Madrid North Contact Water Pond As-Built Report, Hope Bay Project

Prepared for

TMAC Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
1CT022.043
March 2020

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1 Introduction

1.1 General

TMAC Resource Inc. (TMAC) is currently undertaking Phase 2 of the Hope Bay Project (the Project). The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory. Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively. As part of the development at Madrid, a contact water pond (CWP) is required at the Madrid North site to intercept and manage contact water runoff from the Madrid North Waste Rock Pile (WRP). The WRP will be constructed uphill of the CWP layout (SRK 2019a, 2019b). SRK Consulting (Canada) Inc. (SRK) was retained for the design and construction quality assurance of the Madrid North CWP.

The Madrid North CWP was constructed between May and July 2019, with final re-grading works, and the instrumentation system set-up between August and September 2019. This as-built report contains the as-built drawings and all associated quality assurance (QA) and available quality control (QC) documentation pertaining to the CWP construction.

1.2 Report Objectives

The purpose of this as-built report is to provide a factual summary of the CWP construction activities, including timelines, construction materials, construction equipment, quality control and quality assurance activities, and deviations from design. The as-built drawings are provided in Appendix A, and a photo log of the construction activities is provided in Appendix B. All other pertinent information is provided in the relative sections and appendices of this report.

1.3 Design Overview

The design of the CWP incorporates a rockfill berm with a geomembrane liner on the upstream face to contain and manage contact water from the WRP. Contact water is defined as any water coming into contact with ore or waste rock. The CWP liner is anchored and sealed to bedrock at the upstream toe of the berm. The rest of the pond footprint (beyond the main berm structure) will not be lined. Instead the design relies upon the naturally low permeability of the bedrock and frozen overburden within the pond basin to contain contact water up to the water-tight seal at the liner-bedrock tie-in point. Permafrost present within the berm foundation will be maintained due to the thermal protection of the berm fill (minimum fill thickness greater than 2 m). The CWP design is presented in SRK (2019c).

The Madrid CWP is designed to have a maximum residence time of two weeks for contact water in the pond i.e. the CWP will normally be kept in a dry state to minimize ponded water. As per the existing approved water management plan (TMAC 2017), water that meets discharge criteria may be discharged to the tundra or used for dust suppression on site. Site personnel will manage the pond using a pump and water truck to transport the contact water to approved storage or discharge areas. If water quality does not meet discharge criteria, the contact water will be transported to the Doris Tailings Impoundment Area (TIA) or Doris pollution control pond for disposal.

The storage capacity of the pond is designed to accommodate contact water runoff from the upstream WRP catchment for the 1:100 year, 24-hour storm event (55 mm) plus the maximum daily snowmelt (18 mm) (SRK 2017). The upstream catchment area was conservatively calculated as approximately 50,000 m^2 or 5 hectares (ha). Assuming a high runoff coefficient of 1 the storage volume required is 3,650 m^3. As per the as-built survey information (see Appendix A) the storage volume available is 9,300 m^3 up to the pond's full supply level (FSL) at elevation 69.7 m.

The main components of the Madrid North CWP include:

- **CWP Berm.** The shell of the berm was designed to consist primarily of run-of-quarry (ROQ) rock. On the upstream berm face, 0.5 m of Transition material and 0.3 m of Bedding material were designed to facilitate installation of the geomembrane liner (SRK 2018). The Transition layer is included between the Bedding material and the ROQ berm shell as a filter layer to provide protection against the larger ROQ penetrating through the Bedding material. The berm shell is designed with an upstream (lined) slope at 3H:1V and a downstream slope at 2H:1V. The crest elevation of the berm is designed at 70.5 m.

- **Geomembrane Liner.** A high-density polypropylene (HDPE) geomembrane liner was designed on the upstream slope of the berm to act as an impermeable barrier for seepage control. The design elevation of the top of liner is 70.0 m, which is 0.5 m below the berm crest. The liner is anchored at the crest with a minimum overlap of 2 m and 0.5 m thickness of Transition material cover that forms the final piece of the berm fill. At the toe of the upstream slope, the liner is anchored and sealed to bedrock.

- **Liner to Bedrock Tie-in.** The liner to bedrock tie-in involves steel plates and bolts spaced at 0.3 m to anchor the liner to bedrock. Some overburden excavation was anticipated to expose bedrock at the tie-in point based on aerial imagery. Where necessary, dental concrete was placed to smooth out irregular bedrock surfaces. An allowance for concrete plinths was included in the design if larger undulations in the bedrock were encountered. Concrete plinths were designed so that the liner is welded directly to the top of concrete using a HDPE embedment strip, and for the concrete to provide a watertight seal to the bedrock. The concrete plinths were designed to be a maximum of 0.5 m high.

For further details on the materials listed above, the Hope Bay Earthworks and Geotechnical Engineering Technical Specifications document (SRK 2018) should be consulted.

During construction, some components of the design were changed based on unexpected conditions encountered in the field. All changes were approved by the SRK Site Engineer. The design changes did not impact the overall design intent of the CWP. The main design changes are listed below and discussed in further detail in Section 3:

- Deeper overburden encountered at the upstream toe requiring deeper excavation
- Modification of the CWP berm alignment
- Taller concrete plinths
- Steeper downstream slope of CWP berm

1.4 Participants

The participants involved with the construction of the CWP are listed in Table 1-1. This list of companies is collectively referred to as the 'Project Team' throughout this report.

Table 1-1: Participants Involved in the Construction of Madrid CWP

Role	Company
Client / Owner	TMAC Resources Inc.
Design Engineer	SRK Consulting (Canada) Inc.
Engineer of Record	SRK Consulting (Canada) Inc.
Site Construction QA	SRK Consulting (Canada) Inc.
Offsite Laboratory Testing	Tetra Tech
Site Surveyor	Sub-Arctic Geomatics Ltd.
Construction Contractor and Earthworks QC	Nuna Logistics Limited
Construction Sub-Contractor	Nahanni Construction Limited
Liner Contractor and Liner QC	A&A Technical Services

1.5 Main Tasks and Timeline

SRK provided construction quality assurance (QA) for the CWP and associated civil earthworks during key components of the construction. This included inspection of foundation conditions, inspection of the liner to bedrock tie-in point, construction of the concrete plinths, plinth leak testing, and plinth remedial works.

SRK did not provide full-time QA. SRK was on site between June 3 to 4, June 13 to 18, June 25 to July 9, and July 11 to 18, 2019 (four QA visits in total). Items documented in this report that were completed outside of SRK's QA visits are based on communication with TMAC and the QC activities completed by the Construction Contractor.

The main tasks involved with construction of the CWP included:

1. Foundation clearing and snow removal;
2. Placement of ROQ berm;
3. Placement of a construction ROQ 'tote' access road upstream of the liner-bedrock tie-in;
4. Excavation of overburden at the upstream berm toe to expose bedrock, where required;
5. Placement of additional ROQ to fill deeper pockets left from overburden removal;
6. Placement of additional ROQ to build a re-designed southern section of the berm;
7. Placement of Transition and Bedding material on the upstream slopes;
8. Detailed cleaning of bedrock at the liner tie-in point;
9. Dental concreting and/or grouting relatively smooth but irregular bedrock surfaces;
10. Construction of concrete plinths where required to bridge across larger bedrock undulations;

11. Leak testing concrete plinths and repairs if necessary, to fill identified voids or shallow fractures in the bedrock;
12. Non-woven geotextile placement and HDPE liner installation;
13. Placement of final 0.5 m piece on the berm crest to anchor the liner; and
14. Settlement instrumentation installation.

A timeline of the main construction tasks is presented below in Table 1-2. The time periods shown are approximate.

Table 1-2: Madrid CWP Construction Activities and Timeline

Activity	Period	SRK QA Presence
Foundation clearing and snow removal	May 25 to 27, 2019	No
Placement of ROQ berm material	May 30 to June 10, 2019	Partly
Placement of construction tote road	June 10 to June 13, 2019	No
Excavation of overburden at the upstream berm toe to expose bedrock, where required		
• Chainage 0+000 to 0+100 (southern section)	June 10 to 13, 2019	No
• Chainage 0+100 to 0+160 (central section)	June 10 to 12, 2019	No
• Chainage 0+160 to 0+225 (northern section)	June 10 to 26, 2019	Partly
Placement of additional ROQ to fill deeper than anticipated overburden pocket		
• Chainage 0+050 to 0+075 (southern section)	June 14 to 15, 2019	Yes
Placement of Transition and Bedding material on the upstream slopes	June 16 to 25, 2019	Yes
Detailed cleaning of bedrock at the liner tie-in point		
• Chainage 0+000 to 0+100 (southern section)	June 27 to July 01, 2019	Yes
• Chainage 0+100 to 0+160 (central section)	June 20 to 23, 2019	No
• Chainage 0+160 to 0+225 (northern section)	June 27 to July 01, 2019	Yes
Dental concreting, grouting and/or construction of concrete plinths		
• Chainage 0+000 to 0+100 (southern section)	June 30 to July 02, 2019	Yes
• Chainage 0+100 to 0+160 (central section)	June 24, 2019 (dental concrete only)	No
• Chainage 0+160 to 0+225 (northern section)	June 30 to July 02, 2019	Yes
Leak testing concrete plinths	July 03 to 04, 2019	Yes
Patching repairs to concrete plinths		
• Chainage 0+000 to 0+100 (southern section)	Not required	-
• Chainage 0+100 to 0+160 (central section)	Not required	-
• Chainage 0+160 to 0+225 (northern section)	July 13 to 17, 2019	Yes
Placement of additional ROQ to build re-designed southern flank of the berm	July 03 to 06, 2019	Yes

Activity	Period	SRK QA Presence
Geotextile and liner installation		
• Chainage 0+000 to 0+100 (southern section)	July 06 to 08, 2019	Yes
• Chainage 0+100 to 0+160 (central section)	June 28 to 29, 2019	Yes
• Chainage 0+160 to 0+225 (northern section)	July 23 to 25, 2019	No
Placement of final 0.5 m piece on the berm crest to anchor the liner	July 28 to 30, 2019	No
Final crest and downstream slope re-grading	August 01 to 03, 2019 and September 13 to 15, 2019	No
Settlement instrumentation installation	September 16, 2019	No

As indicated in Table 1-2, there were some breaks in construction activities at the CWP due to rain delays, and as equipment and personnel were at times reallocated to other projects on site.

1.6 Climatic Conditions

Figure 1 presents a summary of the mean daily temperatures and precipitation recorded during construction of the CWP. Temperature records are taken from the Doris weather station on site, which are considered representative for the site conditions at Madrid. The start and finish dates of the main tasks associated with the CWP construction are also shown for reference on Figure 1.

During the construction, the minimum recorded mean ambient air temperature was -5˚C on May 25, 2019 (during foundation snow clearing), while the maximum was +18°C on August 02, 2019 (after the majority of construction activities were completed). There was a total of 10 rain days that had equal to or greater than 5 mm/day of rain. The maximum precipitation was 9.7 mm falling on June 14, 2019. A total 130 mm of precipitation occurred during the construction period (i.e. May 25 to September 16, 2019). For comparison, the mean annual precipitation for the site is 210 mm, which includes both rainfall and snow water equivalent (SRK 2017).

1.7 Photo Record

Photographs were taken each day during QA site visits by SRK. A summarized photo record showing the key construction activities is provided in Appendix B. Table 1-3 outlines the contents of the photo record.

Table 1-3: Contents of Photo Log (Appendix B)

Title	Photo Log Page
Berm Footprint Clearing	1
ROQ Material Placement	2 to 3
Overburden Excavation	4
Overburden Excavation Backfill with ROQ	5
Berm Re-Design and Field Fit	6
Bedding and Transition Material Placement	7

Title	**Photo Log Page**
Bedrock Cleaning and Preparation	8
Construction of Concrete Plinths 1 to 10	9 to 17
Dental Concrete and Grouting	18 to 19
Geotextile and Liner Placement	20 to 22
Final Berm Shaping	23

2 Construction Documentation

2.1 Construction Drawings

Table 2-1 lists details for the latest revision of each Issued for Construction (IFC) drawing. The complete set of construction drawings is provided in Appendix C.

Table 2-1: Madrid North CWP Issued for Construction Drawings

Drawing Number	Title	Latest Revision	Date of Issue
MN-CWP-01	General Arrangement (With Orthophoto)	0	March 19, 2019
MN-CWP-02	General Arrangement	0	March 19, 2019
MN-CWP-03	Contact Water Pond Anticipated Foundation Conditions Plan and Profile	0	March 19, 2019
MN-CWP-04	Contact Water Pond Plan and Profile	0	March 19, 2019
MN-CWP-05	Contact Water Pond Typical Sections	0	March 19, 2019
MN-CWP-06	Contact Water Pond Typical Details	0	March 19, 2019
MN-CWP-07	Liner Tie-in Typical Details	0	March 19, 2019
MN-CWP-08	Contact Water Pond Instrumentation Plan – 1 of 2	0	April 5, 2019
MN-CWP-09	Contact Water Pond Instrumentation Plan – 2 of 2	0	April 5, 2019

2.2 Technical Specifications

The latest revision of the Technical Specifications (Revision H) was used for construction (SRK 2018). Note that the technical specifications document is intended to be all encompassing of earthworks construction projects at the Hope Bay Mine site and therefore contains sections that are not directly relevant to the CWP construction. The site technical specifications document (SRK 2018) should be read in conjunction with this as-built report.

2.3 Daily Site Reporting

SRK had a Site Engineer present during key components of the construction. Full-time QA was not provided by SRK; however, TMAC and the Construction Contractor carried out QC checks and provided photos of construction progress when SRK was not on site. When on site, the SRK Site Engineer generally compiled a set of field photos and notes for each day of construction. These were done to summarize daily construction activities and provide specific details on factual observations used to track progress and inform decisions. The field notes were generally used to assist internal communication between the SRK Site Engineer and the SRK Project Manager in the office but were also shared with the project team external to SRK; including TMAC, Nuna Logistics Limited (Nuna), Sub-Arctic Geomatics (Sub-Arctic), and A & A Technical Services (A&A). These correspondences are considered informal communications and are not presented as part of this report. The content of these messages however has been used when preparing this as-built report and the corresponding as-built drawings.

3 Deviations from Original Design

3.1 General

In general, the Madrid North CWP was built to the lines, grades, and requirements outlined in the Issued for Construction (IFC) Drawings (Appendix C) and Technical Specifications (SRK 2018). Deviations from, and amendments to, the design were undertaken to adapt the design to the encountered field conditions. These design updates are discussed in the following sections and are detailed in the as-built drawings (Appendix A).

3.2 Overburden Excavation

A detailed site investigation was not able to be completed, due to timing, before the initial design of the CWP. Overburden was expected between bedrock outcrops but was anticipated to be thin (in the order of 2 m deep) based on aerial imagery. Therefore, excavation of overburden to expose the bedrock for liner tie-in was anticipated to be relatively minor.

During excavation of overburden to expose bedrock for the liner tie-in, a significant pocket of overburden material was encountered at the southern end of the CWP berm. This overburden pocket was encountered approximately between chainage 0+050 and 0+075 (see As-Built Drawing MN-CWP-03). The overburden pocket was found to be approximately 5 m deep. Due to the timing when this excavation was completed (i.e. at the onset of spring and freshet conditions), notable water was noted flowing into the excavation. This led to some challenges on site to manage the water as the excavation progressed. The liner tie-in point was projected to be at the base of the overburden pocket, and therefore significant efforts would have been required to perform detailed cleaning of the bedrock due to the additional excavation volume and water management challenges. In addition, the near vertical bedrock walls on either side of the overburden pocket would have been very challenging to affix the liner to. Large concrete plinths may have been needed to provide a more gradual transition for the liner tie-in.

As a result, a decision was made in the field by TMAC and the SRK Site Engineer to backfill the excavated overburden pocket with ROQ, and shift the liner tie-in point to higher ground upstream. At this higher ground location further upstream, bedrock was exposed at surface (see As-Built Drawing MN-CWP-04). The bedrock outcrop in this area was found to be less undulating which ultimately allowed for a less challenging liner to bedrock tie-in. A temporary construction ramp consisting of ROQ material was built approximately 10 m north of the CWP berm; built at 0+000 from the Madrid North Waste Rock Access Road. This temporary ramp was used to haul and place ROQ for the overburden pocket backfill and was later used to provide equipment access into the pond area.

Deeper than anticipated overburden was also encountered in the northern end of the CWP, approximately between chainage 0+160 and 0+190 (see As-Built Drawing MN-CWP-03). Overburden was up to 4 m deep at its deepest. However, concrete plinths (specifically Plinth 4) were able to be used and the liner to bedrock tie-in did not shift significantly from the original projected design (see As-Built Drawing MN-CWP-04).

