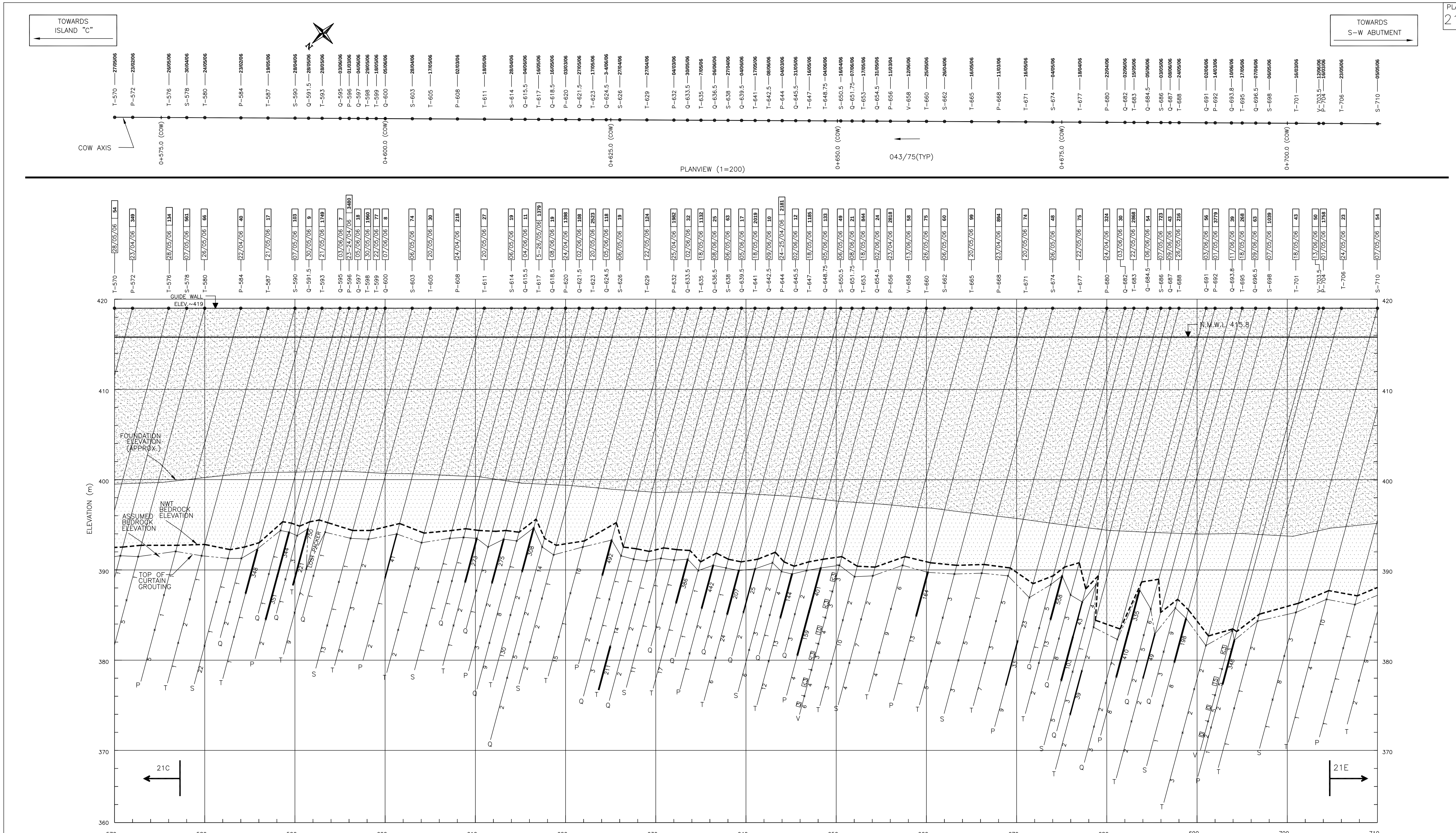
NISHI–KHON/SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

A418 DIKE – CURTAIN GROUTING GROUT HOLE LAYOUT FROM STA. 0+460(COW) TO 0+580(COW)

FORMAT SIZE: A1 | DRAWING NUMBER: 2140–41D2–1021C | REV.: F

PLATE 21D



LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- 23/02/06 DRILLING DATE
- T-072 HOLE AND STATION NUMBER
- 23/02/06 230 GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G COMMUNICATION DURING GROUTING
- D COMMUNICATION DURING DRILLING
- LUGEON VALUE (FROM WATER TEST)
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- PACKER SETTING

STATION (COW)
LONGITUDINAL PROFILE ALONG COW AXIS: FORMAT A1 (1=200)

NOTE:
- LOST CASING AT STA. 0+575 (2 m), 0+582 (4 m), 0+587 (20 m), 0+594.5 (2 m) 0+603 (2 m), 0+650 (2 m), 0+689 (6 m), 0+693.5, 0+707 (2 m) & 0+708 (4 m)
- HIT STEEL AT STA. 0+690 (32.6 m DEEP).
- LOST DRILLING BIT AT STA. 0+581.
- LOST PACKER AT STA. 0+599.
- LOST DRILLING RODS AT STA. 0+659 (12 m WITH DOWN THE HOLE HAMMER) & 0+681.5 (2 m).

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

NKSL AS-BUILT

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
1	TERTIARY HOLES SHOWN	FEB 18 2006	

REFERENCE DRAWINGS — REVISIONS

SECTION:
SCALE: AS SHOWN
DESIGNED: GB
DRAWN: DL
CHECKED: GB
APPROVED: SA

DIAVIK DIAMOND MINES INC.

ENGINEERS STAMP
NKSL DRAWING NUMBER 015803-3xxx-xxxx-xxxx-00

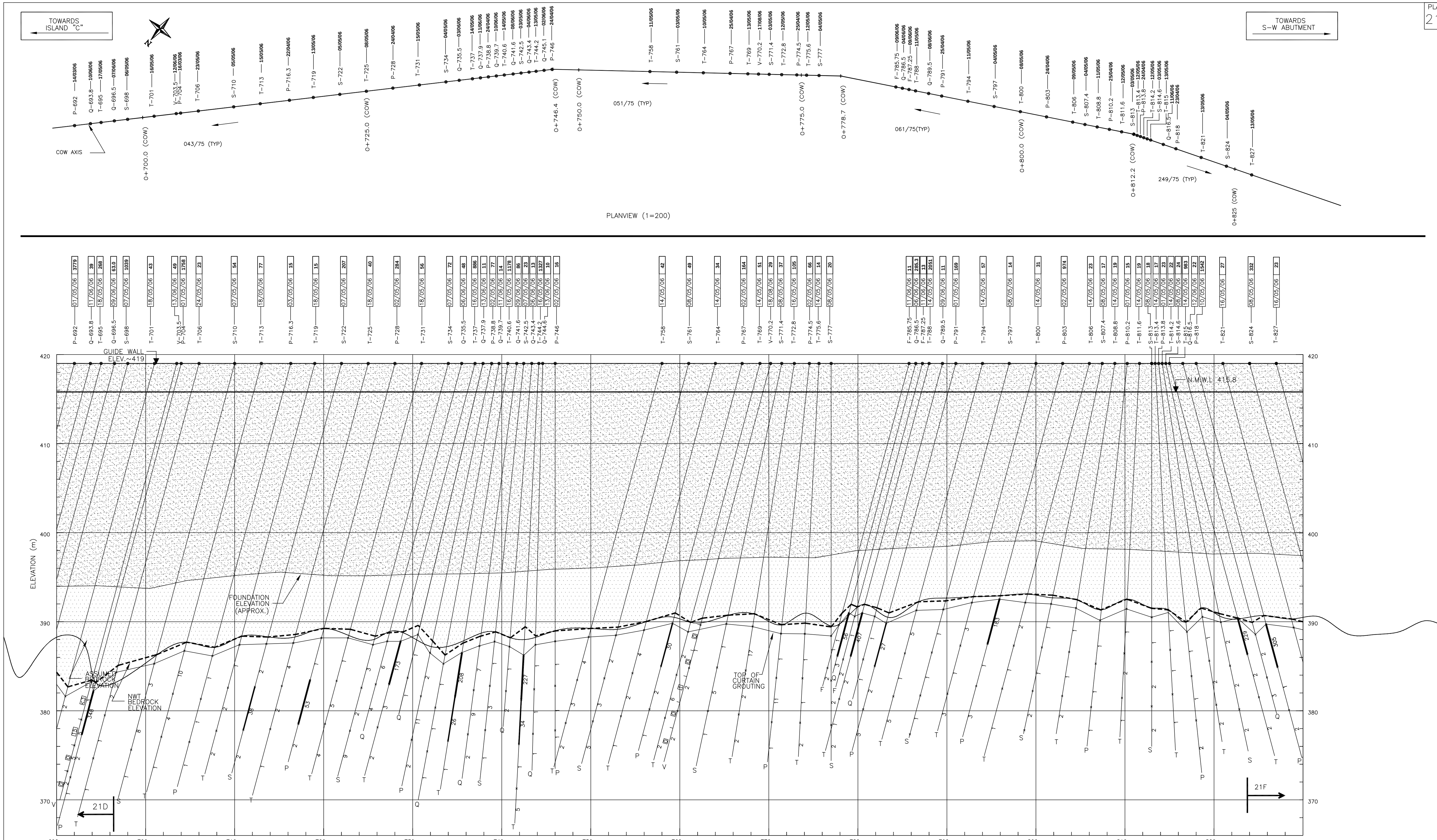
NISHI-KHON/ SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

A418 DIKE – CURTAIN GROUTING GROUT HOLE LAYOUT FROM STA. 0+580(COW) TO 0+700(COW)

FORMAT SIZE: A1
DRAWING NUMBER: 2140-41D2-1021D
REV.: F

PLATE 21E



LONGITUDINAL PROFILE ALONG COW AXIS (1=200)

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- 23/02/06 DRILLING DATE
- T-072 HOLE AND STATION NUMBER
- 23/02/06 | 230 GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G COMMUNICATION DURING GROUTING
- D COMMUNICATION DURING DRILLING
- LUGEON VALUE (FROM WATER TEST)
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- × PACKER SETTING

NOTE:
LOST CASINGS AT 0+707 (2 m), 0+708 (4 m), 0+716 (2 m), 0+734 (4 m), 0+740.6 (30 m), 0+742.5 (2 m), 0+770 (8 m) & 0+774.2 (2 m)

NKSL AS-BUILT

DWG. NO.	DESCRIPTION
.	.