These two deeper than anticipated overburden areas resulted in two main design deviations. Firstly in the southern section, it resulted in the overburden excavation area being backfilled and moving the alignment of the liner tie-in further north into the CWP basin. Secondly in the northern section, it resulted in taller than anticipated concrete plinths. However, both changes, while noteworthy, do not impact the overall design intent of the CWP.

The middle section of the CWP (chainage 0+100 to 0+160) was not expected to require overburden excavation in the design, based on interpretation of aerial imagery. Minor overburden was encountered during construction; however, it was relatively thin (less than 0.3 m thick) and the final liner to bedrock tie-in was more or less the same as the design locations.

3.3 Berm Alignment Modification

After filling in the southern overburden pocket with ROQ, a field decision was made by TMAC and the SRK Site Engineer to modify the CWP berm alignment. This was done in order to simplify the liner to bedrock tie-in. The modification involved adding a new berm, approximately 20 m long and perpendicular to the existing berm, at chainage 0+040. The liner was then tied into a bedrock outcrop to the northwest. This enabled the length of the liner to bedrock tie-in to be shortened and allowed the temporary access ramp (built into the excavation backfill area) to be used as part of the berm fill. The implications of the berm re-alignment meant that the CWP basin area, and therefore pond capacity, was slightly reduced. However, the reduction in storage area was minimal and most of the area that was cut-off by the new berm was above the full supply level (FSL) (i.e. above elev. 69.7 m).

The small area behind the new berm, if not backfilled, was identified as a potential ponding area. Therefore, the SRK Site Engineer directed the Construction Contractor to completely backfill the area behind this berm segment. Although the catchment area behind the new berm is small, the SRK Site Engineer also instructed the Construction Contractor to line the backfilled area. This was intended so that any precipitation falling in this area, much of which is above the FSL, could drain into the lined CWP basin, rather than infiltrate through the backfill and into the excavated overburden / ROQ backfill area. This was also intended to help limit the amount of water and reduce the pressures that otherwise might have developed behind the liner.

A design was produced by SRK for the berm re-alignment and agreed to by TMAC. Some field fitting was required during the construction of the re-designed berm. This area is presented in the as-built drawings (see As-Built Drawing MN-CWP-03 in Appendix A).

3.4 Concrete Plinths

The CWP design included an allowance for concrete plinths, if required, once the overburden was excavated and the bedrock exposed. Concrete plinths were designed to be a minimum of 0.3 m high, with a maximum height of 0.5 m.

During excavation of overburden, a number of overburden pockets were encountered, as well as many undulations in the bedrock. Some areas ended up having near vertical bedrock faces up to 2 m high. Except for the one large overburden pocket that was backfilled, concrete plinths were used to bridge across the excavated pockets and/or bedrock undulations to facilitate a smooth liner tie-in. As-built Drawing MN-CWP-04 shows the number and location of concrete plinths that were constructed. Some of the concrete plinths (e.g. Plinth 4) were required to be constructed taller than the maximum design plinth height. Therefore, backfill was specified on both sides of the plinth for additional lateral support.

The GSE polylock embedment strip, as recommended in the original design to allow the liner to be welded to the top of concrete, was not available on site. Instead, the liner was bolted directly into the top of concrete using Sopramastic and the stainless-steel plate. This method still achieves the same purpose. Further details of the liner tie-in are provided in Section 5.10.

3.5 Berm Crest

The CWP design included a final capping layer of 0.5 m of Transition material on the entire width of the berm crest. This brought the crest elevation to 70.5 m. The intent of the layer is to act as an anchor for the liner and provide additional freeboard for wave run-up. During construction, only a portion of the final 0.5 m Transition layer was placed across the width of the crest. The amount placed is equivalent to the minimum amount required for liner anchoring resistance as well as the additional freeboard. There were concerns that ponding would occur on the crest between the placed Transition material and the outer safety berm; however, berm breaks were established for drainage. The current crest configuration meets the minimum design intent and will be monitored by site personnel to check for ponding. If ponding does occur, additional fill will likely be required.

3.6 Berm Downstream Slope

After completion of earthworks and liner installation, the final CWP layout was surveyed by Sub-Arctic. SRK reviewed the as-built survey and identified that the downstream slopes were steeper than design slope of 2H:1V. The oversteepened slopes were also noted at various times during the ongoing QA checks by SRK whilst on site. The outside as-built slopes were typically between 1.7H:1V to 1.9H:1V, but some sections were as steep as 1.65H:1V. SRK instructed TMAC to place additional fill or regrade the slopes to achieve the design slope of 2H:1V. Instead, TMAC requested SRK to complete a stability analysis to determine if the steeper than design slopes were stable in the current arrangement to meet the minimum required factors of safety.

SRK completed a stability analysis to assess the risk of geotechnical instability of the CWP berm in its as-built condition. The results of the analysis indicate that the berm is stable and meets minimum factors of safety (FoS), provided the overburden in the foundation remains frozen, or as a minimum, doesn’t thaw beyond the average active layer thickness in this area (typically around 1 m). If the overburden completely thaws, the FoS may reduce below the criteria of 1.5 but this doesn’t mean that immediate failure is expected. Therefore, the risk of failure is low. Additionally, if a failure were to occur it would be slow and progressive rather than rapid, i.e. there would be sufficient warning provided adequate monitoring is in place.

SRK is therefore satisfied that the berm’s downstream slope does not currently need to be regraded to meet a slope of 2H:1V. Further details of the analysis are provided in Appendix D.

SRK recommended increased monitoring frequency of the survey plates and pins installed in the CWP berm until enough confidence is established that the berm is stable, and no movements are occurring. Monitoring requirements for the CWP will be provided in the CWP Operations, Maintenance and Surveillance (OMS) manual currently being developed by TMAC and SRK.

3.7 Settlement Instruments

At the time this as-built report was completed, the surficial settlement monitoring points were installed in 16 of 19 proposed locations on the CWP. The surficial settlement monitoring points should be revisited, and if determined necessary by the design Engineer, the remaining points should be installed in the summer of 2020 after the snow has melted.

The four settlement monitoring plates were installed as per the design. A summary of the constructed instrumentation plan is shown in the As-Built Drawing MN-CWP-09.

3.8 Construction Access Road

A construction access road, or ‘tote’ road, was constructed upstream of the CWP berm within the CWP basin area to provide equipment access. Equipment access was required for overburden excavation activities at the upstream toe. The tote road was built with a minimum of 1 m thick ROQ and does not impact the design intent of the CWP. It will remain in-place and can continue to be used for access, depending on the water level within the CWP basin.

3.9 Quality Assurance and Quality Control Testing

Quality assurance in the Technical Specifications (SRK 2018) outlines that two particle size distribution (PSD) tests (as per ASTM C136) were to be completed during production of Transition material. Due to the large particle sizes, the material was not shipped off-site for analysis but rather visual PSD was completed on-site as discussed further in Section 6.

For Bedding material, the Technical Specifications (SRK 2018) state that in-place compaction testing in accordance with ASTM D2922 (Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods) was to be completed during placement. Due to the larger allowable deformations for the Bedding material on the outer slope of the CWP berm, compaction testing was not completed. Instead field observations were made for the placed material and all Bedding material was compacted via tamping with the excavator bucket. In line with these same reasons, the maximum density testing in accordance with ASTM D698 (Standard Test Methods for Laboratory Compaction) was also not completed.

Furthermore, the Technical Specifications state that QA and QC testing would be completed on-site. Rather, the testing was completed off-site by Tetra Tech in their Yellowknife laboratory.

4 Construction Materials

A variety of materials were used in constructing the Madrid North CWP. The rock and granular materials were produced on-site by quarrying and crushing, and concrete was mixed and produced at the Doris batch plant. All other materials were sourced from off-site manufacturers. Table 4-1 presents a summary of the materials used, as well as the location and the source of the material.

Table 4-1: Summary of Materials used in the CWP Construction

Material	Location/Use	Source
Run-of-quarry (ROQ)	Berm fill, deep overburden pocket backfill, construction 'tote' road	Quarry D
Transition – 200 mm minus crush	Filter between the Bedding material and ROQ material on the berm's upstream slope	Quarry #2, on-site crusher
Bedding – 25 mm minus crush	Protection layer below the geomembrane liner	Quarry #2, on-site crusher
Concrete	Dental concrete and plinth construction	Produced at the Doris batch plant
Grout	Multicrete Sub Zero Grout was used for filling deeper cracks in the bedrock	Off-site vendor (Multicrete)
Mortar	Sikaset Plug was used to repair small voids beneath the plinths	Off-site vendor (Sika)
Bentonite-Aggregate Mixture	Used as backfill either side of constructed plinths	Produced at the Doris batch plant
HDPE Geomembrane Liner	Upstream slope of the CWP berm for water retention system	Off-site vendor (SOLMAX)
Non-woven Geotextile	Used as an underliner protection layer	Off-site vendor (WINFAB)
Bituminous Sealant (Sopramastic)	Used below the liner and above the liner (beneath the steel strip) at the liner tie-in point as an additional water barrier	Off-site vendor (Soprema)
Steel rebar	Used for concrete plinth construction	Off-site vendor (Unknown)

4.1 Run-Of-Quarry Material

All ROQ material used as backfill and as above ground berm shell material is geochemically suitable basalt, quarried on-site from Quarry D by drilling and blasting methods. Quarry D was developed prior to the start of construction. Oversize was sorted during the loading of the haul trucks. ROQ was subject to visual QA/QC only and was generally noted to be well graded with very few oversize pieces (greater than 1 m diameter) as outlined in the Technical Specifications (SRK 2018).

4.2 Transition Material

Transition material was produced by the on-site crusher using the primary jaw circuit only. The 200 mm minus material was used as a Transition layer between the Bedding material and the ROQ material to help mitigate particle migration. This material was subject to visual QA/QC only.

The Transition material was stockpiled near the crusher in Quarry #2 and hauled to CWP when required.

4.3 Bedding Material

The 25 mm minus crush was produced to meet the particle size envelope stated in the Technical Specifications (SRK 2018). QA testing of this material included PSD testing as described in Section 6. This material was stockpiled in Quarry #2 and hauled directly to the CWP as necessary.

4.4 Concrete

All concrete required for dental concrete and concrete plinths was mixed and produced by Nahanni on-site at the Doris batch plant and transported to the CWP via a concrete mixing truck. Concrete was mixed according to the approved concrete mix design currently used for all concrete produced and used at the Hope Bay Mine Site. Table 4-2 summarizes the concrete mix design with superplasticizer and air entrainment.

Table 4-2: Concrete Mix Design

Component	Batch Size					
	1 m^3	2 m^3	3 m^3	4 m^3	5 m^3	6 m^3
Water (gallons)	60	120	180	240	300	360
Cement (kg)	500	1,000	1,500	2,000	2,500	3,000
Coarse Aggregate (kg)	1,835	3,670	5,505	7,340	9,175	11,010
Water Reducer (ml)	300	600	900	1,200	1,500	1,800
Superplasticizer (Supercizer 7) (kg)	2.8	5.6	8.4	11.2	14	16.8
AIR (ml)	40	80	120	160	200	240

Source: Nahanni Construction Limited.

A total of six batches were mixed for the CWP construction, and each batch was approximately 6 m^3. Table 4-3 provides a summary of the concrete batches produced and the approximate location of each concrete batch in the CWP.

Table 4-3: Concrete Production Summary

Concrete Batch	Production Date	QC Samples	Approximate Location in the CWP
1	June 24, 2019	0	Central section between 0+100 to 0+160 (dental concrete only)
2	June 30, 2019	0	Plinth 1, 2, 3 and dental concrete between Plinth 2 and Plinth 4
3	June 30, 2019	6	Plinth 6 and 7 and dental concrete between Plinth 6 to Plinth 8
4	July 02, 2019	2	Plinth 8 and dental concrete between Plinth 5 to Plinth 7
5	July 02, 2019	2	Majority of Plinth 4, additional dental concrete between Plinth 2 and 3
6	July 02, 2019	2	Remainder of Plinth 4, Plinth 9 and 10, all dental concrete between 0+000 to 0+100

The mixed concrete used at the CWP was subject to quality control (QC) testing which is detailed in Section 6.

4.5 Grout and Mortar

Multicrete Sub Zero Grout (manufactured by Multicrete in 20 kg bags) was used for filling deeper cracks in the bedrock beneath the liner tie-in point. Sikaset Plug mortar (manufactured by Sika in 1 kg bags) was used to repair small voids beneath the concrete plinths identified during leak testing. Both grout and mortar were mixed by hand in buckets by Nahanni using water and electric hand mixing tools. Only visual QA/QC was performed for these materials.

Section 5.9 offers further details regarding the concrete plinth construction and plinth remedial works. Product datasheets for the Multicrete Sub Zero Grout and Sikaset Plug are provided in Appendix E.

4.6 Bentonite-Aggregate Mixture

The bentonite-aggregate mixture was mixed and produced by Nahanni on-site at the Doris batch plant and transported to the CWP via a concrete mixing truck. The mix design specified Bedding material with a minimum bentonite content of 10% by weight. The mixed product was subject to quality control (QC) testing which is detailed in Section 6.

4.7 HDPE Geomembrane Liner

The 1.5 mm (60 mil) HDPE liner was manufactured by SOLMAX. Liner rolls were generally transported to the CWP immediately prior to use; however, they were permitted to be stored outside with an appropriate protective covering. QC testing was performed by A&A Technical Services. Visual QA was performed by SRK and found that the liner installation was as per the technical specifications.

The liner product datasheet is provided in Appendix F and the A&A technical services QC testing paperwork is provided in Appendix G.

4.8 Non-woven Geotextile

The 12 oz/yd^2 non-woven geotextile was manufactured by TITAN. Geotextile rolls were generally transported to the CWP immediately prior to use; however, they were permitted to be stored outside with an appropriate protective covering. Only visual QA/QC was performed which found that the geotextile installation was as per the technical specifications. The purpose of the non-woven geotextile is to provide protection to the HDPE geomembrane liner.

The geotextile product datasheet is provided in Appendix F.

4.9 Summary of Material Quantities

The as-built material quantities used for the Madrid North CWP construction are summarized in Table 4-4. In-place (compacted) quantities are derived from survey data supplied by Sub-Arctic.

The as-built ROQ quantity was approximately 15% higher than the estimated neat-line design quantities. This can be attributed primarily to general bulking and compaction adjustments, and the berm alignment modification and additional overburden excavation backfill. The additional excavation and berm adjustments also caused the quantities of the Transition, Bedding, liner and geotextile material to increase above the estimated design quantities. The final surfacing layer was not required since the ROQ and Transition material in the top of the berm crest was determined to be adequately trafficable. Concrete volumes were not estimated in the original design since bedrock conditions were unknown at the time.

Table 4-4: As-Built and Design Material Quantities

Material	**Quantity (neat-line)**	
	As-Built	**Design** (1)
Overburden Excavation	301 m^3	250 m^3
ROQ Material	15,509 m^3	13,450 m^3
Transition material	1,705 m^3	770 m^3
Bedding Material	644 m^3	450 m^3
Surfacing Material (berm crest and access road)	0 m^3	280 m^3
HDPE Geomembrane Liner	3,289 m^2	2,005 m^2 (2)
Non-Woven Geotextile	3,289 m^2	2,005 m^2 (2)
Concrete	36 m^3 (3)	N/A
Bentonite-Aggregate Mixture	10 m^3 (4)	N/A

Note(s):

1. All design quantities presented are to neat-lines and do not allow/account for bulking and compaction.
2. HDPE and non-woven geotextile design quantities do not account for patches, sacrificial panels, overlaps or wastage.
3. Estimated volume based on the number of concrete batches produced (approximately 6 m^3 per batch).
4. Estimated volume based on the number of batches produced (two batches each approximately 5 m^3).

5 CWP Construction

5.1 Equipment

5.1.1 Mobile Equipment

Conventional earth moving equipment was used in construction of the Madrid North CWP as listed in Table 5-1.

Table 5-1: Summary of Equipment used for CWP Construction

Equipment Type	Manufacturer	Model	Attachments
Bulldozer	Caterpillar	D6	n/a
	Caterpillar	D8	Ripper tooth
Backhoe Excavator	Caterpillar	385	n/a
	Caterpillar	345	Rock hammer
	Caterpillar	325	n/a
	Caterpillar	308	n/a
Articulating Haul Trucks	Caterpillar	740 (x 4)	n/a
	Caterpillar	725 (x 1)	n/a
Vibratory Drum Compactor	Caterpillar	CS-74B	n/a
Crane	Grove	RT-625	Spreader bar assembly
Concrete Mixer Transport Truck	Kenworth	Unknown	11 m^3 Mixing Barrel

A variety of other non-mobile equipment was also used to support the construction activities. This equipment included but was not limited to:

- HDPE liner welding equipment;
- A Godwin Dri-Prime pump and two electric sump pumps to facilitate surface water management within the overburden excavations;
- Numerous hand tools including shovels, trowels, rakes, and brooms used to support detailed cleaning of the liner to bedrock tie-in point and pouring of dental concrete and concrete plinths;
- An air compressor and attachments to support detailed cleaning of the liner to bedrock tie-in point; and
- A hand compactor to support placement of the bentonite-aggregate backfill.

5.1.2 Crusher

The Transition and Bedding material were crushed using a Clemro crusher located at Quarry #2. The crushing circuit consisted of a primary jaw crusher, a classification screen, and a secondary cone crusher. A CAT 988 loader was used to feed the crusher with select ROQ, sourced exclusively from Quarry #2.

5.2 Survey Control

Survey control and reporting was performed by Sub-Arctic. Surveying was performed with Leica GPS / GNSS equipment using the UTM zone 13 coordinate system and NAD83 datum. All survey data was processed on site by Sub-Arctic personnel. Interim as-built surveys were generally sent to SRK periodically or after completion of specific activities. The survey data was used to check grades, minimum thicknesses, and extents for field decisions, as well as to prepare the as-built drawings (Appendix A). Typical accuracy of the system was within ±5cm.

5.3 Foundation Preparation

Foundation preparation involved clearing snow from the CWP berm footprint. Snow clearing took place between May 25 to 27, 2019. Cleared snow was stockpiled at the downstream toe outside of the berm footprint area. SRK was not on site to observe the main clearing activities but was advised by TMAC that all foundation clearing activities was completed in accordance with the technical specifications (SRK 2018).

5.4 Placement of ROQ Material

The ROQ material produced in Quarry D was sorted in the quarry with the CAT 385 excavator and subsequently loaded into the CAT 725 and 740 haul trucks using this same machine. Placement of ROQ for the CWP berm was generally done by end dumping and pushing with a CAT D6 or CAT D8 bulldozer. As reported by the Construction Contractor, the lift thickness was maintained to a maximum of 1.85 m at all times, unless the total height of fill was less than 1.85 m in which case lift thicknesses were restricted to a maximum of 0.9 m. For the periods SRK was on site, periodic QA checks on ROQ lift thickness was completed. Each lift was compacted using the vibratory compactor and/or by loaded haul trucks using the area as a trafficking surface.

The first lift of ROQ was placed over the entire footprint and then subsequent lifts placed up to the final elevation of ROQ in the CWP berm. Additional ROQ was used to backfill the deep overburden pocket that was excavated from the southern end of the CWP basin, and for the berm realignment. ROQ placement activities when SRK was not on site are based on communications from TMAC and the Construction Contractor.

The final downstream slope of the CWP berm was graded and shaped using CAT 325 and 345 excavators. As discussed in Section 3.5, the final slope achieved was slightly steeper than the design slope of 2H:1V.

5.5 Placement of Transition Material

Transition material was hauled to the CWP and placed on the upstream 3H:1V slope of the berm with CAT 325 and 345 excavators. Transition material was generally placed as a single 500 mm lift by casting material into place with an excavator from the berm crest and bucket tamping. Final compaction was achieved using the vibratory compactor.

The final 0.5 m thick piece of Transition material was placed on the CWP berm crest once all liner had been installed. The final Transition layer on the crest acts as an anchor for the liner. Transition material was not placed along the entire crest width as per the design, and instead was only placed approximately 3 to 4 m wide to cover the liner overlap for anchoring purposes. The design deviation is discussed in Section 3.5.

5.6 Placement of Bedding Material

As outlined in Section 4.3, Bedding material generally comprised a 25 mm (1 inch) minus crushed rock.

Bedding material was hauled to the CWP with CAT 725/740 haul trucks and placed on top of the Transition material layer on the 3H:1V upstream slope of the berm. Bedding material was generally off loaded directly from the back of the haul trucks using the 325 or 345 excavators or stockpiled on the crest for future use. Material was then placed by the excavator by casting into place and then pulled upward along the slope, beginning near the base of the slope and advancing to the slope’s crest. Compaction of Bedding material on the upstream slope was achieved through bucket tamping. All Bedding material was typically placed in a single 300 mm lift.

5.7 Overburden Excavation

Overburden excavation was required at the upstream toe of the CWP berm to expose bedrock for the liner-to-bedrock tie-in. Excavation was completed using the CAT 325 and 345 excavators. The CAT 308 excavator was also used for specific areas requiring a smaller excavator. Excavated material was loaded into haul trucks and hauled to the Naartok East Overburden Stockpile. Equipment access was provided by the construction of a ‘tote’ road within the CWP basin, upstream of the berm. The anticipated overburden depth in the design was one to two meters deep where overburden was visible in aerial imagery; however, the overburden was found to be deeper than expected at these locations (as discussed in Section 3.2).

At the southern end of the CWP between chainage 0+050 to 0+100, overburden was excavated to approximately 5 m deep, at which point bedrock had still not been encountered. A field decision was made to backfill the excavation with ROQ and relocate the upstream toe of the berm further north into the CWP basin, so that the toe could tie-into shallower and/or exposed bedrock.

For the central piece of the CWP (chainage 0+100 to 0+160), the overburden was relatively thin, approximately 0.1 to 0.3 m thick. Bedrock in this section was easily exposed.

At the northern end of the CWP between chainage 0+160 to 0+225, the overburden typically ranged between 1 to 2 m deep, with one deeper pocket up to 4 m deep. Overburden was excavated to bedrock for this entire section.

The final excavated overburden slopes upstream of the berm were covered with a minimum 1 m thick ROQ rock cladding to stabilize the slope and maintain permafrost conditions. Water entering the excavation areas was managed by mobile pumps, with water either pumped uphill of the CWP, within the CWP catchment area, when the water truck was not available or pumped into the water truck and transported to the Doris Pollution Control Pond.

5.8 Bedrock Preparation

Once bedrock was exposed at the liner tie-in, it was cleaned of remaining overburden and loose material with manual labour. Air compressors and other hand tools were used to clean the tie-in surface. Areas of naturally fractured bedrock were scaled back using the 308 excavator to remove loose rock. Areas of fractured rock were also grouted with Multicrete Sub Zero Grout prior to dental concrete and liner tie-in. Generally the bedrock was found to be competent rock with minimal or fairly discrete fractured zones.

5.9 Concrete Placement

Concrete placement (pours) included both dental concrete and concrete placement for plinths. Where the bedrock was relatively smooth, with minor irregularities, a layer of dental concrete approximately 5 to 10 cm thick was placed to provide a smooth, uniform surface for the liner tie-in. Where bedrock was found to be undulating and/or with steep (near vertical) sides, concrete plinths were constructed to bridge across the undulations or to provide smoother transitions for the steeper bedrock. The liner was then bolted directly into the top of the concrete plinth and sealed.

Dental concrete was placed on prepared bedrock surfaces using the crane and concrete bucket and finished by hand, in place, using trowels. The upstream edge of the dental concrete was squared off after it had cured and covered with Sopramastic as an additional seal. The central section of the CWP between 0+100 to 0+160 was relatively smooth and only dental concrete was required (placed on June 24, 2019). For the remaining sections, a combination of dental concrete and concrete plinths were required (placed between June 30 to July 02, 2019).

Prior to construction of the plinths, the bedrock was prepared and cleaned (Section 5.8). Timber formwork was then constructed by Nahanni labourers at the plinth locations identified by the SRK Site Engineer. Steel rebar was placed with 0.3 m horizontal spacing and drilled and embedded with epoxy a minimum 0.3 m into the bedrock at the base and in the plinth side walls. The steel rebar was 15 mm in diameter. Once the formwork and rebar were installed, the bedrock was given a final clean with the air compressor, to remove loose debris prior to concrete placement. Concrete was placed using a Grove RT-625 crane and concrete bucket. The concrete was poured into place by hand shovelling. The final surface was finished by hand using trowels. A total of ten (10) concrete plinths were constructed between June 30 to July 02, 2019, and their locations are illustrated in the as-built drawings (Appendix A).

All concrete (dental and plinths) were covered with tarps after placement and allowed to cure for a minimum of 24 hours. SRK as-built drawing MN-CWP-04 (Appendix A) shows the placement of all concrete plinths. Note that no notable loads will be placed on the plinths, rather their main function is to provide an impermeable tie-in between the bedrock and liner.

5.9.1 Plinth Leak Detection and Repair

Prior to the concrete plinths being poured, water had continued to flow into the open excavations and was not adequately managed during the concrete pour. This is thought to have resulted in loose sediment on the sides sloughing into the base of the excavation and into the base of the plinth formwork. This issue was not identified by the construction team prior to the concrete pours. As a result, after removing the plinth formwork, a number of plinths were identified to have small voids at their base and an inadequate concrete to bedrock seal. Voids were identified by performing leak detection testing. This testing was done by pumping water from one side of the plinth and observing if the water level on the other side also dropped. If the water levels on both sides of the plinth decreased at the same time, this indicated the two sides were hydraulically connected and the presence of a void existed. Coloured food dye was also used in some of the leak tests to assist with visual observations. All leak detection testing for the concrete plinths was performed under supervision of the SRK Site Engineer.

Of the ten (10) plinths constructed, six (6) were identified by the SRK Site Engineer as having leaks. The first round of leak detection tests was carried out between July 03 to 04, 2019. After the leaks were identified, SRK and TMAC discussed a number of potential remediation options including additional concrete placement, bentonite backfill, bentonite-aggregate backfill, leak repair mortar and/or a combination of the proposed options. On July 06, 2019, SRK communicated to TMAC that leak repair mortar (Sikaset Plug) should be used to patch voids followed by a backfill of bentonite-aggregate mixture on both sides of the plinth.

Remediation works for the concrete plinths was completed between July 13 and 17, 2019. After remediation works, the plinths were re-tested for leaks and all plinths passed the second round of leak detection testing. Pages 9 to 17 in the construction photo log show the construction and remediation activities undertaken for each plinth. Table 5-2 summarizes the concrete plinths constructed for the CWP.

Table 5-2: Summary of Concrete Plinths Constructed for the CWP

Concrete Plinth	Maximum Length (m) (1)	Maximum Height (m) (2)	Nominal Width (m)	First Leak Test (Pass/Fail)	Second Leak Test After Repairs (Pass/Fail)
Plinth 1	3.7	0.7	0.5	N/A (3)	
Plinth 2	3.0	0.5	0.5	Fail	Pass
Plinth 3	1.8	0.6	0.5	Fail	Pass
Plinth 4	6.4	1.6	0.5	Fail	Pass
Plinth 5	5.1	1.5	0.5	Fail	Pass
Plinth 6	5.3	0.3	0.5	N/A (4)	
Plinth 7	4.4	0.5	0.5	Fail	Pass
Plinth 8	3.4	1.2	0.5	Fail	Pass
Plinth 9	2.1	0.3	0.5	Pass	N/A
Plinth 10	4.6	0.8	0.5	Pass	N/A

Notes:

1. As per the as-built survey information.
2. Estimated in the field by the SRK Field Engineer.
3. Plinth 1 was not able to be tested due to the way it was poured. However, the Field Engineer observed that ponded water upstream of the plinth did not drop in height over time.
4. Plinth 6 was not tested since it was built in a relatively long, flat section with minimal height.

5.10 Geotextile and Liner Placement

Geotextile and liner panels were placed perpendicular to the berm axis. The geotextile was placed first on top of the Bedding layer, with an overlap of 0.3 to 0.5 m between geotextile panels. Geotextile was generally placed using manual labour by rolling out the geotextiles rolls. The Bedding layer was inspected and approved by the SRK Site Engineer prior to geotextile installation.

For the liner placement, the Grove RT-625 crane equipped with a spreader bar assembly, was used to lift the rolls of liner. The liner contractor (A&A), assisted by labourers (Nahanni), pulled the liner from the crest and ensured the panels were properly aligned. The HDPE liner seams were then welded in place by A&A and all seams were pressure tested to check the quality of the seal. A small number of punctures were identified following liner installation, and these were patched over and welded to the liner panel. SRK as-built drawing MN-CWP-10 (Appendix A) shows the placement of all liner panels and patches. A&A's liner installation and quality control report is provided in Appendix G.

The liner tie-in at the upstream toe of the berm involved bolting the liner either directly into bedrock (through dental concrete) or into the top of the concrete plinths. Hilti rock anchor bolts (expansion bolts) were used and drilled into the bedrock and/or concrete. Prior to drilling and bolting the liner into place, a strip of Sopramastic bituminous sealant approximately 0.3 m wide was applied beneath the liner. Above the liner, a second strip of Sopramastic was applied prior to placing a 0.2 m wide stainless-steel plate. Holes were drilled through the steel plate and liner into the underlying bedrock or concrete plinth. Hilti bolts were then hammered in to lock everything in place. A single line of bolts was placed at a bolt spacing of 0.3 m. A final layer of Sopramstic was applied over the bolts and steel plate to finish the liner tie-in.

The liner tie-in at the area of Plinth 10 (liner panels 15 and 16 as illustrated on Drawing MN-CWP-10) was challenging due to continuous water flow which filled up in this low area and rose above the liner tie-in point. Water was observed flowing out of the ROQ backfill in the excavated overburden pocket, meaning this water would put pressure behind the liner. Efforts were made to manage the water by pumping it to the other side of the CWP or removing it from the system entirely with the water truck. Despite these efforts water continued to rise to an approximate static level 0.2 to 0.3 m above the top of Plinth 10 (Plinth 10 elevation is 65.6 m).

After liner panels 15 and 16 were installed, the lowest portion of the panels were observed to behave like a 'waterbed', indicating that water had built up behind the liner. Approximately two days after installation of these panels, water was observed slowly seeping out from the liner tie-in point into the upstream basin side. SRK advised TMAC to install two relief wells in liner panels 15 and 16 to allow water behind the liner to be pumped and removed. Two HDPE pipes 2 inches in diameter were installed through the liner by making two small cuts and welding a boot patch over the hole and to the HDPE pipe. In addition, SRK recommended the liner tie-in be refitted with two lines of bolting at a smaller spacing and that the lower portion of liner panels 15 and 16 be backfilled with up to 1 m of Bedding material to act as a counter-weight to the water pressure behind the liner. The two relief wells were installed on July 09, 2019. The new liner tie-in and liner backfill were completed after July 18, 2019 when SRK was not on site. TMAC advised SRK that no seepage from the liner was observed after the remediation works.

The source of the water behind the liner is thought to be meltwater from the overburden active layer and from precipitation falling behind the realigned berm during construction. To reduce the potential for water to flow behind the liner, the area behind the realigned berm was backfilled and lined so that any precipitation in this area would flow into the CWP basin and on top of the liner, rather than behind it.

Geotextile and liner deployment were initiated for the central section of the CWP berm between stations 0+100 to 0+160 on June 28 to 29, 2019 (liner panels 1 through 9 as illustrated on Drawing MN-CWP-10). This section was made available for liner placement early in the construction since the bedrock was easily exposed and prepared for liner tie-in. Lining of the southern section (0+000 to 0+100), including the backfilled area behind the re-aligned berm, was completed between July 06 to 08, 2019. The final northern section (0+160 to 0+225) of the berm was lined between July 23 to 25, 2019.

5.11 Instrumentation

Settlement instruments were installed to monitor the performance of the CWP berm. Most of the instrumentation was installed immediately following construction. The instrumentation comprises of the following:

- Surficial settlement monitoring points; and
- Fixed (shallow) settlement monitoring plates.

Details of each instrument type are presented in the following subsections.

5.11.1 Surficial Settlement Monitoring Points

Nineteen (19) surficial settlement monitoring points were designed for the CWP berm crest and downstream slope. These were installed to monitor larger scale deformation of the berm shell. The monitoring points consist of rock expansion bolts (Hilti bolts) installed in select ROQ boulders embedded within the berm.

A total of 16 of the 19 settlement monitoring points were installed in September 2019 (as-built survey completed on September 23) after completion of berm shell re-shaping. The location of the as-built points is shown on as-built drawing MN-CWP-09 (Appendix A). At the time this report was written, the expansion bolts were not yet installed in three (3) locations along the crest. The surficial settlement monitoring points should be revisited in the summer of 2020 after the snow has melted and should continue to be monitored with measurements picked up by site survey.