REFERENCE DRAWINGS

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
2	REVISED HOLE LAYOUT	MAR 06 2006	
1	TERTIARY HOLES SHOWN	FEB 18 2006	

REVISIONS

		DATE
SECTION:		
SCALE:	AS SHOWN	
DESIGNED:	GB	–
DRAWN:	DL	–
CHECKED:	GB	–
APPROVED:	SA	–

DIAVIK DIAMOND MINES INC.

ENGINEERS STAMP

NKSL DRAWING NUMBER 015803–xxxx–xxxx–xxxx–xx

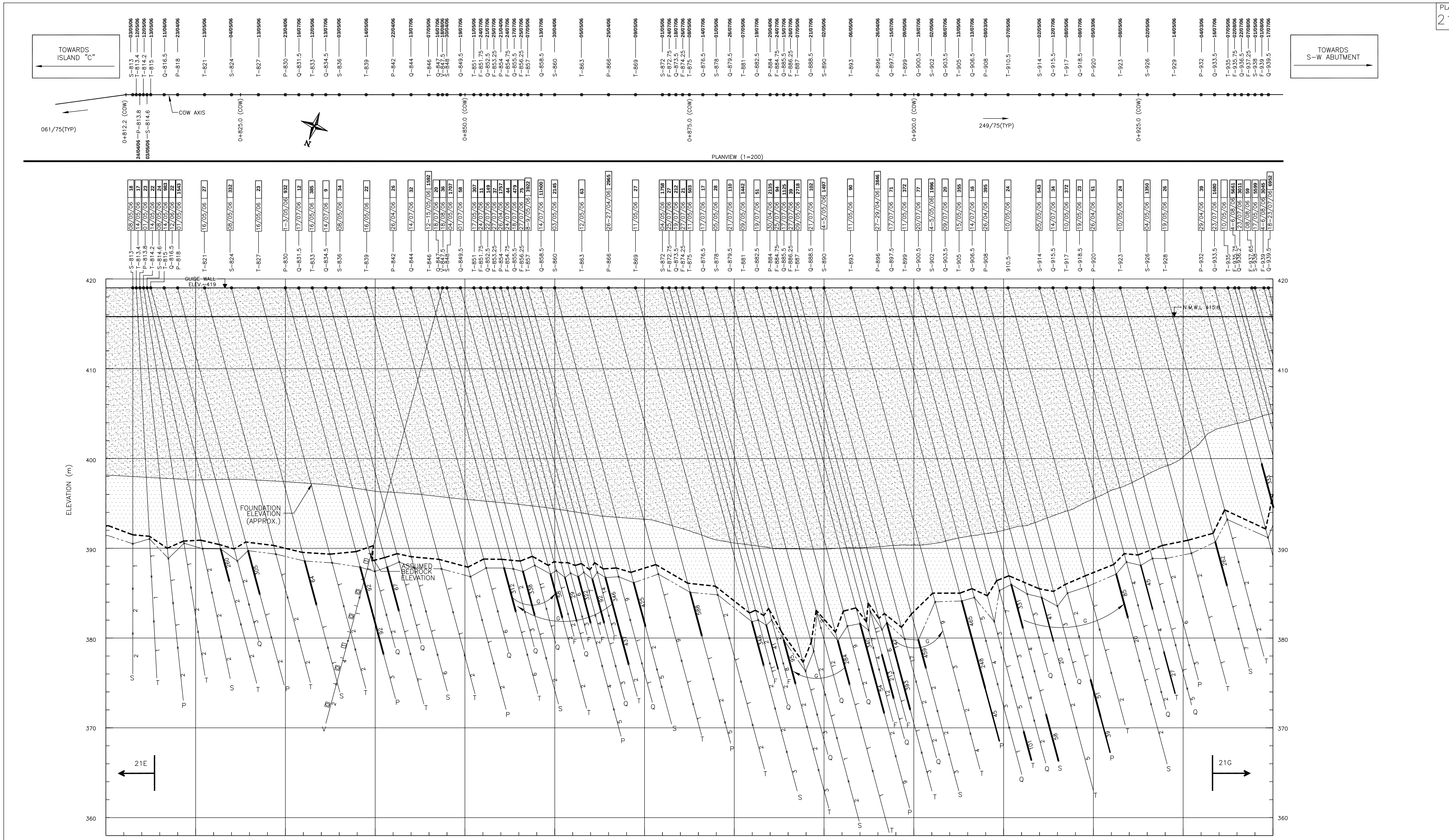
NISHI–KHON/SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

A418 DIKE – CURTAIN GROUTING GROUT HOLE LAYOUT FROM STA. 0+700(COW) TO 0+820(COW)

FORMAT SIZE	DRAWING NUMBER	REV.
A1	2140–41D2–1021E	F

PLATE 21F



STATION (COW)

LONGITUDINAL PROFILE ALONG COW AXIS: FORMAT A1 (1=200)

LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- 23/02/06 DRILLING DATE
- T–072 HOLE AND STATION NUMBER
- 23/02/06 | 230 GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G COMMUNICATION DURING GROUTING
- D COMMUNICATION DURING DRILLING
- LUGEON VALUE (FROM WATER TEST)
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- × PACKER SETTING

NOTE:

- LOST CASINGS AT 0+896 (2 m), 0+911 (2 m), 0+911.5 (2 m) & 0+936.5 (6 m)
- HIT STEEL AT STA. 0+845 (32 m) & 0+938.75 (20 m).
- LOST PACKER AT STA. 0+899 (36 m) & 0+935 (37 m).
- LOST DRILLING RODS (2 m), BIT & OVER SHOT AT STA 0+929 (20 m).

NKSL AS-BUILT

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

DWG. NO.	DESCRIPTION
REFERENCE DRAWINGS	

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
2	REVISED HOLE LAYOUT	MAR 06 2006	
1	TERTIARY HOLES SHOWN	FEB 18 2006	
REVISIONS			

		DATE
SECTION:		
SCALE:	AS SHOWN	–
DESIGNED:	GB	–
DRAWN:	DL	–
CHECKED:	GB	–
APPROVED:	SA	–

DIAVIK DIAMOND MINES INC.

ENGINEERS STAMP

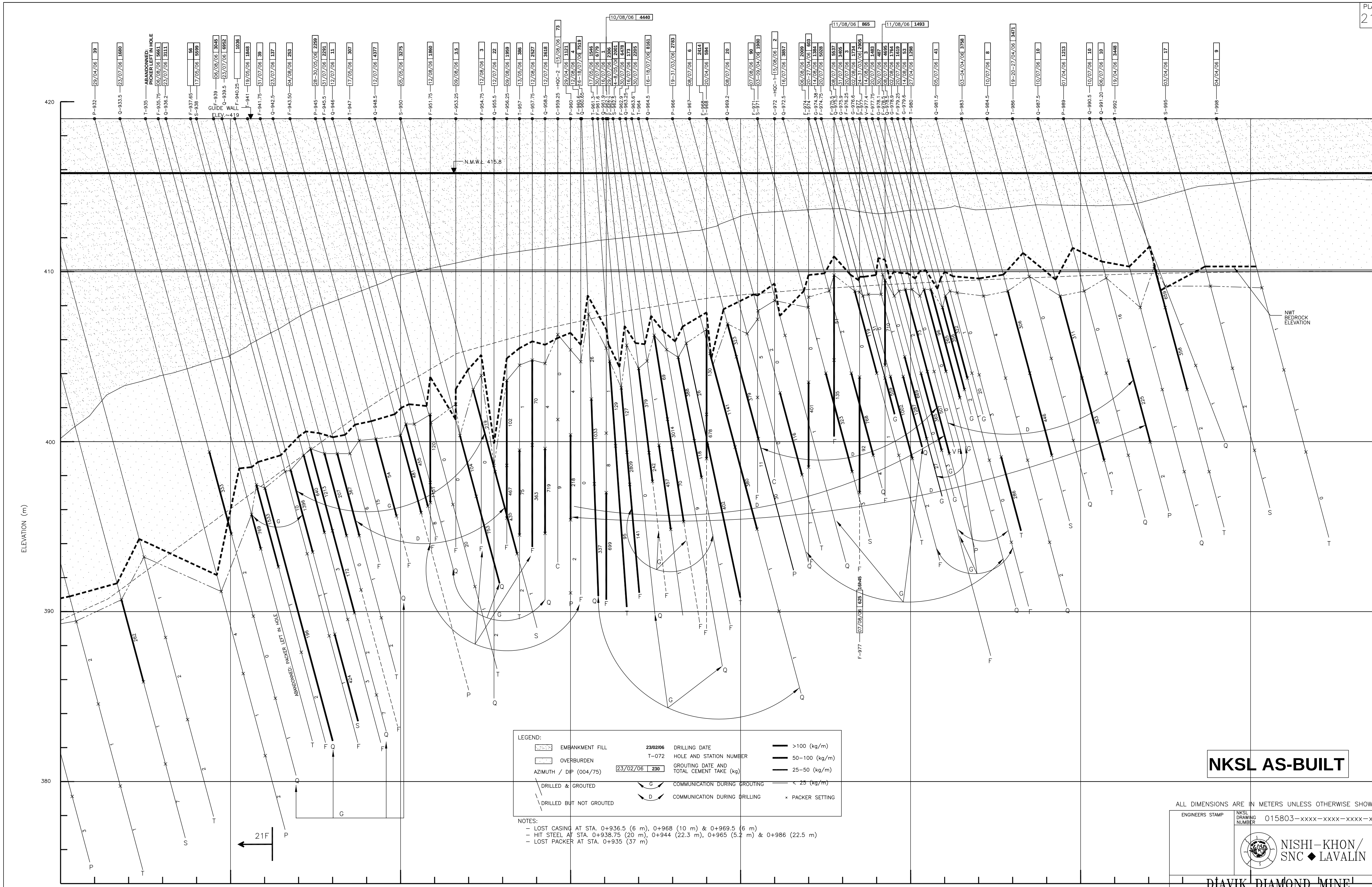
NKSL DRAWING NUMBER 015803–xxxx–xxxx–xxxx–xx