5.11.2 Settlement Monitoring Plates

Four (4) fixed (shallow) settlement monitoring plates were designed to be installed on the CWP crest to monitor for crest deformation. Two of the plates were designed to be installed on the upstream crest edge to monitor for deformations under the liner. These settlement plates provide the added benefit of being further embedded into the berm and provide settlement measurements over a larger area that is typically less effected by movement in multiple directions (i.e. horizontal and vertical movements that might be seen in the surficial monitoring points in the event the boulders rotate as they settle). The settlement plates consist of 10 mm thick steel plate 500 mm x 500 mm wide. A 30 mm steel rod approximately 0.7 m high was then welded to the centre of the plate to allow the plate to be backfilled. The steel rod will be high enough so that it remains uncovered and the top of steel rod can be easily surveyed.

All four settlement monitoring plates were installed in July 2019 (as-built survey completed on July 28). The as-built locations are shown on as-built drawing MN-CWP-09 (Appendix A).

6 Quality Assurance and Quality Control

6.1 General

Quality assurance (QA) and quality control (QC) for the CWP was generally completed in accordance with the Technical Specifications (SRK 2018). Deviations from the technical specifications is outlined in the previous sections (see Section 3.9). SRK was responsible for the QA while Nuna (Construction Contractor) and TMAC assumed responsibly for QC of berm fill materials. A&A assumed responsibility for QC of liner materials and installation. Nahanni assumed responsibility for QC of concrete and bentonite-aggregate mixtures produced on site.

A total of eight (8) QA/QC laboratory tests were performed during construction of the CWP. These tests included particle size distribution tests (one for Bedding material and two for the bentonite-aggregate mixture) and concrete strength tests (five in total). All tests were analyzed off-site and the results are provided in Appendix H.

6.2 Particle Size Distribution Testing

Particle size distribution (PSD) testing performed during construction of the CWP is discussed in the subsections below. The results of all tests carried out are summarized in Figures 2 and 3 for the Bedding and bentonite-aggregate mix materials, respectively. All laboratory test certificates are included in Appendix H.

6.2.1 Bedding Material

The Technical Specifications state that one QC sample is to be collected by Nuna for every 1,000 m^3 produced and that one QA sample is to be collected by SRK for every 2,000 m^3 produced. Since the total volume of Bedding material used for construction in the CWP was less than 1,000 m^3 (approximately 644 m^3 was used), QC laboratory tests were not completed.

Despite the reduced frequency for QA sampling and the small construction volume, one sample of Bedding material was collected for QA testing. The PSD test result indicates that the Bedding material is within the specified gradation range (see Figure 2).

6.2.2 Bentonite-Aggregate Mixture

The bentonite-aggregate mix design specified a minimum bentonite content of 10% by weight. No QC/QA sampling requirements were specified; however, two samples of the bentonite-aggregate mixture were collected by Nahanni and sent for PSD testing to confirm the bentonite quantity. The PSD test results indicate that the percentage of fines from each mix (which is assumed to be the bentonite) is between 14 to 17% which meets the target ratio (see Figure 3).

6.2.3 Transition and ROQ Material

PSD testing was not completed for Transition or ROQ material due to the very coarse gradation of these materials that made completing any testing to ASTM standards difficult. In accordance with the Technical Specifications (SRK 2018), only visual inspection of the Transition and ROQ material was performed by Nuna and SRK, both at the Quarry #2 crusher (for Transition material) and during material placement at the CWP berm. Any oversize or deleterious materials were identified and removed.

6.3 Concrete Strength Testing

Concrete samples were requested by the SRK Site Engineer for QC testing to confirm the cured strength. Concrete production and quality are not covered under the SRK (2018) technical specifications as those specifications concern earthworks and geotechnical engineering. Since the concrete used for the CWP is considered to be non-structural (i.e. non-load bearing) a target strength value was not specified by the Engineer. As a general rule, a strength of 30 MPa after 28 days of curing is a typical concrete strength target for civil applications.

Table 6-1 summarizes the concrete QC sampling and test results. Samples generally met a strength of 30 MPa or more after 8 – 10 days of curing, and therefore testing of the 28 day cured samples wasn't requested.

Table 6-1: Concrete QC Testing Summary

Concrete Batch	Production Date	QC Samples	Curing Time (Days)	Compressive Strength (MPa)
1	June 24, 2019	0	-	-
2	June 30, 2019	0	-	-
3	June 30, 2019	6	Sample 1: 10 days	28.0
			Sample 2: 10 days	29.7
			Sample 3: 28 days	Not tested
			Sample 4: 28 days	Not tested
			Sample 5: 28 days	Not tested
			Sample 6: 56 days	Not tested
4	July 02, 2019	2	Sample 1: 8 days	41.0
			Sample 2: 28 days	Not tested
5	July 02, 2019	2	Sample 1: 8 days	35.8
			Sample 2: 28 days	Not tested
6	July 02, 2019	2	Sample 1: 8 days	41.4
			Sample 2: 28 days	Not tested

6.4 HDPE Liner Testing

QA incorporated visual inspection of the liner rolls prior to deployment, as well as during installation. The sub-grade was also visually inspected by SRK following Bedding and geotextile placement. During liner installation each panel was carefully inspected, and, where defects or damage was noted, patches were installed.

Following construction, A&A completed a Liner Installation Summary report documenting the installation and QC testing. This report is included in Appendix G and generally outlines:

- CWP liner as-built panels (provided by Sub-Arctic);
- Panel log, including panel dimensions and SOLMAX roll number;
- Liner weld QC testing (daily weld tests and non-destructive air pressure tests);
- Liner patches QC testing (vacuum box testing);
- Liner installation certification; and
- Subgrade acceptance and warranty.

7 Closure

The Madrid North contact water pond (CWP) is part of the contact water management system for the Madrid North waste rock pile (WRP). It will intercept and manage contact water runoff from the WRP and provide storage for any contact water collected and pumped from the WRP sumps. The primary construction activities for the Madrid North CWP occurred at the at Madrid site between May and July of 2019. Final re-grading works and the instrumentation system set-up were completed between August and September 2019. This as-built report contains the as-built drawings and all associated quality assurance (QA) and the available quality control (QC) documentation pertaining to the CWP construction.

The successful performance of the Madrid North CWP is dependent on maintaining the pond in a normally dry operating state. The maximum residence time for contact water in the pond is two weeks and site personnel are expected to manage the ponded water at the CWP using a pump and water truck. Contact water will be tested and discharged to the environment if it meets discharge criteria or transported to approved storage facilities at Doris (such as the Doris TIA or pollution control pond).

Ongoing monitoring and visual inspections of the Madrid CWP should be completed on site. The CWP should also have a detailed inspection, including full review of all monitoring data, completed by a certified professional geotechnical or civil engineer on an annual basis. Monitoring requirements for the CWP will be provided in the CWP Operations, Maintenance and Surveillance (OMS) manual currently being developed by TMAC and SRK.

This report, ***"Hope Bay Project, Madrid North Contact Water Pond As-Built Report"***, was prepared by SRK Consulting (Canada) Inc.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

8 References

SRK Consulting (Canada) Inc., 2017. Climate and Hydrological Parameters Summary Report, Hope Bay Project. Report prepared for TMAC Resources Inc., 1CT022.013. November 2017.

SRK Consulting (Canada) Inc., 2018. Technical Specifications Earthworks and Geotechnical Engineering, Hope Bay Project. Prepared for TMAC Resources Inc., 1CT022.031. April 2018. Revision H – Issued for Construction.

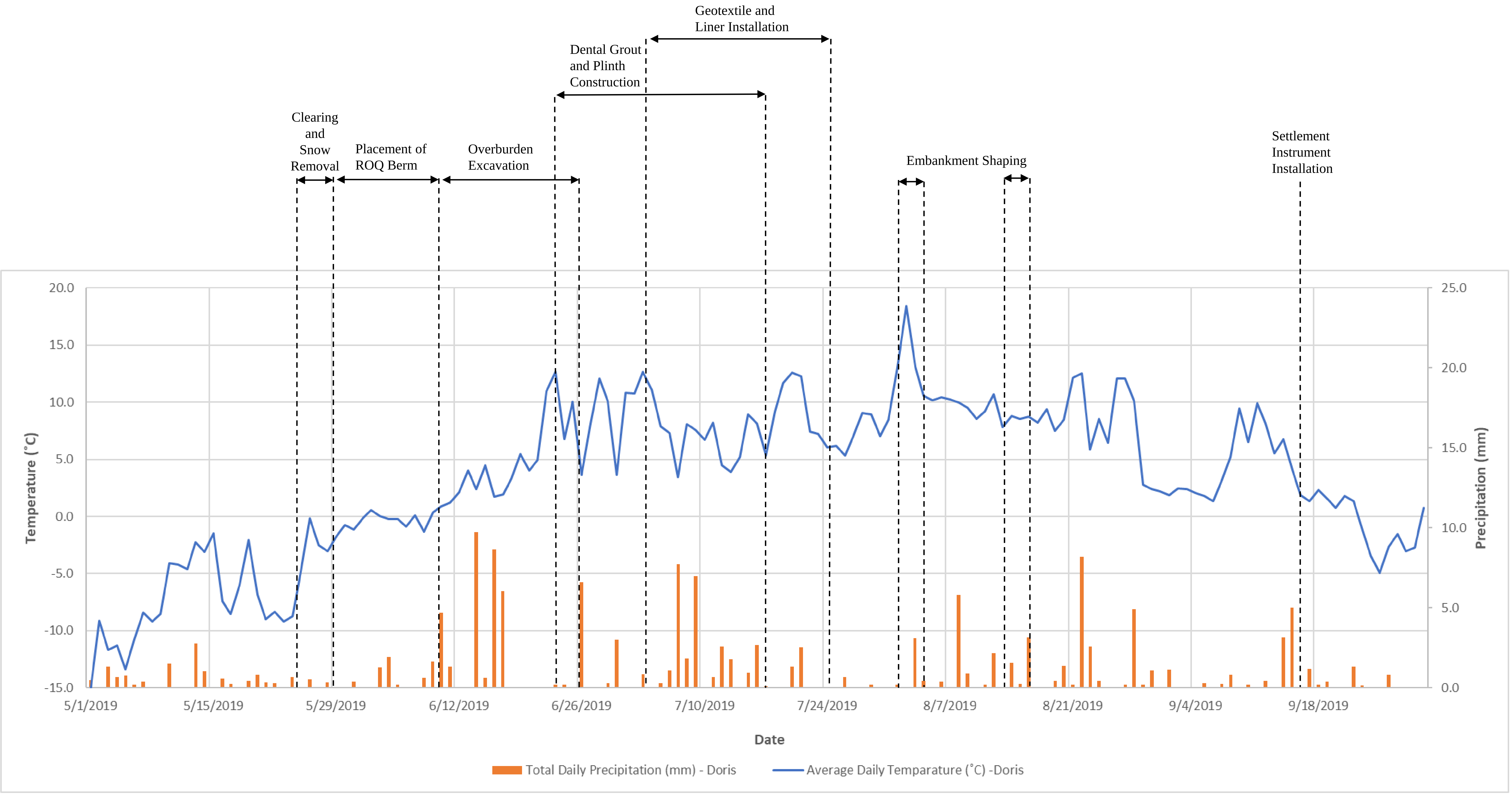
SRK Consulting (Canada) Inc., 2019a. Engineering Drawings for the Madrid North Waste Rock Pile, Hope Bay Project. Prepared for TMAC Resources Inc., 1CT022.043. Issued for Construction – Rev01. August 2019.

SRK Consulting (Canada) Inc., 2019b. Detailed Design of the Waste Rock Pile at Madrid North, Hope Bay Project. Memo prepared for TMAC Resources Inc., 1CT022.043. September 2019.

SRK Consulting (Canada) Inc., 2019c. Detailed Design of the Contact Water Pond Berm at Madrid North, Hope Bay Project. Memo prepared for TMAC Resources Inc., 1CT022.043. March 2019.

TMAC Resources (TMAC) Inc., 2017. Doris and Madrid Water Management Plan, Hope Bay. November 2017.

Figures



Note:

- Weather data obtained from the Doris weather station on site

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Job No: 1CT022.043

Filename: MadridCWP_AsBuilt_Figures.ppt

TMAC RESOURCES

TMAC Resources Inc.

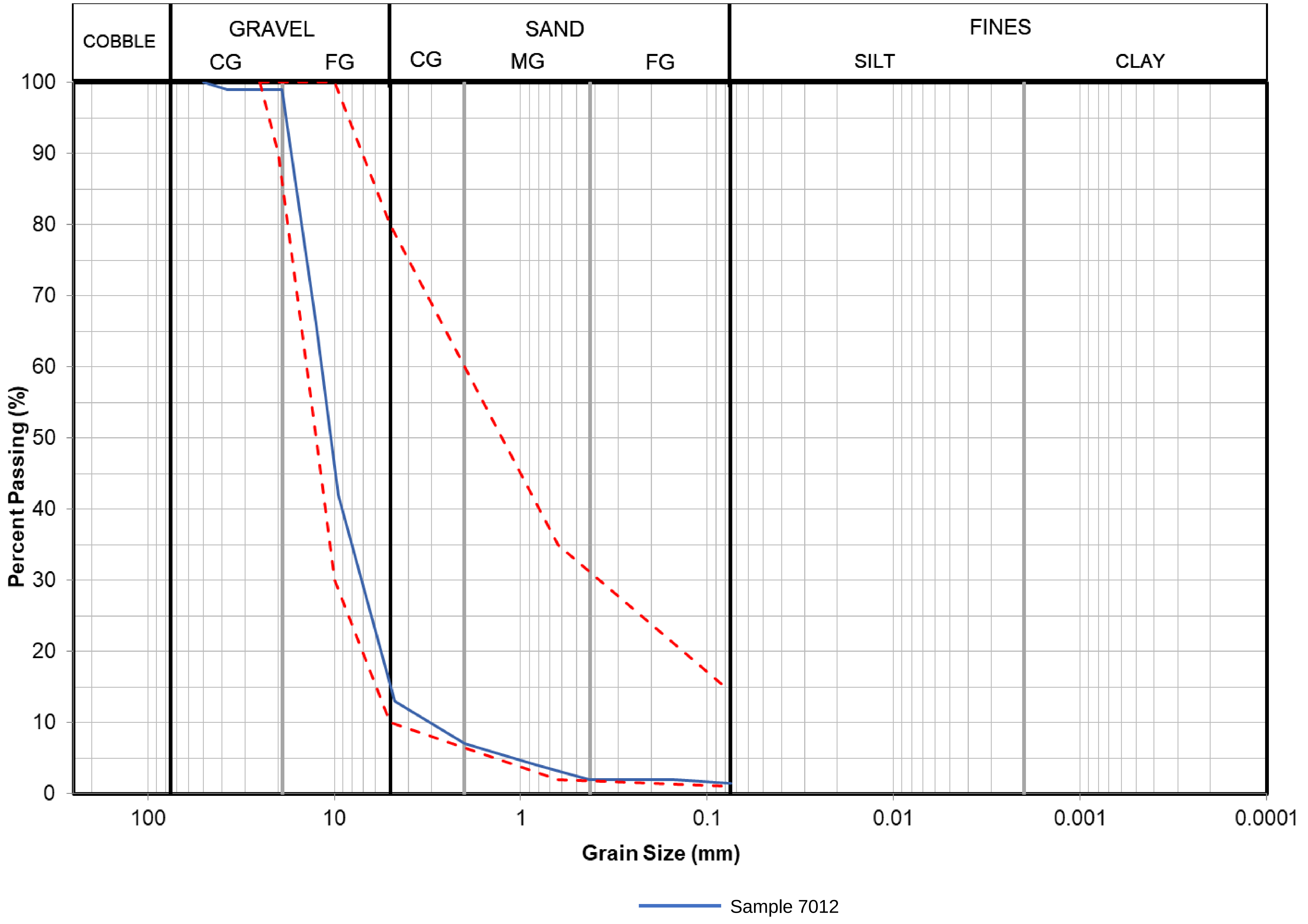
Madrid North Contact Water Pond

Construction Temperature and Precipitation Summary

Date: March 2020

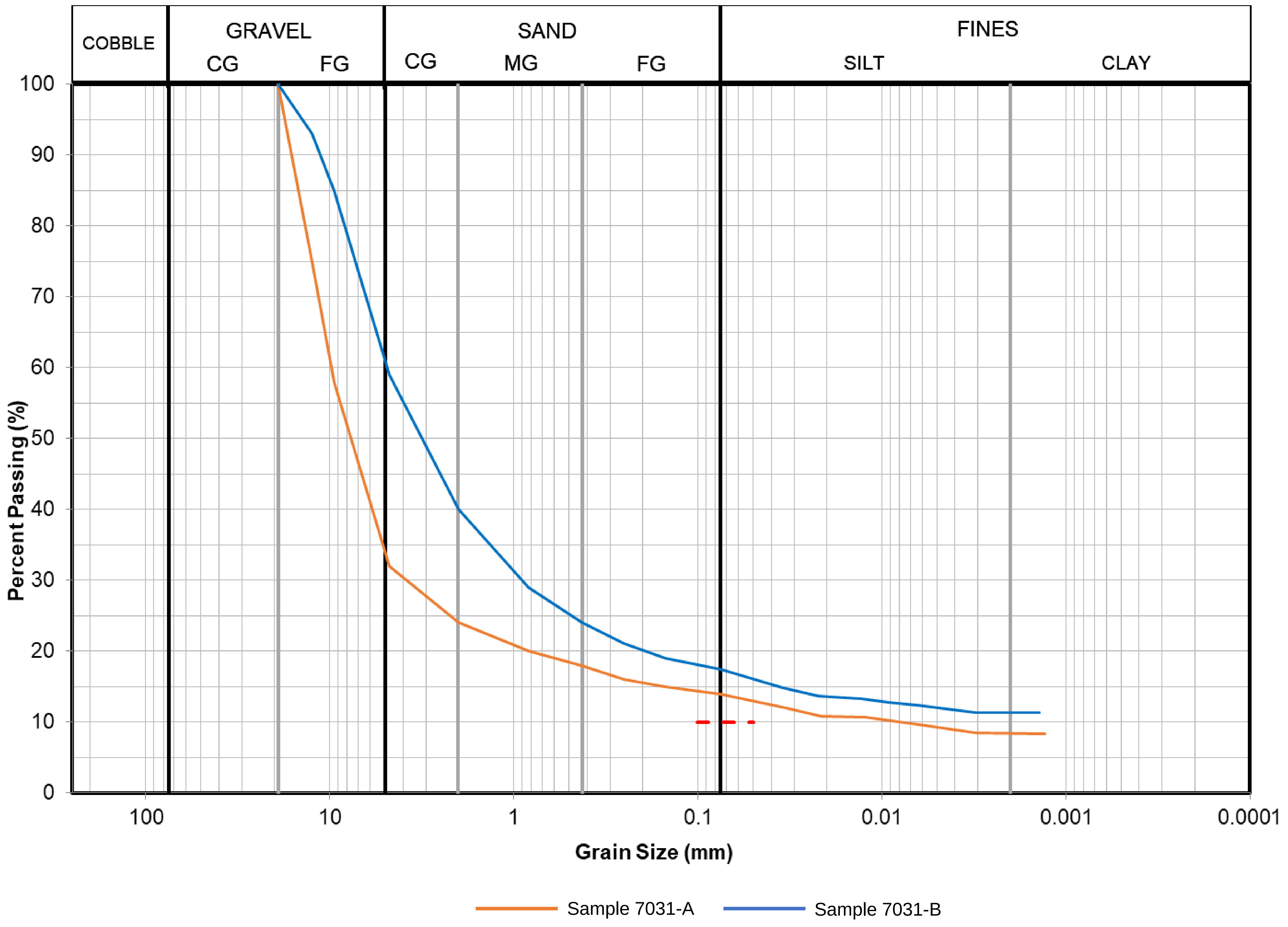
Approved: RW

Figure 1



Note: Technical specification limits for bedding material are shown as red dashed lines

srk consulting	TMAC RESOURCES	Madrid North Contact Water Pond
		Bedding Material Particle Size Distribution
Job No: 1CT022.043 Filename: MadridCWP_AsBuilt_Figures.ppt	TMAC Resources Inc.	Date: March 2020 Approved: RW Figure 2



Note: Technical specification limits for bentonite mix is shown as red dashed lines; target fines percentage is greater than 10% fines

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Job No: 1CT022.043

Filename: MadridCWP_AsBuilt_Figures.ppt

TMAC RESOURCES

TMAC Resources Inc.

Madrid North Contact Water Pond

Bentonite Crush Particle Size Distribution

Date: March 2020	Approved: RW	Figure 3

Appendix A – As-Built Drawings

As-Built Drawings for the Madrid North Contact Water Pond

Hope Bay Project, Nunavut, Canada

Active Drawing Status

Drawing Number	Drawing Title	Issue	Date	Revision
MN-CWP-01	General Arrangement (With Orthophoto)	As-Built	2020/03/24	AB1
MN-CWP-02	General Arrangement	As-Built	2020/03/24	AB1
MN-CWP-03	Contact Water Pond Foundation Conditions Plan and Profile	As-Built	2020/03/24	AB1
MN-CWP-04	Contact Water Pond As-Built Berm and Concrete Plinths	As-Built	2020/03/24	AB1
MN-CWP-05	Contact Water Pond Typical Sections	As-Built	2020/03/24	AB1
MN-CWP-06	Contact Water Pond Typical Sections	As-Built	2020/03/24	AB1
MN-CWP-07	Contact Water Pond Typical Details	As-Built	2020/03/24	AB1
MN-CWP-08	Liner Tie-in Typical Details	As-Built	2020/03/24	AB1
MN-CWP-09	Contact Water Pond Instrumentation Plan	As-Built	2020/03/24	AB1
MN-CWP-10	As-Built Liner Panel Layout	As-Built	2020/03/24	AB1

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RESOURCES

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LICENSEE
2020.03.24
NT/NU

srk consulting

Project Number: 1CT022.043

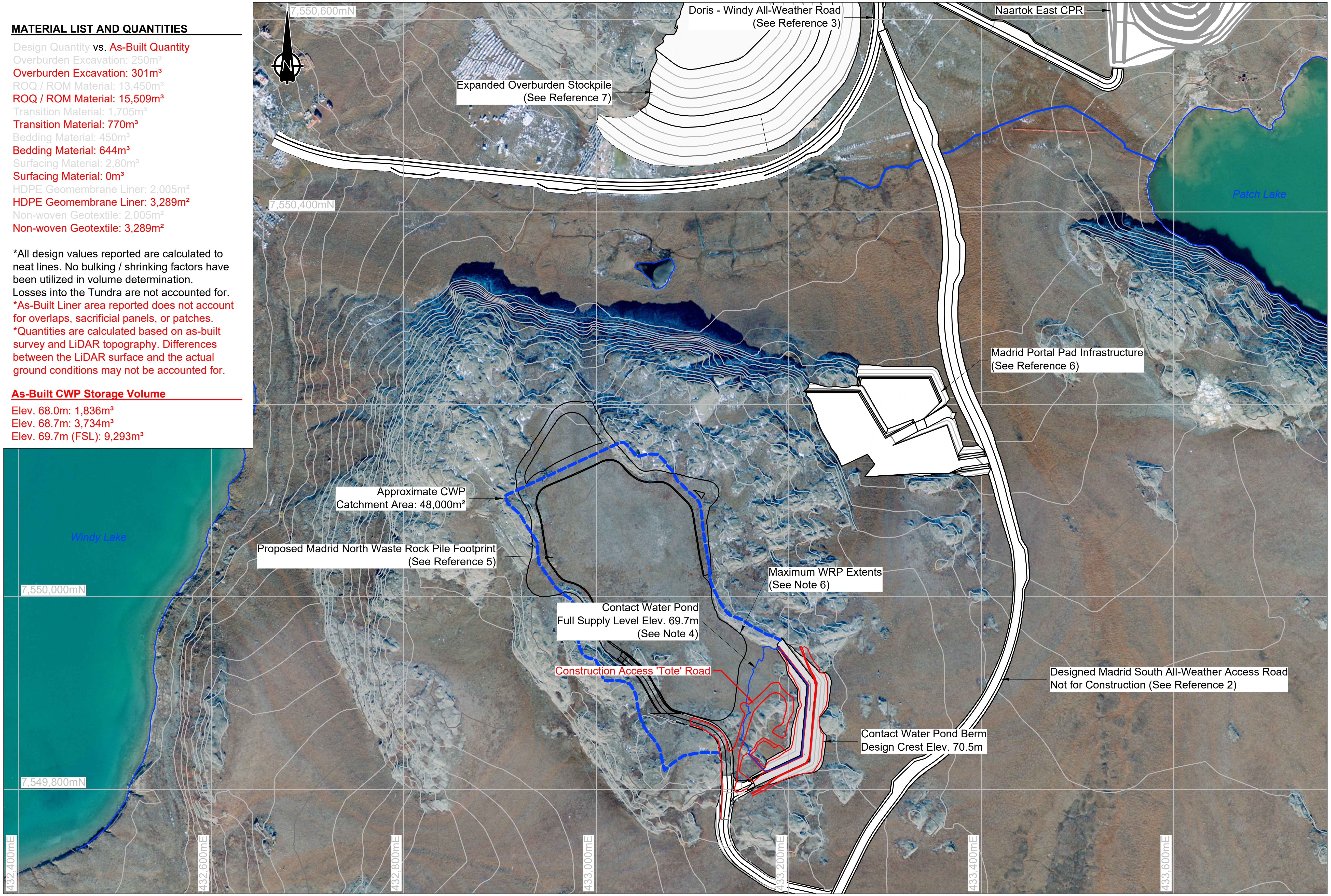
MATERIAL LIST AND QUANTITIES

Design Quantity vs. As-Built Quantity
Overburden Excavation: 250m³
Overburden Excavation: 301m³
ROQ / ROM Material: 13,450m³
ROQ / ROM Material: 15,509m³
Transition Material: 1,705m³
Transition Material: 770m³
Bedding Material: 450m³
Bedding Material: 644m³
Surfacing Material: 2,80m³
Surfacing Material: 0m³
HDPE Geomembrane Liner: 2,005m²
HDPE Geomembrane Liner: 3,289m²
Non-woven Geotextile: 2,005m²
Non-woven Geotextile: 3,289m²

*All design values reported are calculated to neat lines. No bulking / shrinking factors have been utilized in volume determination.
Losses into the Tundra are not accounted for.
*As-Built Liner area reported does not account for overlaps, sacrificial panels, or patches.
*Quantities are calculated based on as-built survey and LiDAR topography. Differences between the LiDAR surface and the actual ground conditions may not be accounted for.

As-Built CWP Storage Volume

Elev. 68.0m: 1,836m³
Elev. 68.7m: 3,734m³
Elev. 69.7m (FSL): 9,293m³



LEGEND

═	Proposed Infrastructure
▨	Design Footprint
🟥	As-built Infrastructure
🟦	Proposed Contact Water Pond

NOTES

1. Contours shown at 2.0m intervals, based off of LiDAR, 2007.
2. All units shown in meters unless otherwise specified.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
4. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen day) residence time for water in the pond.
5. Imagery provided by client, 2007.
6. WRP toe must stay above elevation 70.0m where it is immediately upstream of the CWP.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope Bay Project, Nunavut, Canada. Revision 0 Issued for Construction drawings prepared for TMAC Resources Inc.. Project Number: 1CT022.043. March 2019.
3. Engineering Drawings for the Doris-Windy All-Weather Road, Doris Infrastructure Project, Nunavut, Canada. Revision AB1. As-Built drawings prepared for Hope Bay Mining Ltd.. Project Number: 1CH008.033/058. May 11, 2012.
4. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.
5. Engineering Drawings for the Madrid North Waste Rock Pile, Hope Bay Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources Inc. Project Number, 1CT022.043. August 2019.
6. Engineering Drawings for the Madrid North Portal Surface Infrastructure Pad, Hope Bay Project. Revision 1. Prepared for TMAC Resources Inc. Project Number, 1CT022.051. October 2019.
7. Engineering Drawings for the Naartok East CPR Overburden Stockpile, Madrid North Project, Hope Bay. Revision 0. Prepared for TMAC Resources Inc. Project Number 1CT022.043. December 2019
8. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.

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							0	Issued for Construction	RW	EMR	19/03/19
- -	- -	- -	- -	- -	- -	- -	A	Issued for Discussion	RW	EMR	19/03/05

REFERENCE DRAWINGS
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REVIEWED: RW
CHECKED: RW
APPROVED: JBK
DATE: March 24, 2020
FILE NAME: 1CT022.043 - GA.dwg

TMAC RESOURCES

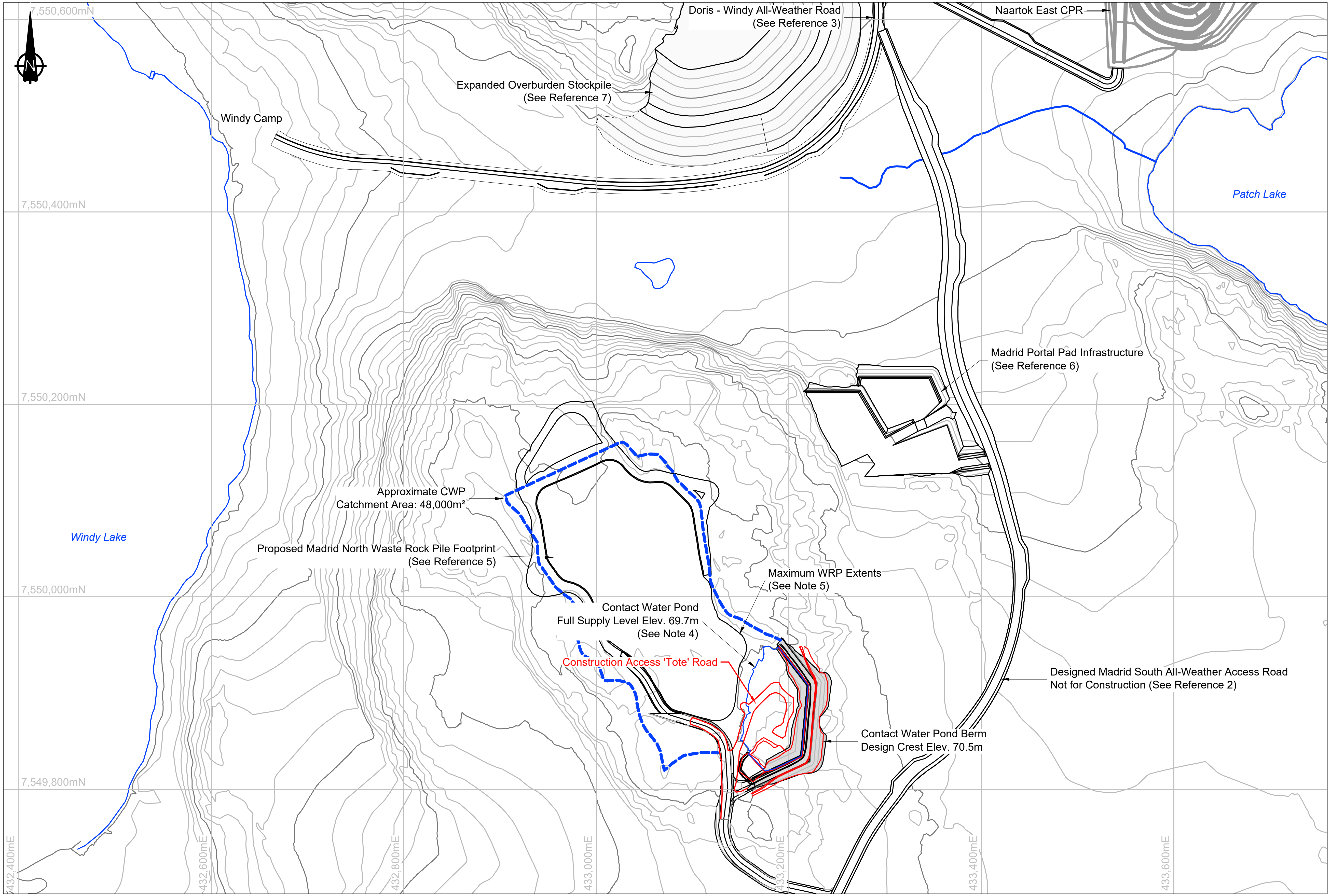
Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
General Arrangement
(With Orthophoto)

DRAWING NO.: MN-CWP-01
SHEET: 1 OF 10
REVISION NO.: AB1



LEGEND

═	Proposed Infrastructure
▨	Design Footprint
🟥	As-built Infrastructure
🟦	Proposed Contact Water Pond

NOTES

1. Contours shown at 2.0m intervals from LiDAR, 2007.
2. All units shown in meters unless otherwise specified.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018)
4. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
5. WRP toe must stay above elevation 70.0m where it is immediately upstream of the CWP.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope Bay Project, Nunavut, Canada. Revision 1 Issued for Construction drawings prepared for TMAC Resources Inc. Project Number: 1CT022.043. March 2019.
3. Engineering Drawings for the Doris-Windy All-Weather Road, Doris Infrastructure Project, Nunavut, Canada. Revision AB1. As-Built drawings prepared for Hope Bay Mining Ltd. Project Number: 1CH008.033/058. May 11, 2012.
4. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.
5. Engineering Drawings for the Madrid North Waste Rock Pile, Hope Bay Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources Inc. Project Number, 1CT022.043. August 2019.
6. Engineering Drawings for the Madrid North Portal Surface Infrastructure Pad, Hope Bay Project. Revision 1. Prepared for TMAC Resources Inc. Project Number, 1CT022.051. October 2019.
7. Engineering Drawings for the Naartok East CPR Overburden Stockpile, Madrid North Project, Hope Bay. Revision 0. Prepared for TMAC Resources Inc. Project Num,ber 1CT022.043. December 2019.
8. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.