NISHI–KHON/SNC ◆ LAVALIN

DIAVIK DIAMOND MINE

A418 DIKE – CURTAIN GROUTING GROUT HOLE LAYOUT FROM STA. 0+820(COW) TO 0+940(COW)

FORMAT SIZE	DRAWING NUMBER	REV.
A1	2140–41D2–1021F	F



LEGEND:

- EMBANKMENT FILL
- OVERBURDEN
- AZIMUTH / DIP (004/75)
- DRILLED & GROUTED
- DRILLED BUT NOT GROUTED
- 23/02/06 — DRILLING DATE
- T–072 — HOLE AND STATION NUMBER
- 23/02/06 | 230 — GROUTING DATE AND TOTAL CEMENT TAKE (kg)
- G — COMMUNICATION DURING GROUTING
- D — COMMUNICATION DURING DRILLING
- >100 (kg/m)
- 50–100 (kg/m)
- 25–50 (kg/m)
- < 25 (kg/m)
- × PACKER SETTING

NOTES:

- LOST CASING AT STA. 0+936.5 (6 m), 0+968 (10 m) & 0+969.5 (6 m)
- HIT STEEL AT STA. 0+938.75 (20 m), 0+944 (22.3 m), 0+965 (5.2 m) & 0+986 (22.5 m)
- LOST PACKER AT STA. 0+935 (37 m)

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

NO.	DESCRIPTION	DATE	BY
F	AS BUILT	28 FEB 2007	
2	REVISED HOLE LAYOUT	MAR 06 2006	
1	TERTIARY HOLES SHOWN	FEB 18 2006	

REVISIONS

REFERENCE DRAWINGS

		DATE
SECTION:		
SCALE:	AS SHOWN	–
DESIGNED:	GB	–
DRAWN:	DL	–
CHECKED:	GB	–
APPROVED:	SA	–

ENGINEERS STAMP

NKSL DRAWING NUMBER 015803–xxxx–xxxx–xxxx–xx

NISHI–KHON/ SNC ◆ LAVALIN

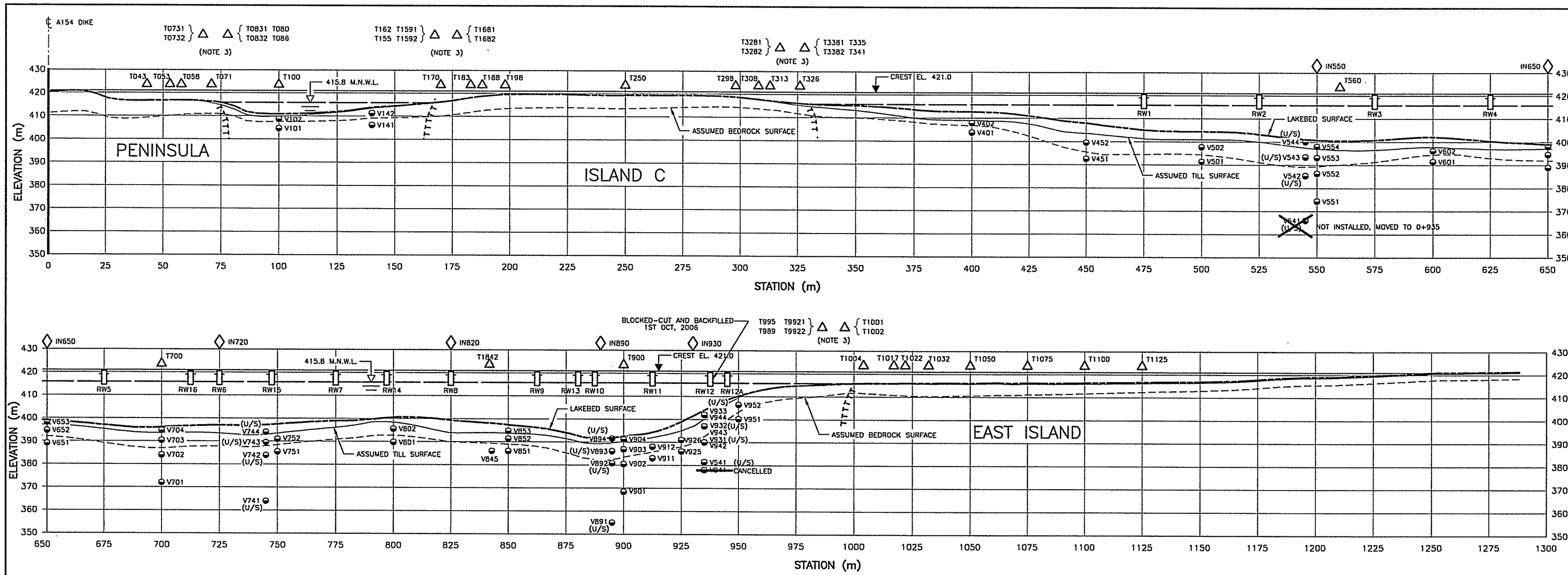
DIAVIK DIAMOND MINES INC.

DIAVIK DIAMOND MINE

A418 DIKE – CURTAIN GROUTING GROUT HOLE LAYOUT FROM STA. 0+940(COW) TO 0+998(COW)

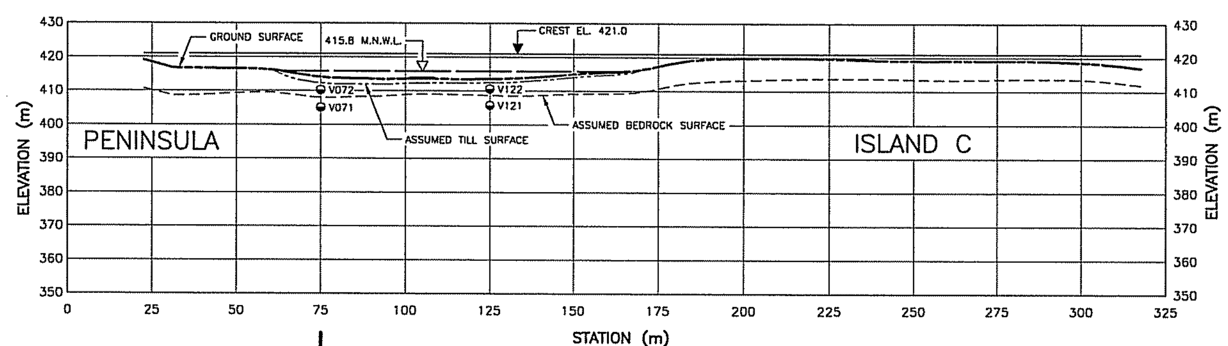
FORMAT SIZE	DRAWING NUMBER	REV.
A1	2140–41D2–1021G	F

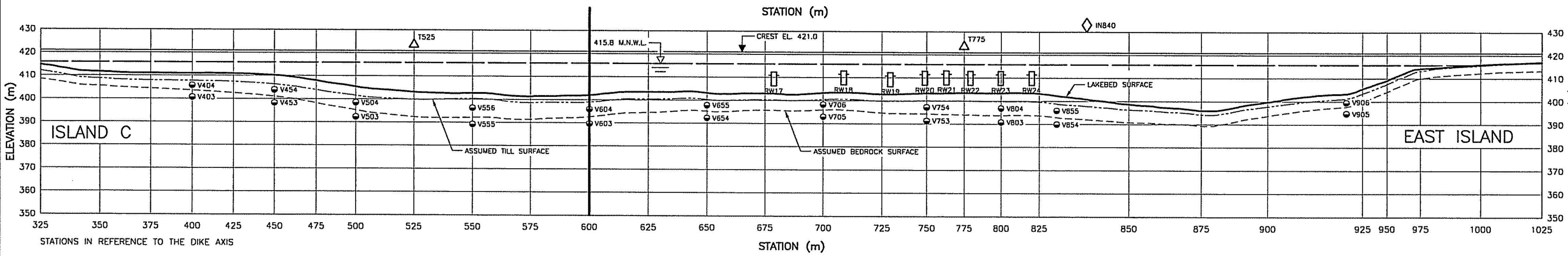
PLATE 26



PROFILE ALONG DIKE AXIS

VERT. 1 : 1000
HORI. 1 : 1000





PROFILE ALONG BERM TOE

VERT. 1 : 1000
HORI. 1 : 1000

NOTES:

1. ASSUMED TILL SURFACE AND BEDROCK SURFACE INTERPRETED FROM 1996-2004 EXPLORATION DATA.
2. LAKEBED SURFACE BASED ON "CONTOUR PLAN OF STUDY AREA" DEVELOPED BY CHALLENGER SURVEYS AND SERVICES LTD., 1997.
3. FOR TYPICAL THERMISTOR CABLE LOCATION AT THERMOSYPHON GROUPS, SEE DWG. 2140-41D2-1015.
4. FOR ACTUAL INSTRUMENT LOCATIONS REFER TO DWGS SK-LDGC-AB-005 AND SK-LDGC-AB-006
5. FOR THE EXACT AS-BUILT LOCATIONS SEE THE LDGC INSTRUMENTATION DRAWINGS.