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REFERENCE DRAWINGS

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LICENSEE
2020.03.24

srk consulting

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CHECKED: RW
APPROVED: JBK
DATE: March 24, 2020
FILE NAME: 1CT022.043 - GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
General Arrangement

DRAWING NO. MN-CWP-02
SHEET 2 OF 10
REVISION NO. AB1

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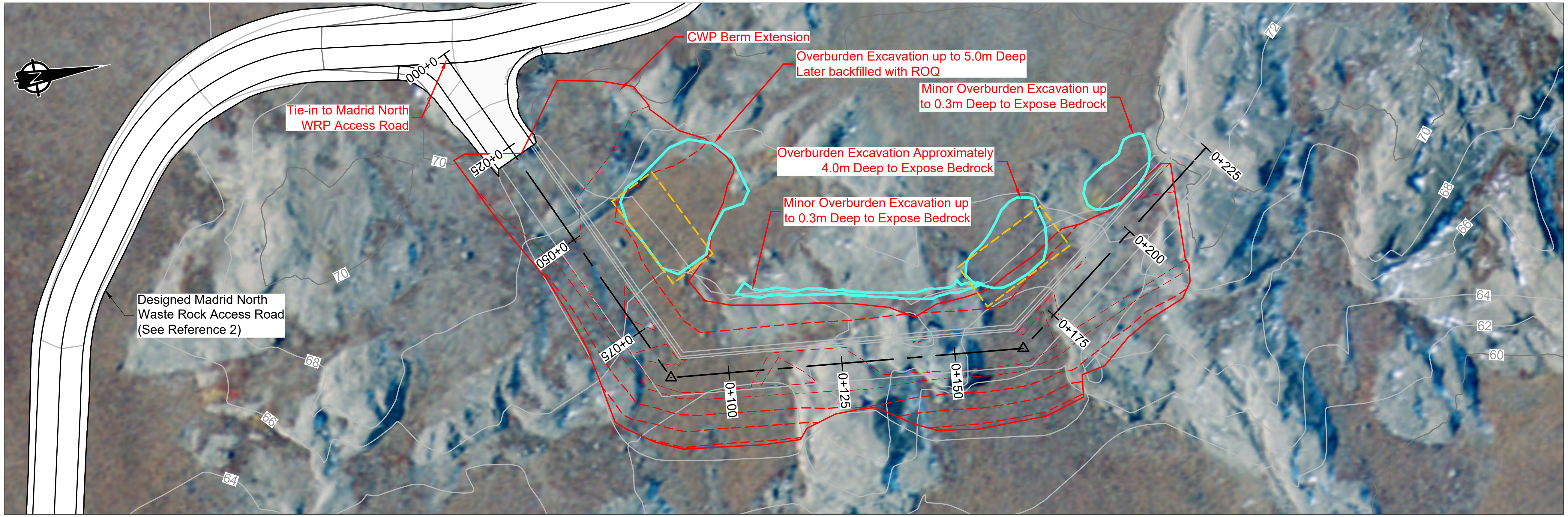
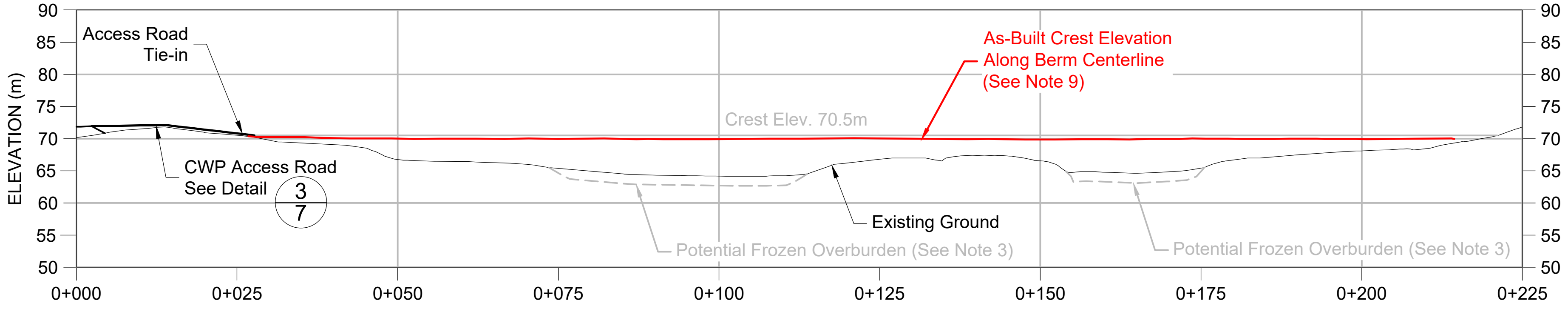


Contact Water Pond Berm Plan View



Contact Water Pond Berm Profile View

LEGEND

🟨 Anticipated Overburden Excavation Area (Design)

🟦 As-built Overburden Excavation (See Note 7)

▭ Design Contact Water Pond Berm

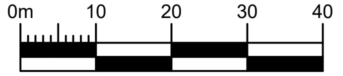
🟥 As-Built Contact Water Pond Berm

NOTES

1. Contours shown at 1.0m intervals, based off LiDAR, 2007.
2. All dimensions shown in meters unless otherwise stated.
3. The majority of the CWP berm footprint is expected to encounter bedrock outcrop. However, based on aerial imagery overburden may be encountered in low-lying areas.
4. If overburden is encountered at the upstream toe, it will be excavated to bedrock to allow liner to tie-in to the bedrock foundation.
5. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
6. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
7. As-built overburden excavation extents are approximate, and are based on as-built surveys and site observation.
8. Construction access 'tote' road (MN-CWP-01 & 02) is not shown on this drawing.
9. As-built crest elevation along berm centerline is approximately 70.0m (i.e. minimum elevation of the liner). As-built crest elevation along the upstream and downstream crest edge is approximately 70.5m. See as-built cross sections on MN-CWP-05 & 06.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.
4. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.



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2020.03.24

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TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Foundation Conditions Plan and Profile

DRAWING NO. MN-CWP-03
SHEET 3 OF 10
REVISION NO. AB1

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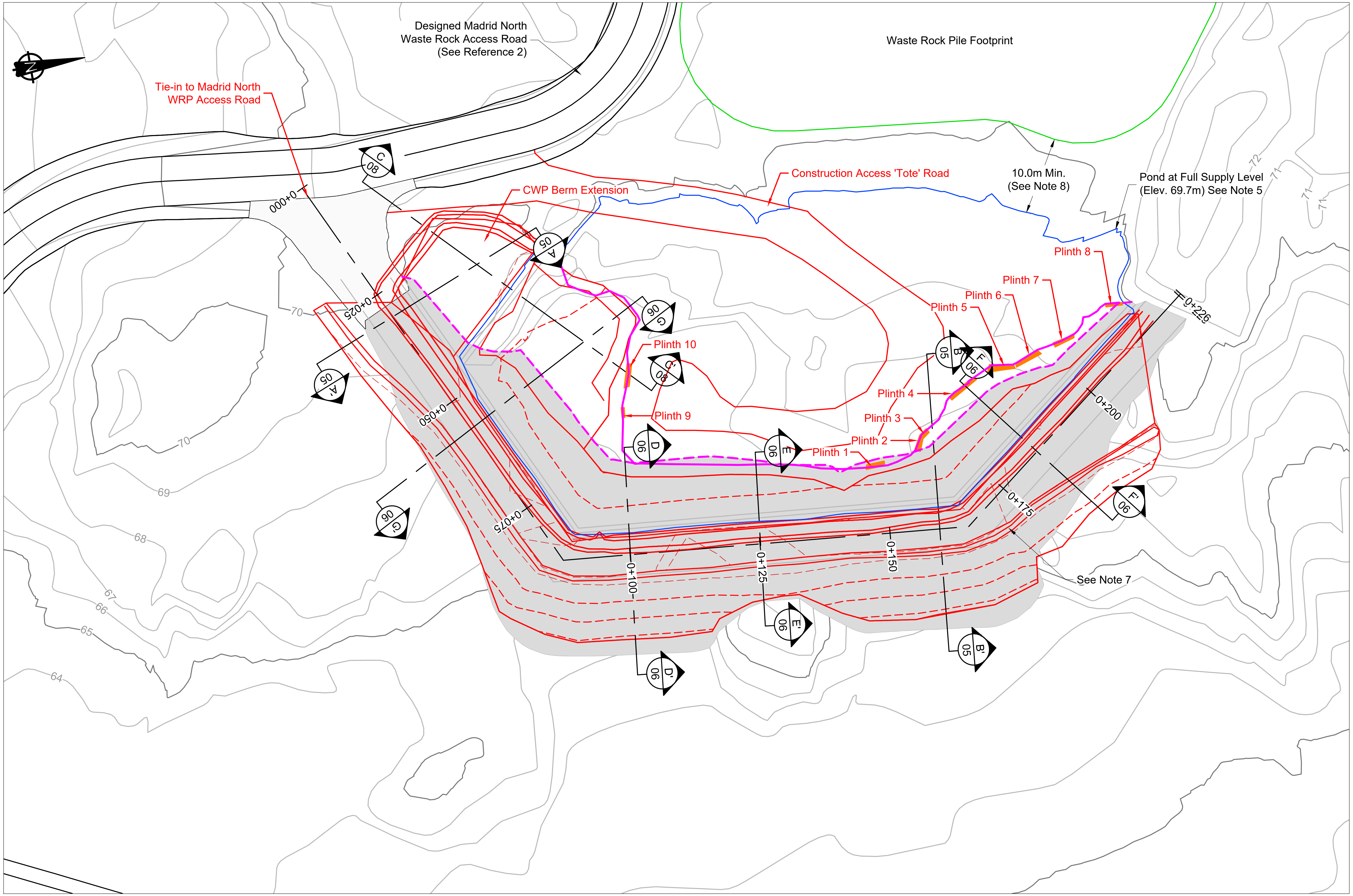

LEGEND

- - -	Design Liner to Bedrock Tie-in
—	As-Built Liner to Bedrock Tie-in
☐	Contact Water Pond
☐	As-Built Contact Water Pond Berm
▨	Design Contact Water Pond Berm
▬	As-Built Plinth Location
☐	Maximum Proposed Waste Rock Pile Footprint

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. The majority of the CWP berm footprint is expected to encounter bedrock outcrop. However, based on aerial imagery overburden may be encountered in low-lying areas.
4. If overburden is encountered at the upstream toe, it will be excavated to bedrock to allow liner to tie-in to the bedrock foundation.
5. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
6. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
7. Where the height of the berm exceeds 3.0m, safety berms or barries are required on the crest. See Typical Berm Barrier Options on drawing MN-CWP-06.
8. WRP toe must stay above elevation 70.0m or a minimum of 10m away from the pond's full supply extents.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.
4. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.

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REFERENCE DRAWINGS

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0	Issued for Construction	RW	EMR	19/03/19
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FILE NAME: 1CT022.043 - PP.dwg

MAC RESOURCES

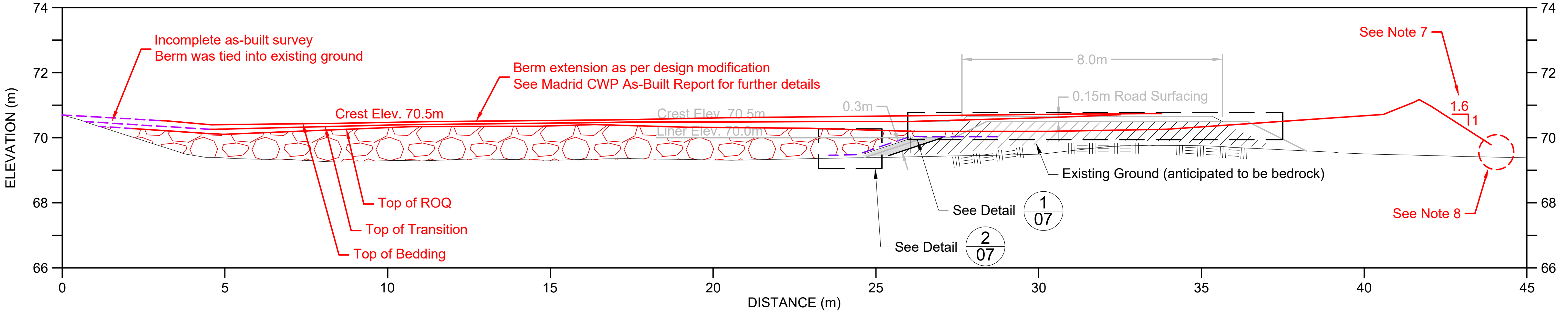
Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond As-Built
Berm and Concrete Plinths

DRAWING NO.: MN-CWP-04
SHEET 4 OF 10
REVISION NO.: AB1



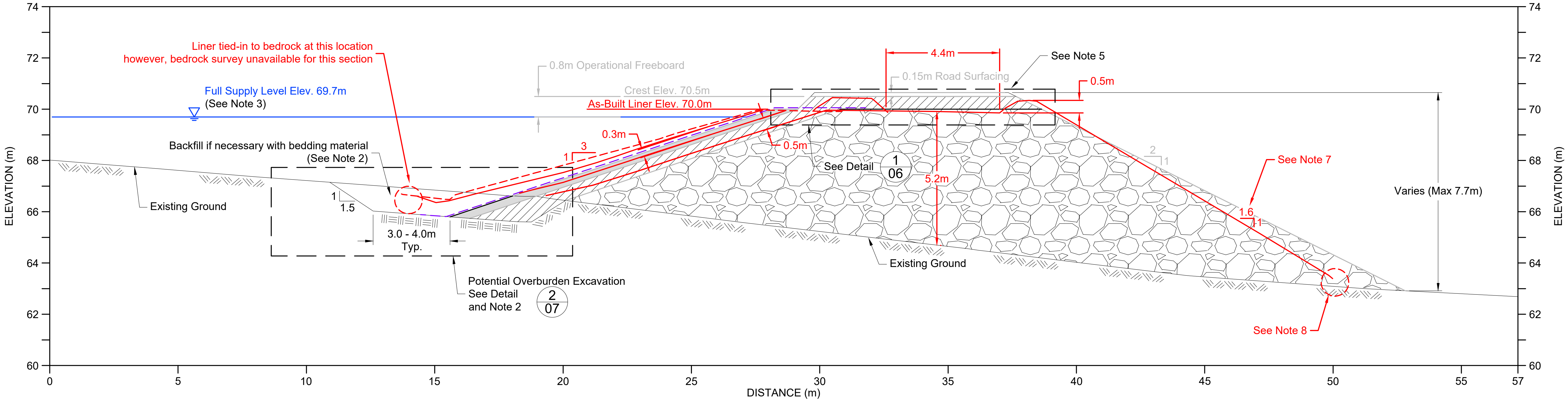
A
04
Cross Section A-A' - Berm Sections less than 1.5m

LEGEND

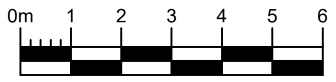
- - -	Design Liner System	▭	Design Bedding Material
— — —	As-Built Liner System	▨	Design Transition Material
——	As-Built Survey	⬭	Design Run of Quarry (ROQ) or Run of Mine (ROM) Material

NOTES

1. All dimensions shown in meters unless otherwise stated.
2. If overburden is encountered at the upstream toe, it will be excavated to bedrock to tie-in to the bedrock foundation. Thickness of excavation will vary and will depend on conditions encountered. Excavation to be backfilled with bedding material if necessary to protect the liner tie-in.
3. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
4. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
5. Where the height of the berm exceeds 3.0m, safety berms or barriers are required on the crest. See Typical Berm Barrier Options on drawing MN-CWP-06.
6. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.
7. Stability analyses completed on over-steepened downstream slopes have determined that the risk of instability is low. See Appendix D of the Madrid CWP As-Built Report for further details.
8. Updated topography survey not available. Difference is attributed to differences between LiDAR survey and actual field conditions.