LEGEND:

- ◇IN — INCLINOMETER
- V — VIBRATING WIRE PIEZOMETER
- △T — THERMISTOR CABLE
- RW — RELIEF WELL
- FROZEN / UNFROZEN — ASSUMED PERMAFROST BOUNDARY
- M.N.W.L. — MAXIMUM NORMAL WATER LEVEL (1:2 YEARS)

REGISTERED PROFESSIONAL ENGINEER D.A. RATTUE LICENSEE N.W.T.

NKSL AS-BUILT

1 : 1000 0 10 20 30 40 50m

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

ENGINEERS STAMP — NKSL DRAWING NUMBER 015803-3160-48DD-0003-01

NISHI-KHON/ SNC ◆ LAVALIN

DIAVIK DIAMOND MINE
A418 DIKE
INSTRUMENTATION
DIKE CREST AND TOE PROFILES

FORMAT SIZE: A1 — DRAWING NUMBER: 2140-41D2-1026 — REV.: G

DIAVIK DIAMOND MINES INC.

DWG. NO.	DESCRIPTION
41D2-1027	LISTS OF INSTRUMENTS
41D2-1030, 31, 32	INSTRUMENTATION - DETAILS
41D2-1025 AND 28	INSTRUMENTATION - PLAN / CROSS-SECTIONS
41D2-1015	THERMOSYPHONS - PLAN, SECTIONS AND DETAILS
41D2-1011, 12	PROFILE

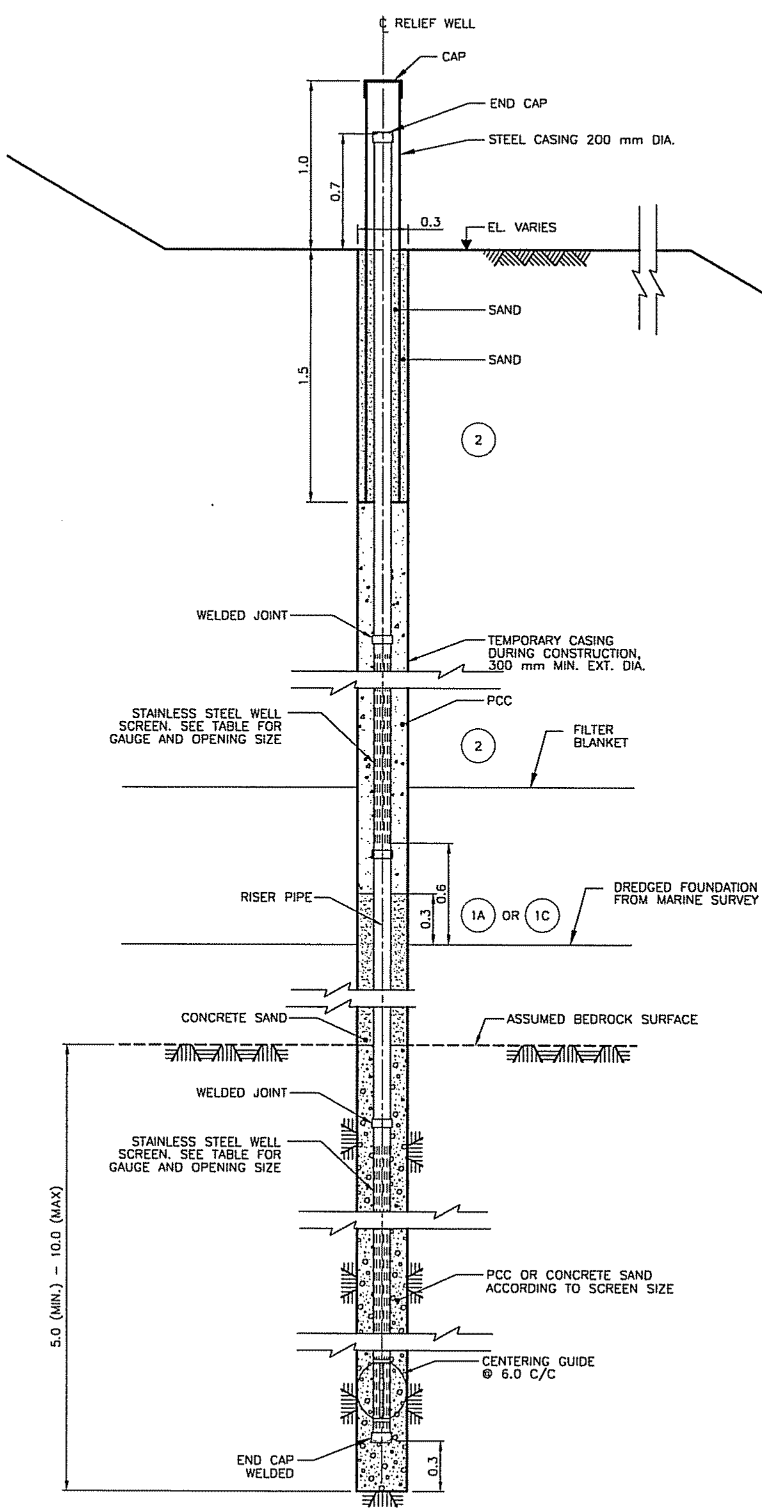
REFERENCE DRAWINGS

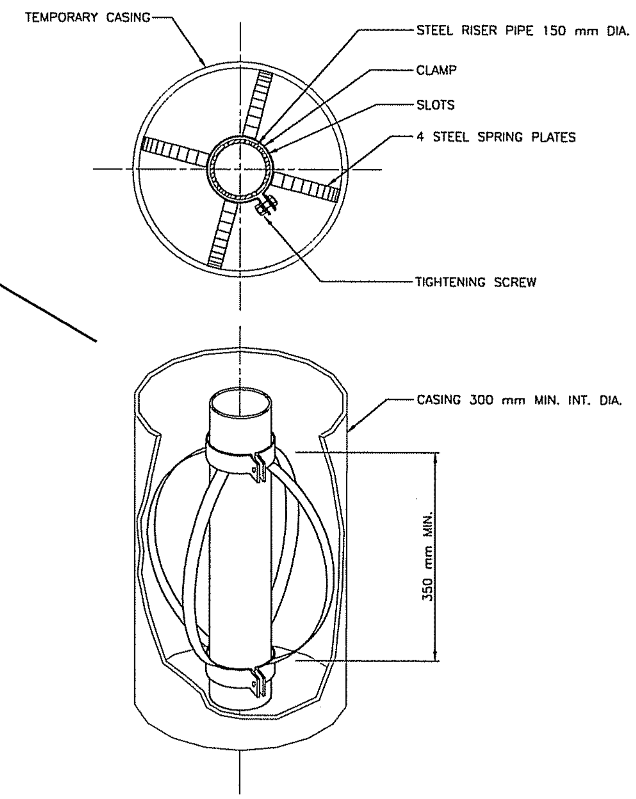
NO.	DESCRIPTION	DATE	BY
G	RELIEF WELLS AT TOE ADDED	31 OCT. 2007	
F	AS BUILT	28 FEB 2007	
2	REVISED AS SHOWN	XX JUL. 2006	
1	REVISED AS SHOWN	10 FEB. 2005	
0	ISSUED FOR CONSTRUCTION	03 NOV. 2004	
A	PRELIMINARY - 100%	30 JUL. 2004	

REVISIONS

		DATE
SECTION:		
SCALE:	AS SHOWN	
DESIGNED:	D. LEMELIN	MAY 2004
DRAWN:	L. TCHEKIKEN	MAY 2004
CHECKED:	S. ZHOU	MAY 2004
APPROVED:	A. RATTUE	MAY 2004

DERNIERE SAUVEGARDE: 2007/10/31 - 8:43am
CHEMIN: \\Sli-mtl-cad\016702\NKSL AS BUILT DWGS - FINAL\2140-41D2-1026-3_AS-BUILT_24OCT2007.DWG



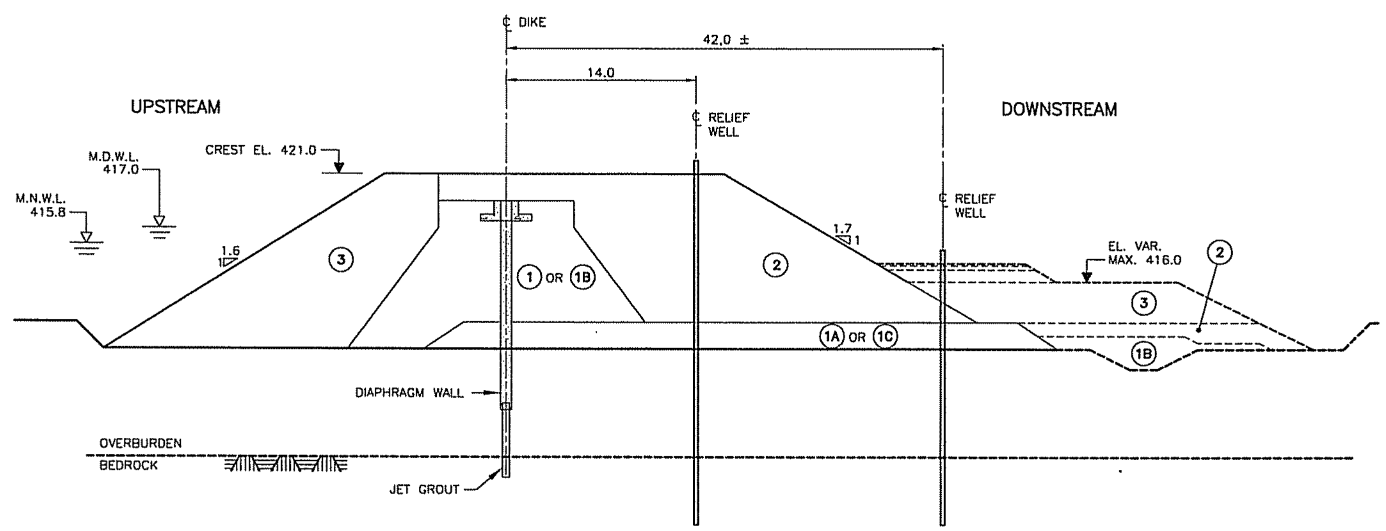


DETAIL 1
N.T.S.

RELIEF WELLS
(NOTE 2)

RELIEF WELL No.	STATION	OFFSET (m)	TILL EL. (m)	ROCK EL. (m)	WELL LENGTH (m)	LOWER SCREEN	UPPER SCREEN	
RW1	0+475	14.0	405	394	31.7	HG 0,100"	HG 0,100"	
RW2	0+525	14.0	402	396	30.3	HG 0,100"	HG 0,100"	
RW3	0+574	14.0	401	394	32.5	HG 0,100"	HG 0,100"	
RW4	0+625	14.0	401	393	33.5	HG 0,100"	HG 0,100"	
RW5	0+675	14.0	399	393	33.7	HG 0,100"	HG 0,100"	
RW6	0+725	14.0	398	392	35.0	HG 0,100"	HG 0,100"	
RW7	0+775	14.0	398	391	35.7	HG 0,100"	HG 0,100"	
RW8	0+825	14.0	398	390	36.1	HG 0,100"	HG 0,100"	
RW9	0+862.5	14.0	396	388	38.1	HG 0,100"	HG 0,100"	
RW10	0+887.5	14.0	391	381	45.4	HG 0,100"	HG 0,100"	
RW11	0+915	14.0	395	387	39.6	HG 0,100"	HG 0,100"	
RW12	0+640	14.0	404	400	26.5	HG 0,100"	HG 0,100"	ABANDONED
RW12A	0+945	14.0	408	403	23.6	HG 0,030"	HG 0,100"	ADDITIONAL RELIEF WELLS INSTALLED FROM CREST AFTER DEWATERING (SEE NOTE 3)
RW13	0+880	14.0	389	381	45.1	SLOTTED	N.A.	
RW14	0+790	14.0	399	392	35.6	SLOTTED	N.A.	
RW15	0+740	14.0	397	391	36.7	SLOTTED	N.A.	
RW16	0+715	14.0	394	390	37.7	SLOTTED	N.A.	
RW17	0+680	42,0	398,9	391.4	21.3	HG 0,100"	HG 0,100"	RELIEF WELLS INSTALLED AT TOE AFTER DEWATERING
RW18	0+710	42,5	398,0	391.9	20.2	HG 0,030"	LG 0,100"	
RW19	0+730	42,5	398,3	391.9	24.6	HG 0,100"	LG 0,100"	
RW20	0+747,6	43,0	399,3	393.7	20.2	HG 0,030"	HG 0,100"	
RW21	0+762,5	43,0	400,3	395.1	17.2	HG 0,100"	LG 0,100"	
RW22	0+780,1	43,0	400,4	394	20.4	HG 0,100"	LG 0,100"	
RW23	0+795	43,4	400,3	396.1	20.2	HG 0,100"	HG 0,100"	
RW24	0+820,1	43,4	399,7	394.5	22.1	HG 0,100"	LG 0,100"	

NOTE: HG – HEAVY GAUGE
LG – LIGHT GAUGE



A418 DIKE
RELIEF WELL INSTALLATION
TYPICAL CROSS–SECTION

1 : 250

NOTES:

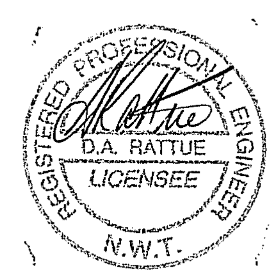
1. RELIEF WELLS INSTALLED PRIOR TO COMMENCING DEWATERING, EXCEPT WHERE OTHERWISE NOTED.
2. TILL AND ROCK ELEVATIONS ARE APPROXIMATE AND ARE INTERPRETED FROM AVAILABLE DATA. ACTUAL ELEVATIONS MAY DIFFER.
3. RELIEF WELLS 13 TO 16 WERE 75mm SLOTTED STEEL PIPE DEVELOPED USING AIRLIFT. SEE DWG 2140–41D2–1030 FOR DETAILS.

LEGEND:

FILL LEVEL
ASSUMED BEDROCK LEVEL
M.N.W.L. MAXIMUM NORMAL WATER LEVEL (1:2 YEARS)
M.D.W.L. MAXIMUM DESIGN WATER LEVEL (1:10 000 YEARS)
PCC PLASTIC CONCRETE COARSE AGGREGATE
RFI CONTRACTORS REQUEST FOR INFORMATION/ CLARIFICATION.

ZONES:

1 0–56 mm CRUSHED STONE (DUMPED OR PLACED)
1A 0–56 mm CRUSHED STONE (CLAMSHELL)
1B 0–56 mm CRUSHED STONE (DUMPED OR PLACED)
1C 0–56 mm CRUSHED STONE (CLAMSHELL)
2 0–200 mm CRUSHED STONE
3 0–900 mm QUARRY ROCK



NKSL AS-BUILT

1 : 250 0 2.5 5 7.5 10 12.5 m

ALL DIMENSIONS ARE IN METERS UNLESS OTHERWISE SHOWN.

ENGINEERS STAMP
NKSL DRAWING NUMBER 015803–3160–48DD–0007–01

NISHI–KHON/ SNC ◆ LAVALIN

DIAVIK DIAMOND MINE
A418 DIKE
RELIEF WELLS
SECTIONS AND DETAIL

FORMAT SIZE	DRAWING NUMBER	REV.
A1	2140–41D2–1029	G

REFERENCE DRAWINGS

DWG. NO.	DESCRIPTION
41D2–1026	INSTRUMENTATION – PROFILES

REVISIONS

NO.	DESCRIPTION	DATE	BY
G	RELIEF WELLS AT TOE ADDED	31 OCT. 2007	G.B.
F	AS BUILT	28 FEB 2007	
1	REVISED AS SHOWN	10 FEB. 2005	
0	ISSUED FOR CONSTRUCTION	03 NOV 2004	
A	PRELIMINARY – 100%	30 JUL. 2004	

		DATE
SECTION:		
SCALE:	1 : 250	
DESIGNED:	D. LEMELIN	MAY 2004
DRAWN:	L. TCHEKIKEN	MAY 2004
CHECKED:	S. ZHOU	MAY 2004
APPROVED:	A. RATTUE	MAY 2004

DIAVIK DIAMOND MINES INC.

DERNIÈRE SAUVEGARDE: 2007/10/31 – 9:21am
CHEMIN: \\Sli-mtl-cad\016702\NKSL AS BUILT DWGS – FINAL\2140-41D2-1029-2_AS-BUILT_24OCT2007.dwg

APPENDIX D

A418 DIKE SITE INSPECTION PHOTOS

Photo D1: North Abutment upstream slope near Station 0+000, looking south from the A154 Dike.

Photo D2: North Abutment top of dike near Station 0+000, looking south.

Photo D3: North Abutment downstream slope near Station 0+000, looking south from the A154 Dike.

Photo D4: North Abutment upstream slope near Station 0+150, looking north toward A154 Dike.

Photo D5: South Abutment downstream slope near Station 1+000, looking east.

Photo D6: Downstream slope near Station 0+350, looking south.

Photo D7: General view of the DPS-6 infield area from the downstream crest of the A418 Dike near Station 0+800.

Photo D8: General view of the A418 Open Pit with the A418 Dike in the background.
Photo taken from the far side of the open pit.

Photo D9: South Abutment Thermosyphon Cluster.

Photo D10: North Island C Thermosyphon Cluster (shown in foreground) and North Abutment Thermosyphon Cluster (shown in background).

Photo D11: General view of thermosyphon cluster control panel.

Photo D12: General view of thermosyphon radiators.

Photo D13: DPS-6 dike pumping station with connected pipelines to relief wells and infield collection sumps.

Photo D14: DPS-6 intake pond showing small sinkholes observed at the base of the pond.

Photo D15: Redirected water from one depressurization well being discharged into DPS-6 intake pond.