B
04
Cross Section B-B' - Berm Sections 1.5m or higher



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REFERENCE DRAWINGS		REVISIONS										PROFESSIONAL ENGINEERS STAMP

REGISTERED PROFESSIONAL ENGINEER
R.C. WILLIAMS
LICENSEE
2020.03.24
NTNU

srk consulting

DESIGN: RW	DRAWN: TAH	REVIEWED: RW
CHECKED: RW	APPROVED: JBK	DATE: March 24, 2020
FILE NAME: 1CT022.043 - PP.dwg		

TMAC RESOURCES

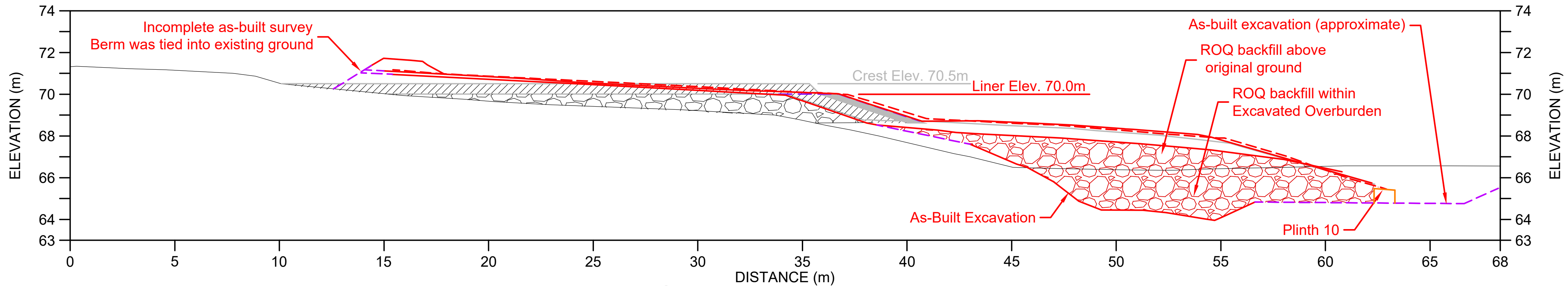
Hope Bay Project

SRK JOB NO.: 1CT022.043

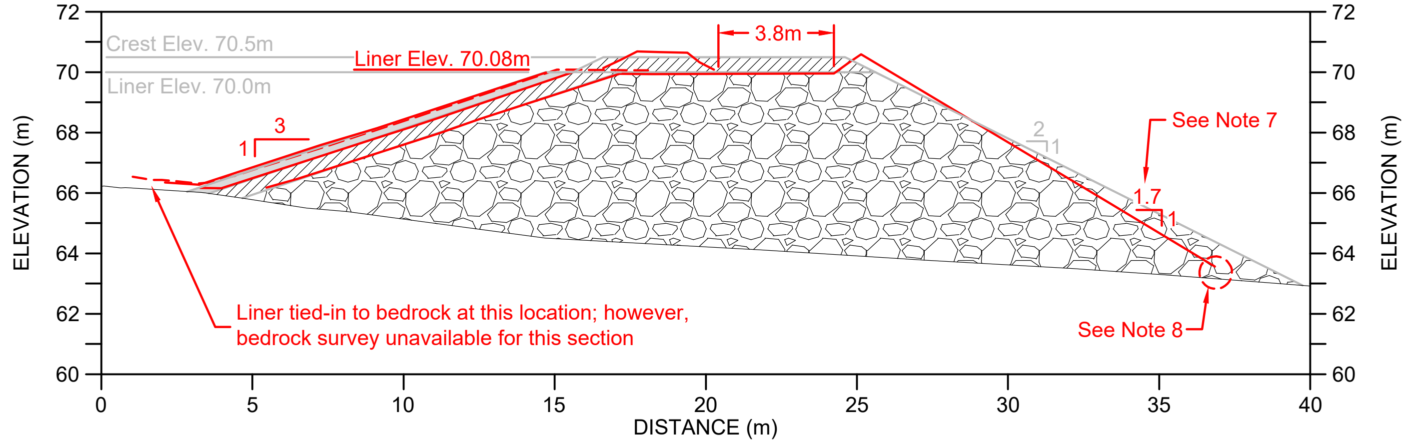
Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Typical Sections

DRAWING NO.	SHEET	REVISION NO.
MN-CWP-05	5 OF 10	AB1



C
04
Cross Section C-C'



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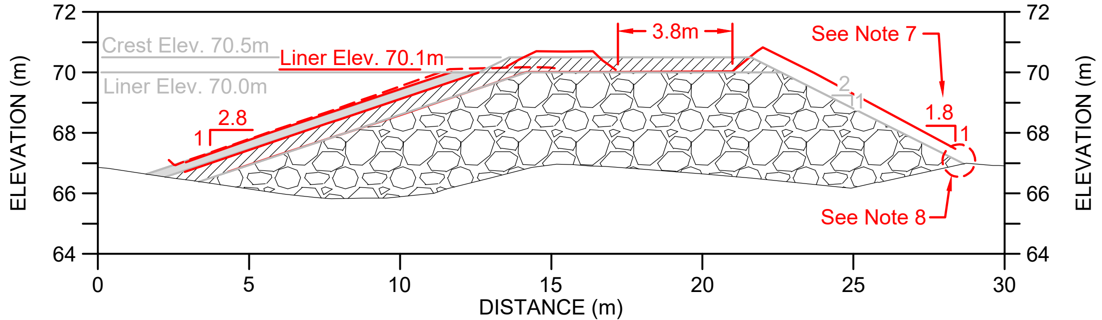
Cross Section D-D'



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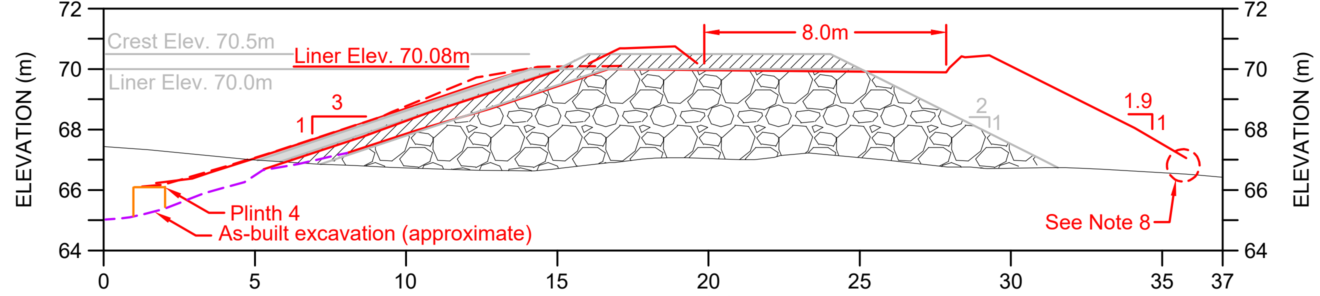
Cross Section E-E'



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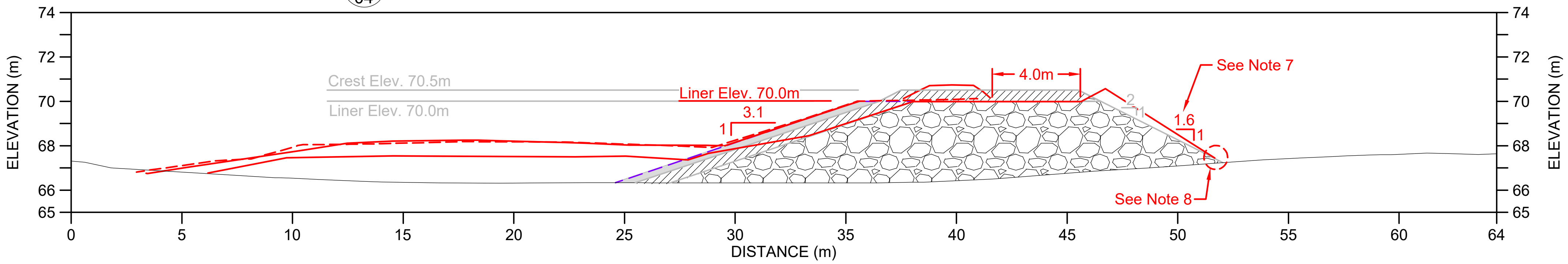
04
Cross Section F-F'



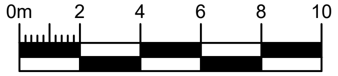
G
04
Cross Section G-G'

LEGEND

╌╌	Design Liner System	░	Design Bedding Material
╌╌	As-Built Liner System	▨	Design Transition Material
──	As-Built Survey	▱	Design Run of Quarry (ROQ) or Run of Mine (ROM) Material

NOTES

1. All dimensions shown in meters unless otherwise stated.
2. If overburden is encountered at the upstream toe, it will be excavated to bedrock to tie-in to the bedrock foundation. Thickness of excavation will vary and will depend on conditions encountered. Excavation to be backfilled with bedding material if necessary to protect the liner tie-in.
3. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
4. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
5. Where the height of the berm exceeds 3.0m, safety berms or barriers are required on the crest. See Typical Berm Barrier Options on drawing MN-CWP-07.
6. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.
7. Stability analyses completed on over-steepend downstream slopes have been determined that the risk of instability is low. See Appendix D of the Madrid CWP As-Built Report for further details.
8. Updated topography survey not available. Difference is attributed to differences between LiDAR and actual field conditions.



REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
- -	- -

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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AB1	As-Built	RW	JBK	20/03/24

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CHECKED: RW	APPROVED: JBK	DATE: March 24, 2020

FILE NAME: 1CT022.043 - PP.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Typical Sections

DRAWING NO.: MN-CWP-06
SHEET: 6 OF 10
REVISION NO.: AB1

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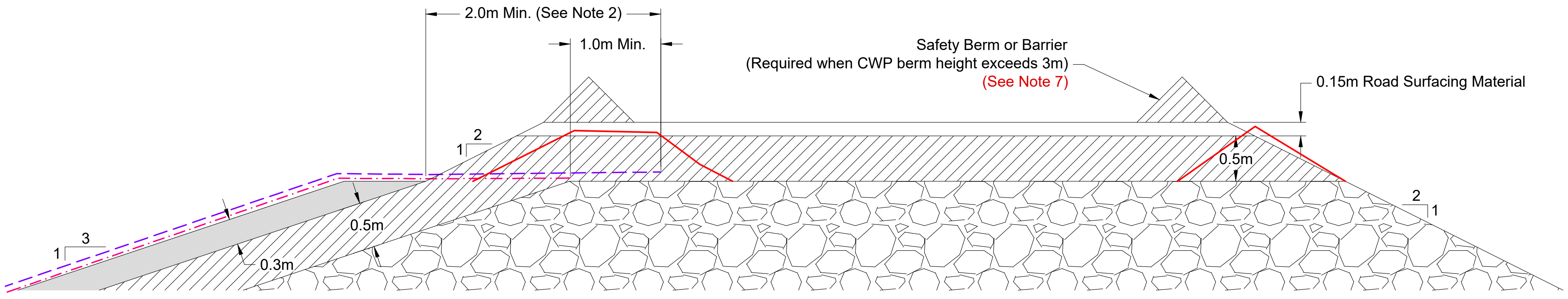


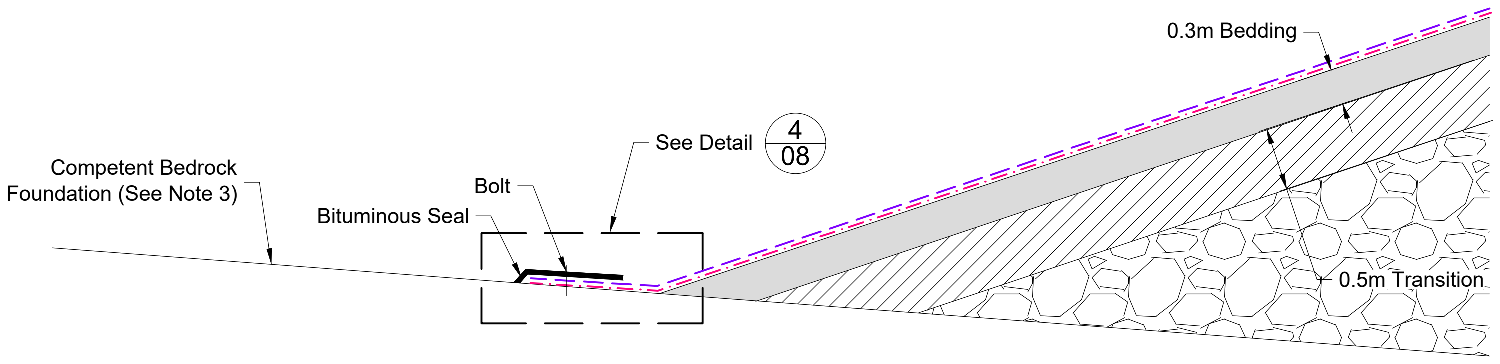
1 05 **Typical Liner Anchor Detail**

LEGEND

- - -	Liner	▨	Transition Material
- · -	Non-woven Geotextile	⬡	Run of Quarry (ROQ) or Run of Mine (ROM) Material
░	Bedding Material	■	Bituminous Seal

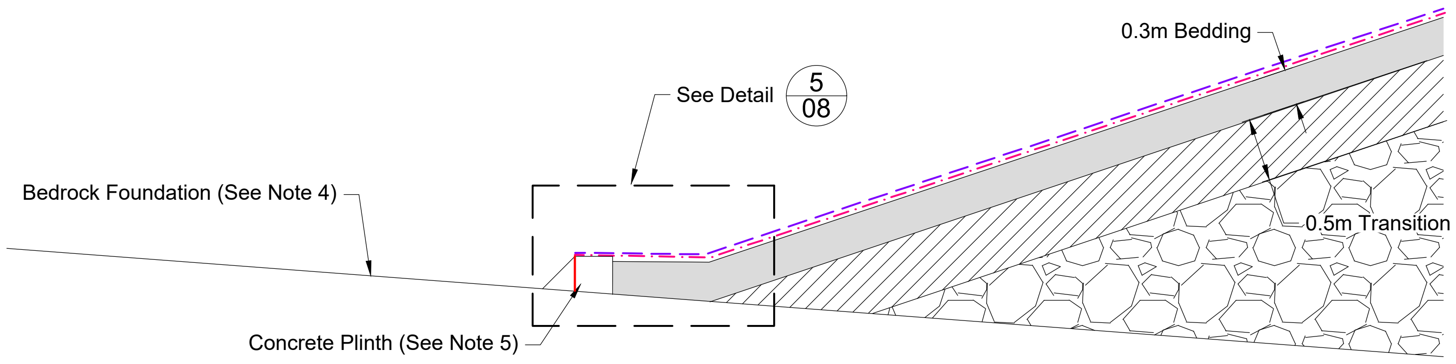
NOTES

1. All dimensions shown in meters unless otherwise stated.
2. Minimum 1.0m liner overlap with ROQ/ROM material. Total covered liner overlap must be a minimum of 2.0m. Non-woven geotextile to terminate at ROQ/ROM.
3. If competent bedrock conditions are encountered, liner can be mechanically tied in to bedrock. A bituminous seal may also be applied. Bedrock conditions to be inspected and approved by field engineer.
4. If bedrock conditions are unfavourable (e.g. weathered, highly fractured) or the bedrock surface is highly irregular, a concrete plinth may be required to facilitate liner tie-in. Bedrock conditions to be inspected and approved by the field engineer.
5. Liner to be affixed to top of concrete plinth with GSE Polylock Concrete Embedment Strip or Approved Alterative. Steel reinforcement bars also required and should be typically drilled and grouted a minimum 450mm into bedrock.
6. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
7. Safety berms on the downstream crest edge were constructed with regular breaks to allow drainage and prevent ponding on the crest.
8. As-built concrete plinths varied in height as required to adapt to the field conditions. See the Madrid CWP As-Built Report for further details.
9. Safety berm height to suit light vehicles and water trucks.