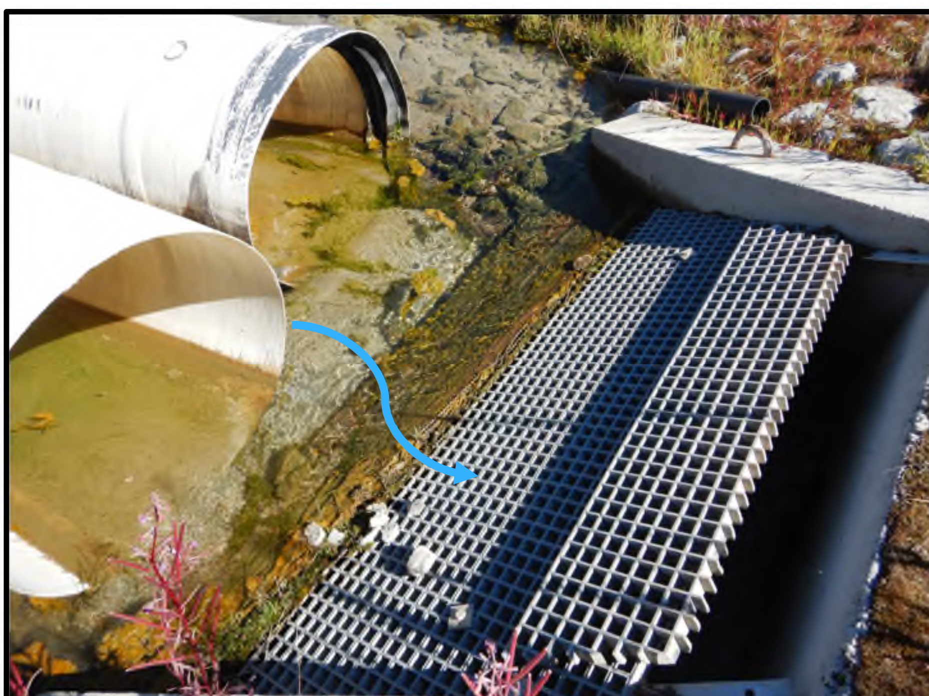


Photo D16: DPS-6 water intake showing steel grate retaining oversized debris (blue arrow indicates direction of flow).

Photo D17: Protective shelters housing the infield depressurization headers and pipework.

Photo D18: Infield depressurization headers and pipework within protective shelters.

Photo D19: Sea can enclosure for the infield depressurization water collection system and booster pump.

Photo D20: Booster pump and header pipes within the sea can enclosure shown on Photo D19.

Photo D21: Downstream pool of collected water near Station 0+070, looking north.

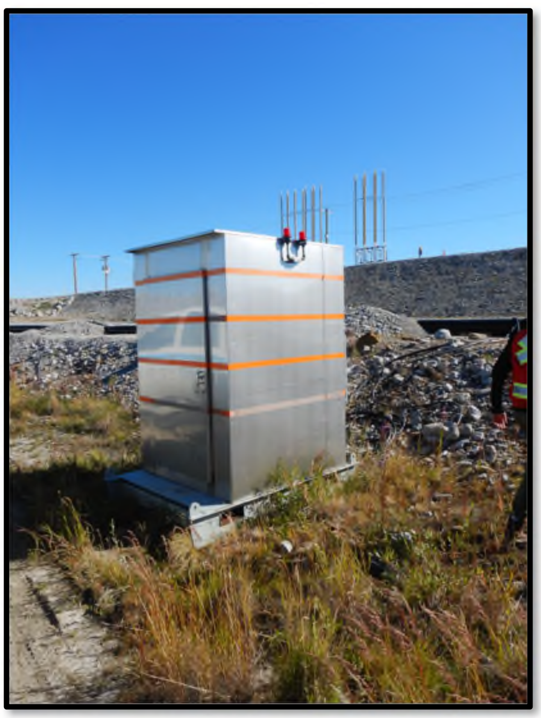


Photo D22: Electrical substation for submersible pump that pumps water from the pool near Station 0+070 to DPS-6.

Photo D23: Downstream toe ditch near Station 0+450 showing sediment accumulation upstream of check dam.

Photo D24: Downstream toe ditch near Station 0+550 showing abundant vegetation.

Photo D25: Downstream toe ditch near Station 0+550 showing blisters of air and water found in the ditch sediments.

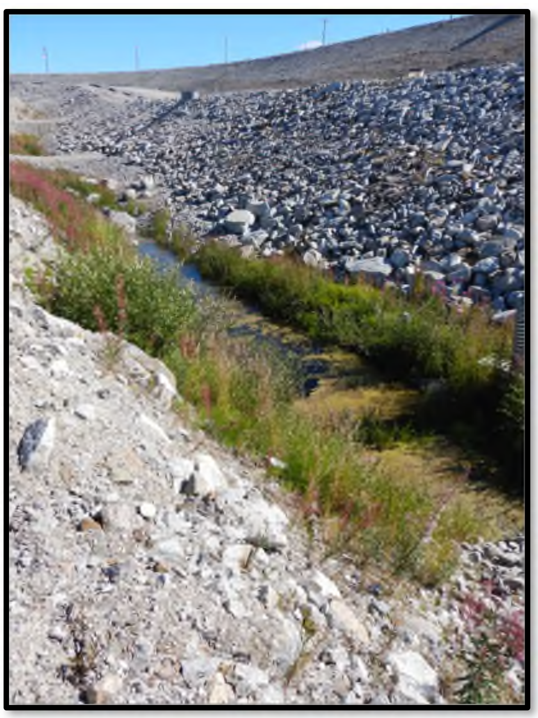


Photo D26: Downstream toe ditch near Station 0+650 showing ponded water along the base of the ditch.

Photo D27: One of three data logger shelters along the downstream crest of the A418 dike.

Photo D28: Multi-channel instrumentation data logger within data logger shelter.

Photo D29: Backup battery pack for multi-channel instrumentation data logger within data logger shelter.

Photo D30: Survey prism monument (survey marker) along the downstream crest.

Photo D31: Protective instrumentation housing for vibrating wire piezometers along the downstream crest.

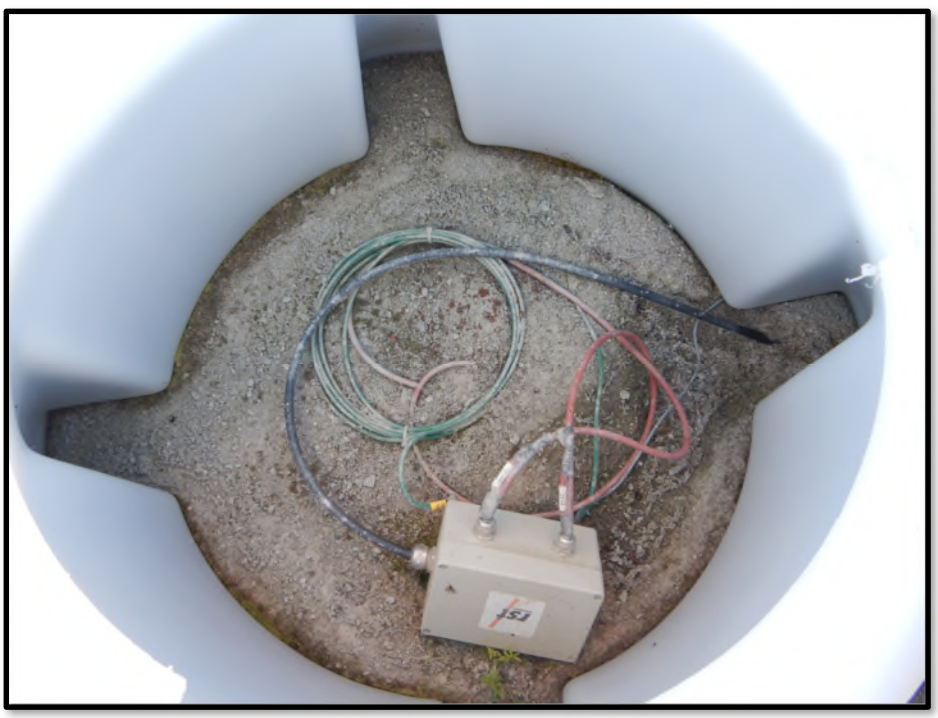


Photo D32: Vibrating wire piezometer junction box within a protective instrumentation housing.

Photo D33: Protective instrumentation housing for an inclinometer along the upstream crest.

Photo D34: Inclinometer casing within the protective instrumentation housing shown in Photo D33.

Photo D35: Protective casing for a survey monument.

Photo D36: Survey monument within the protective casing shown in Photo D35.

Photo D37: Protective instrumentation housing for a ground temperature cable installed along the top of dike.

Photo D38: Ground temperature cable connector within protective instrumentation housing showing in Photo D37.

Photo D39: Blast vibration monitoring geophone mounting plate installed along the downstream crest.

Photo D40: Inactive pressure relief well along the downstream crest.

Photo D41: One of nine post-construction in situ density evaluation test holes that were undertaken in 2016 along the upstream crest between Stations 0+550 and 0+850.

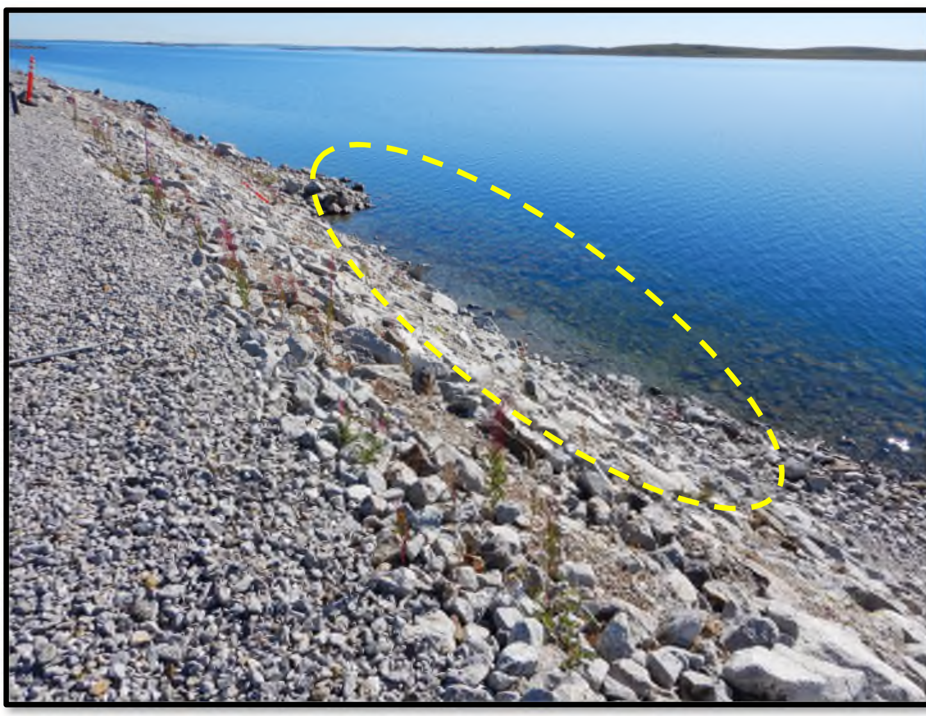


Photo D42: Gap in erosion protection along the upstream slope near Station 0+750.

Photo D43: Thaw settlement of upstream thermal berm near Station 0+100.

Photo D44: Partially blocked culvert along downstream water collection ditch near Station 0+800.

Photo D45: Downstream slope undulation observed near Station 0+900 (photo taken by Tetra Tech in 2022).

Photo D46: Same downstream slope undulation shown in Photo D45 (photo provided by DDMI from 2007).

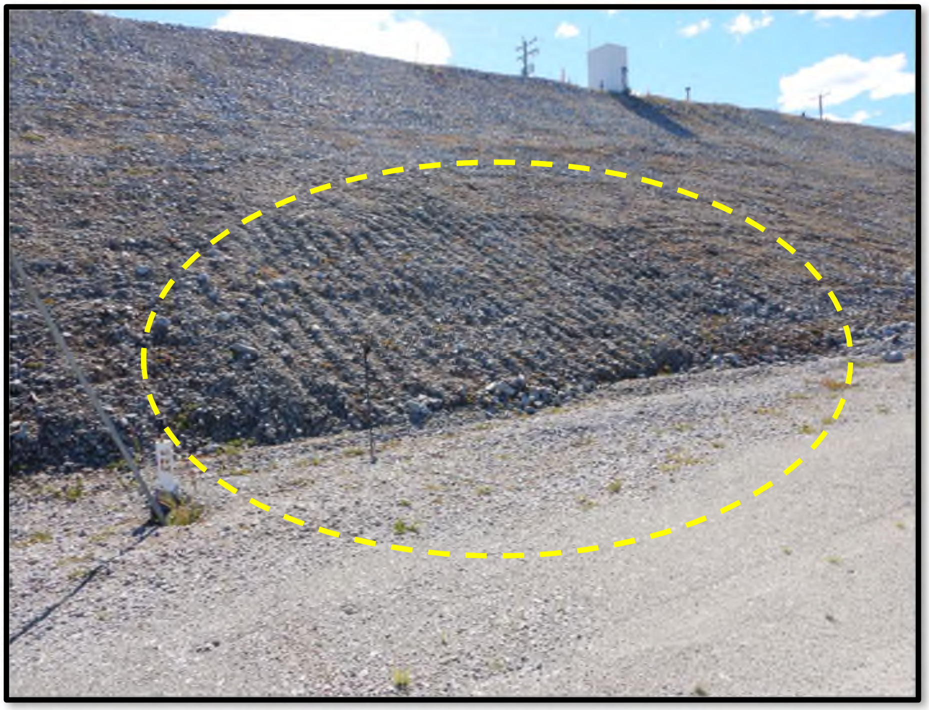


Photo D47: Downstream slope regrading observed near Station 0+575 (photo taken by Tetra Tech in 2022).

Photo D48: Same downstream slope regrading shown in Photo D47 (photo provided by DDMI from 2007).

APPENDIX E

STAFF INTERVIEWS QUESTIONNAIRE

TETRA TECH

QUESTIONNAIRE

ISSUED FOR USE

To:	Art Yeomans DDMI Technical Services	**Date:**	November 9, 2022
Cc:	Dan Guigon DDMI Technical Services	**Memo No.:**	3226-03-1
From:	Thomas Bradshaw, Nigel Goldup Tetra Tech Canada Inc.	**File:**	704-ENG.EARC03226-03
Subject:	A418 Dike 2022 Dam Safety Review – Staff Interviews Questionnaire Diavik Diamond Mine, Northwest Territories		

1.0 INTRODUCTION

Diavik Diamond Mines (2012) Inc. (DDMI) retained Tetra Tech Canada Inc. (Tetra Tech) to undertake a dam safety review (DSR) for the A418 Dike located at the Diavik Diamond Mine (Diavik or the Mine), Northwest Territories (NT). The scope of the DSR includes preparation and completion of interviews with staff responsible for the safe operation, maintenance, and surveillance of the A418 Dike and its associated infrastructure. This includes submission of a questionnaire to DDMI to facilitate the review process and gather information on the overall dike safety management system (DSMS).

Tetra Tech has developed a series of questions, to be answered by DDMI staff involved in the safe operation and maintenance of the dike, on different components of the A418 Dike's DSMS. The questions were prepared following guidance from the Canadian Dam Association (CDA), including the *Dam Safety Guidelines* (CDA 2013) and *Technical Bulletin: Dam Safety Reviews* (CDA 2016). Tetra Tech's experience on dam safety and general understanding of the A418 Dike and its associated infrastructure were also used to prepare the questionnaire.

It is understood that some of the questions have already been addressed by DDMI staff during the site visit; however, to ensure the answers were understood correctly please provide the response again for documentation purposes. These questions and their responses will be compiled and will form part of the DSR report.

2.0 STAFF INTERVIEWS QUESTIONNAIRE

Staff interview questions are generally organized under different components of the A418 Dike and its associated infrastructure to meet the intent of the DSR; however, some questions may have overlap with previous responses. Where response to a question was either partly or completely answered by a previous question, reference can be made to the appropriate question number.

2.1 Dike Safety Management Questions

1. Who is the Engineer-of-Record for the A418 Dike and its associated infrastructure?

   Benoit Mathieu of SNC Lavalin.

2. Who holds ultimate responsibility for the safety of the A418 Dike and its associated infrastructure?

   President and Chief Operating Officer, Angela Bigg.

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3. Who is responsible for the day-to-day oversight of the A418 Dike (i.e., monitoring, surveillance, maintenance)?

   The D5 Qualified Site Representative (QSR – Dan Guigon) and D5 Responsible Dam Engineer (RDE – Arthur Yeomans) are on opposite shifts and share that responsibility.

4. Some responsibilities for dike safety (e.g., monitoring, regulatory, capital works) might be shared between different divisions of DDMI. Who is ultimately responsible for ensuring that imminent or potential dike safety issues are addressed in a timely manner?

   D5 Nominated Manager – Mufaro Chivasa.

5. How is DDMI's senior management and/or the key person with ultimate responsibility for safety of the dike kept informed on the status of dike safety issues for the A418 Dike?

   External Reviewers generally facilitate a closeout meeting with the D5 nominated manager or their designate at the conclusion of their site visit. Reports and summaries are also issued and distributed to relevant parties.

6. What are the criteria for prioritizing how dike safety issues are addressed for the A418 Dike?

   Trigger Action Response Plans for these facilities are in place with threshold and trigger levels for items that may constitute a dam safety issue. For any or multiple dam safety issues recognized, a Team Based Risk Assessment would be conducted involving all internal and external stake holders, including the EOR to identify and prioritize remedial work.

7. Does DDMI produce an annual report to inform senior management of the A418 Dike's safety issues and their status?

   The annual EOR Inspection Report serves this purpose.

8. Who is responsible for the DSMS for the A418 Dike? Is there an organizational chart outlining lines of authority as well as roles and responsibilities? Does the DSMS include performance metrics? How often are the results reviewed or the metrics updated?

   The D5 Qualified Site Representative (QSR – Dan Guigon) and D5 Responsible Dam Engineer (RDE – Arthur Yeomans) *are on opposite shifts and share that responsibility. Roles, Responsibilities, and Authority are outlined in Section 2 of the OMS. The TARP includes performance metrics and is reviewed and updated annually. The OMS manual includes monitoring frequencies for instrumentation as determined by the Engineer of Record (EoR).*

9. Are any tools in place to track dike deficiencies, non-conformances, and best practice recommendations? What improvements can be made to the system to further facilitate the management of dike safety? Alternately, does DDMI find their current tools and processes to be an effective means to track and mitigate dike safety deficiencies, non-conformances, and best practice recommendations?

   DDMI implements RTBS and Archer to track and ensure the recommendation is completed prior to deadlines. The systems allow actions to be assigned to individuals with sign-off by checkers to ensure work is completed. All actions prior to being signed off in our systems require evidence be attached.

10. How does DDMI intend to address any concerns or deficiencies noted during this DSR (in terms of prioritization, timelines, allocation of resources etc.)?

    Preference is that the reviewers prioritize their recommendations to ensure DDMI understands priority. DDMI implements RTBS and Archer to track and ensure the recommendation is completed prior to deadlines.

11. Is there a staff training program in place for key staff responsible for safety of the A418 Dike? Does DDMI maintain records of regular staff training? Is there an audit of how current staff training is?

    All personnel at DDMI are onboarded through orientation training that provides geotechnical hazard awareness training. This training is documented and meets requirements. The primary purpose of Surface Geotechnical Department is Dam Safety, so all job specific training has been geared towards monitoring to ensure Dam Safety. This work includes review of pertinent SOP's etc. there is no formal signoff for this work. A more formal training program is currently under development that will include Emergency Response Training.

12. Does DDMI have the following DSMS plans in place? If so, where are they kept?

    – Operations, Maintenance, and Surveillance (OMS) Manual

    Yes. Controlled document, available in the document register online or printed in the Emergency Command Centers (several meeting rooms on-site).

    – Emergency Preparedness Plan (EPP)

    Yes. Controlled document, available in the document register online or printed in the Emergency Command Centers (several meeting rooms on-site).

    – Emergency Response Plan (ERP)

    Yes. Controlled document, available in the document register online or printed in the Emergency Command Centers (several meeting rooms on-site).

    – Who is responsible for these plans?

    The D5 Qualified Site Representative (QSR – Dan Guigon) and D5 Responsible Dam Engineer (RDE – Arthur Yeomans).

13. How often are these plans reviewed, tested, or updated?

    Annually.

2.2 Operations, Maintenance, and Surveillance Questions

14. Does DDMI have defined operating procedures for normal, flood, or emergency conditions at the A418 Dike?

    *Yes. These are laid out in the OMS but the terms "normal, **unusual** and emergency situations" are used.*

15. What are the procedures for inspecting the A418 Dike after a major flood or other situations with potential dike safety implications (e.g., unusual seepage, pumps not operable)?

    Outlined in Table 12-5 of OMS: Event Driven Inspection and Surveillance.

16. What are the triggers for invoking emergency procedures related to unusual conditions at the A418 Dike (e.g., increased seepage rates, slumping, flood inflows)?

    Outlined in Section 3.0 of OMS: EMERGENCY AND TRIGGER ACTION RESPONSE PLAN (ERP AND TARP).

17. Describe the maintenance activities and inspection schedules for associated components of the A418 Dike (e.g., site access roads, check dams, monitoring equipment, pumping stations)?

    The A418 Dike is inspected once a week, this includes access roads. Maintenance will be scheduled if any deficiencies are found.

    The ADAS is under continuous monitoring. Maintenance will be performed if any components are found to be malfunctioning.

    The manual instruments are monitored as per the monitoring schedule. Maintenance will be performed if any components are found to be malfunctioning.

    The pumping system is monitored daily. Maintenance will be scheduled if any components are found to be malfunctioning.

18. Does DDMI maintain an operations log or record of actions for the A418 Dike?

    An "Activities" log is kept as part of the weekly inspection report.

19. Who among DDMI's staff are involved with surveillance activities?

    The four Geotechnical Technicians and the Senior Geotechnical Technician (D5 Qualified Site Representative (QSR)).

20. What is the frequency of testing to verify that the A418 Dike's pumping systems (DPS-6 and Relief Wells) will operate under normal flows?

    The DPS-6 pump cycle data is reviewed daily to determine the seepage/runoff inflow rate. The pumps cycle at least 30 times per day year-round so any deviation from normal performance is noted and reported to the Mechanical and Electrical departments for follow-up.

21. Do pumping system maintenance procedures for the A418 Dike include inspection, reporting, and repairs?

    Geotechnical personnel will identify issues with the pumping systems during their daily checks and data reviews and notify the Mechanical and Electrical departments when inspections or repairs are required.

22. Describe the operation procedures to control the inflow of water to the A418 Dike during a power outage or when the discharge pumps are not functioning? Is there any redundancy in the system?

    There are two pumps in DPS-6 that alternate pumping so if one fails the other can be used on its own. During a power outage, the seepage/runoff water can be allowed to accumulate in the infield until power is either restored, or alternate power generation or pumping arrangements can be made. The current summer inflows during a power outage are about 3% of the pumping capacity of one DPS-6 pump. There is currently approx. 18,000 m^3 of infield storage capacity before overflow into the A418 Pit. This is approximately 120 days of storage.

23. Is DDMI aware of any operational, maintenance, or surveillance issues for the A418 Dike?

    Minor issues have been identified in past reviews (DSRs and DSIs) but nothing that affects immediate dam safety.

2.3 Emergency Preparedness and Response Questions

24. When did DDMI last test its Emergency Response Plan (ERP) for the A418 Dike?

    Exact date unknown. Typically, one emergency response as been done annually with a focus on the PKC last two years. A418 Pit/Underground emergency responses are recorded following events in the A418 SLR, with appropriate responses as required.

25. When did DDMI last test its Emergency Preparedness Plan (EPP) for the A418 Dike?

    Exact date unknown. Typically, one emergency response as been done annually with a focus on the PKC last two years. A418 Pit/Underground emergency responses are recorded following events in the A418 SLR, with appropriate responses as required.

26. What communications systems are available in the event of an emergency at the A418 Dike?

    From Section 2.2.1 of the OMS: Telecommunications:

    - *Satellite telephone system*
    - *Local mobile radio*
    - *ERT/Leaders Paging System*
    - *Microwave system*
    - *Internet and E-mail*
    - *Standby power supported by power station*

27. Are there any warning systems in place in the event of an emergency at the A418 Dike?

    See above.

28. How does DDMI notify external stakeholders of an emergency event at the A418 Dike?

    Contact list in ERP with flow chart identifying who is contacted and by whom.

29. Is there a list of DDMI staff and external agencies to be notified when a potential or imminent emergency is declared at the A418 Dike?

    Contact list in ERP with flow chart identifying who is contacted and by whom.

30. Is training provided to DDMI staff on the ERP as it relates to the A418 Dike? If so, what staff are trained?

    The D5 Qualified Site Representative (QSR) and D5 Responsible Dam Engineer (RDE) are on opposite shifts and are familiar with the ERP. See previous response regarding training above.

31. Are DDMI staff trained on the ERP always available in the event of an emergency event at the A418 Dike?

    The D5 Qualified Site Representative (QSR) and D5 Responsible Dam Engineer (RDE) are on opposite shifts and share that responsibility. ERP is available and reviewed annually during updates with relevant parties ensuring they are familiar with the topics being discussed.

32. Are DDMI staff generally trained in emergency response and emergency preparedness?

    The ERT and BRRT are trained in emergency response and emergency preparedness and are aware of what personnel and resources are available to them to respond to specific emergency situations.

33. Is information about accessing the A418 Dike readily available to emergency responders? If so, does this include accessing the dike during darkness and extreme weather conditions?

    Maps are included in the ERP. Personnel familiar with the A418 Dike are always on site.

34. What options are available for emergency site access to the A418 Dike should the normal access route become impassable during an emergency?

    Normal access to the A418 Dike crest or toe berm is from the South abutment off of the East Island and from the North abutment off of the A154 Dike via the A154 Dike North abutment. If both of those accesses were blocked, the following options are available:

    1. *Access to the infield from the west via a A418 Pit perimeter road from where the crest and toe berms can be accessed.*

    2. *Access from the A154 Dike south abutment, but a loader would be required to flatten a small safety berm to allow emergency vehicle to access after the stability of the A418 Pit north slope was verified.*

2.4 Geotechnical and Hydrotechnical Questions

35. Is the criteria for the reading of geotechnical instrumentation and their replacement set by the Engineer-of-Record for the A418 Dike?

    Yes.

36. What erosion control and maintenance measures are in place for the slopes of the A418 Dike?

    The gradation of the upstream rock fill is designed to resist wave erosion. The downstream rock fill is designed to resist minor erosion from runoff and minor pipeline leaks. The minor levels of erosion to date do not warrant remedial measures or maintenance.

37. What routine, annual, and third-party inspections are completed for the A418 Dike?

    Weekly visual inspections conducted by the DDMI Geotechnical Technicians.

    Annual Dam Safety Inspection and Operational Review by the Engineer of Record.

    Bi-Annual Third-Party Inspection and Operational Review as specified in the Rio Tinto D5 Standard.

    Third-Party Inspection and Operational Review every 5 years, per CDA standards, as specified by the Water License.

38. Have there been any signs of erosion or slumping on the slopes of the A418 Dike since the last annual inspection?

    None.

39. Have there been any repairs or maintenance activities on the slopes of the A418 Dike since the last annual inspection?

    None.

40. What have been the most extreme hydrological conditions the A418 Dike has been exposed to (e.g., Lac de Gras water levels, discharges)?

    There was a 100-year rainfall event in July 2020 that caused Lac de Gras to rise to a maximum level of +416.35 m in August 2020 which is about 0.75 m above the normal maximum of approx. +415.6 m. The water level rose to +416.2 m in July 2021 but dropped down to +415.5 m by July 2022. The only issues encountered were minor upstream erosion up to a higher elevation in areas that were already susceptible to minor erosion.

41. Is a program in place to inspect the A418 Dike after an extreme precipitation, freshet, or flood event?

    Yes. Outlined in Table 12-5 of OMS: Event Driven Inspection and Surveillance.

42. Do ice jams occur at the outlet of the Lac de Gras which could impact the lake elevation against the A418 Dike?

    It is possible but they have never been observed and, during operations, we have never seen any unusual water level rises that could not be attributed to snowmelt or rainfall.

2.5 Mechanical and Electrical Questions

43. Which DDMI staff are responsible for inspecting the electrical components of the A418 Dike?

    Infrastructure Engineering Electricians.

44. What is the source of power supply for the operation of the A418 Dike and its associated infrastructure?

    13.8 KV highline infrastructure that follows the Dike.

45. What back-up power source(s) are available in case of a power outage at the A418 Dike? When was the back-up power source(s) last tested?

    Portable emergency generators that are tested and run up every month.

46. Which DDMI staff are responsible for inspecting the mechanical components of the A418 Dike?

    Infrastructure MTCE.

47. How are maintenance activities for the A418 Dike's pumping systems planned and documented (e.g., log books, records, reports)?

    Managed through RTBS.

48. How are inspection activities for the A418 Dike's pumping systems planned and at what frequency?

    Managed through RTBS. No PM for the area, repair as required.

49. Are there any spare parts available for the A418 Dike's pumping systems?

    We have spare pumps for DPS-6 but nothing for the infield depressurization pumps.