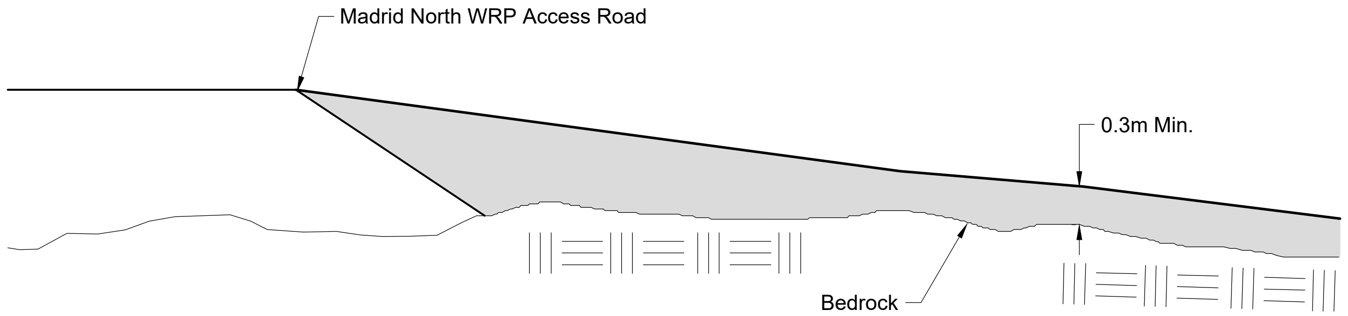


2 05 **Typical Liner Anchor at Bedrock - Mechanical Tie-down Option**

(Constructed as per design)



2 05 **Typical Liner Anchor at Bedrock - Concrete Plinth Option** (See Note 8)



3 04,05 **CWP Access Road Detail**

(Constructed as per design)

Typical Safety Berm or Barrier Options

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							AB1	As-Built	RW	JBK	20/03/24
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FILE NAME: 1CT022.043 - PP.dwg

TMAC RESOURCES

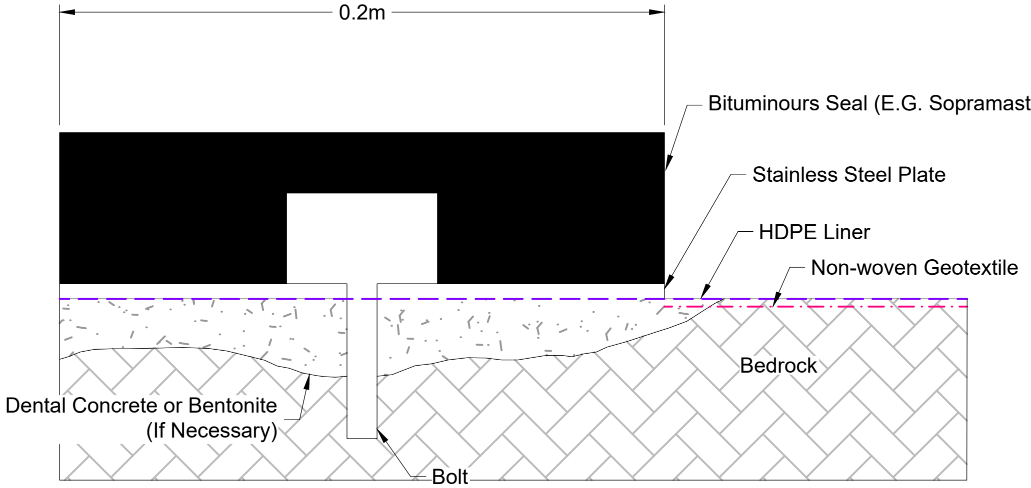
Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Typical Details

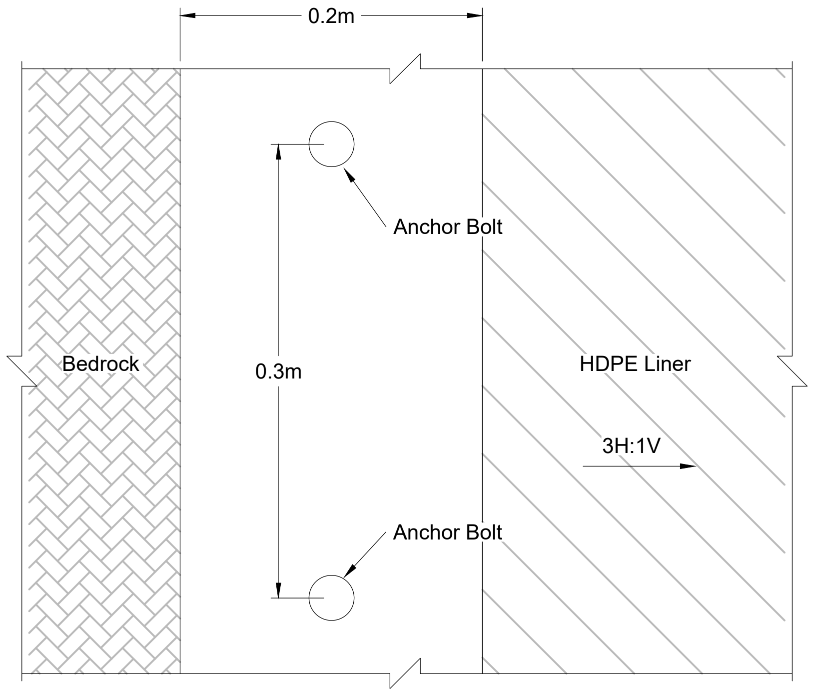
DRAWING NO. MN-CWP-07
SHEET 7 OF 10
REVISION NO. AB1



4
06

Liner Anchored to Bedrock - Side View Typical Detail

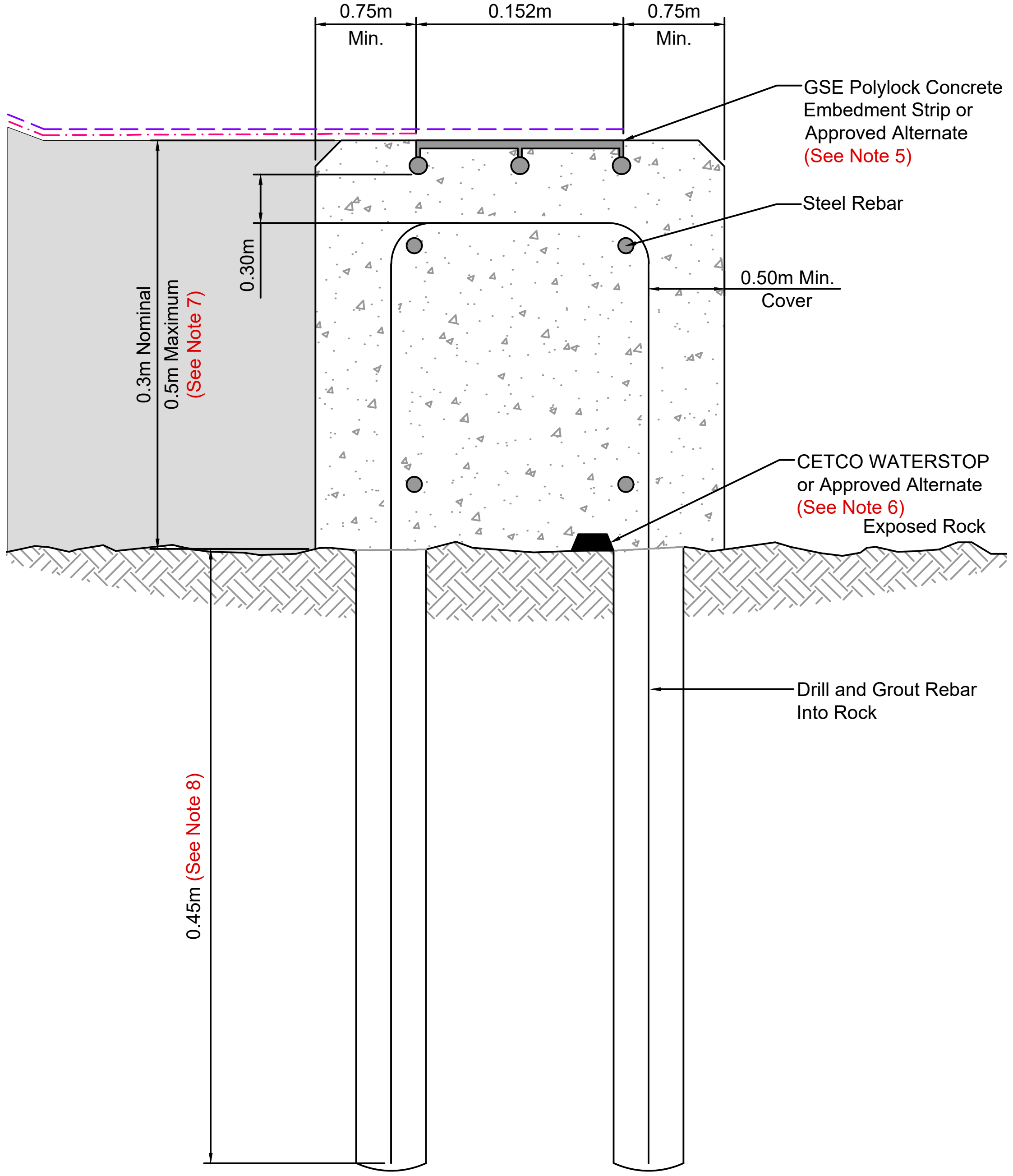
NOT TO SCALE
(Constructed as per design)



4
06

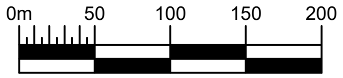
Liner Anchored to Bedrock - Plan View Typical Detail

NOT TO SCALE
(Constructed as per design)



5
06

Liner Anchored to Concrete Plinth - Typical Detail



LEGEND

- - -	HDPE Liner	▨	HDPE Liner
—·—	Non-woven Geotextile	▨	Run of Quarry (ROQ) or Run of Mine (ROM) Material
▒	Bedding Material	▨	Bedrock
▭	Concrete	■	Bituminous Seal

NOTES

1. All dimensions shown in meters unless otherwise stated.
2. Bedrock conditions and contact point for the liner will be inspected in the field by the engineer. The engineer will make a final decision for the required adhesion method.
3. Typical details shown may vary and additional Details will be provided if required.
4. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
5. GSE Polylock Concrete Embedment trip was not available. Instead, liner was bolted and anchored to top of concrete using stainless steel plate and bituminous seal as per detail 4.
6. CETCO Waterstop was not available. Instead, grout (Multicrete Sub Zero Grout) and mortar (Sikaset Plug) were used as necessary to fill bedrock fractures and any voids identified underneath plinths.
7. Where concrete plinths exceeded the maximum design height, bedding material fill was placed on both sides of the plinth for lateral support. Note that concrete plinths are not load bearing.
8. Maximum rebar embedment depth was approximately 0.3m due to equipment limitations.

							AB1	As-Built	RW	JBK	20/03/24
							0	Issued for Construction	RW	EMR	19/03/19
- -	- -	- -	- -	- -	- -	- -	A	Issued for Discussion	RW	EMR	19/03/05
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Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Liner Tie-in Typical Details

DRAWING NO. MN-CWP-08
SHEET 8 OF 10
REVISION NO. AB1

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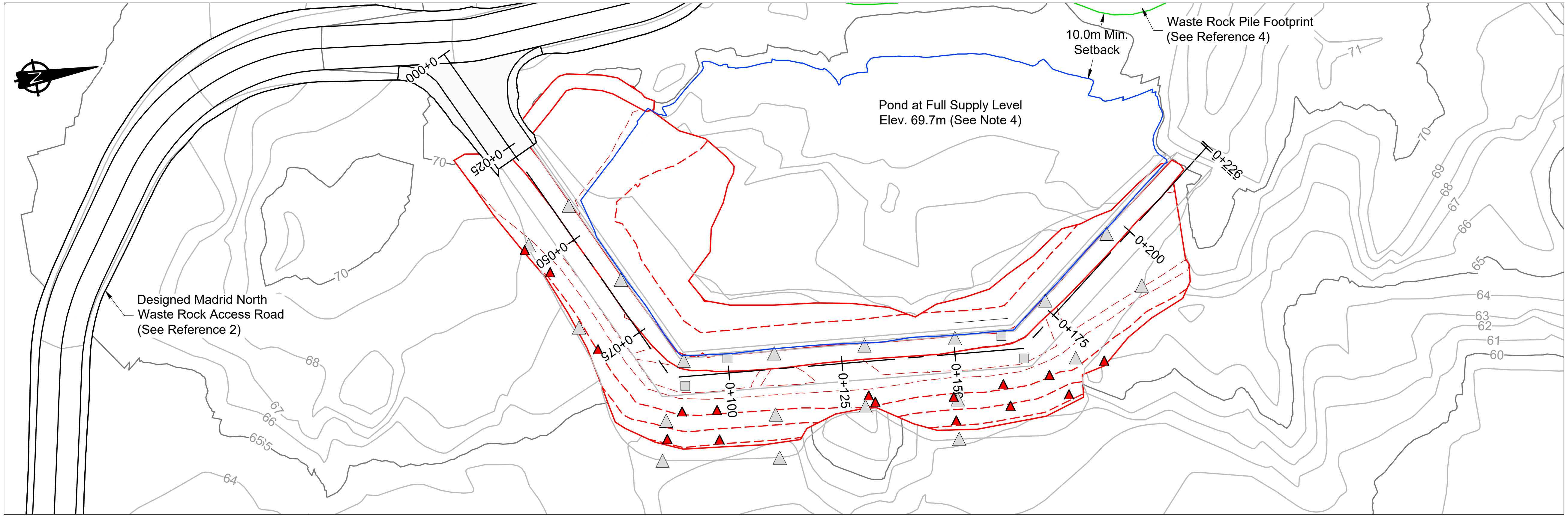
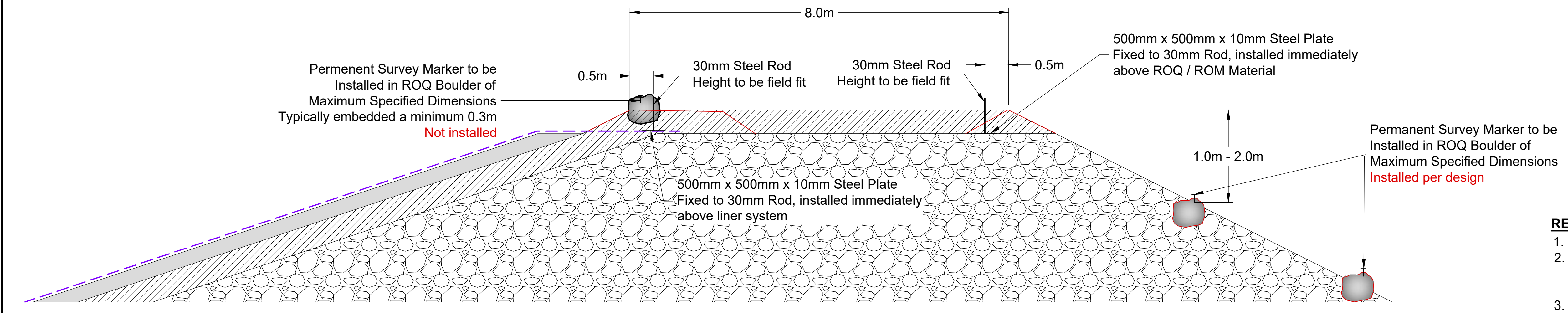


Contact Water Pond Berm Instrumentation Plan

0m 10 20 30 40



Surficial Survey Point Installation (as per design)

0m 1 2 3 4

LEGEND

△	Design Surficial Survey Monitoring Point
▲	As-Built Surficial Survey Monitoring Point
■	Design Settlement Monitoring Plate
🟦	As-Built Settlement Monitoring Plate (See Note 7)
- - -	Liner System
▭	Design Anticipated Overburden
▭	Contact Water Pond
🟥	As-Built Contact Water Pond Berm
🟩	Maximum Proposed Waste Rock Pile Footprint
■	Design Bedding Material
▨	Design Transition Material
▭	Design Run of Quarry (ROQ) or Run of Mine (ROM) Material

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
4. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
5. A total of 16 of the 19 proposed surficial settlement monitoring points were installed in the CWP berm. The surficial settlement monitoring points should be revisited, and if determined necessary by the design Engineer, the remaining points should be installed in the summer of 2020 after the snow has melted.
6. Construction access 'tote' road (MN-CWP-01 & 02) is not shown on this drawing.
7. Settlement monitoring plates were installed; however, as-built survey was unavailable at this time. It is recommended that they be surveyed in the summer of 2020.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.
4. Engineering Drawings for the Madrid North Waste Rock Pile, Hope Bay Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources Inc. Project Number: 1CT022.043. August 2019.
5. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.

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REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
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REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB1	As-Built	RW	JBK	20/03/24
0	Issued for Construction	RW	EMR	19/04/05
A	Issued for Discussion	RW	EMR	19/04/04
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FILE NAME: 1CT022.043 - Instrumentation Plan.dwg

TMAC RESOURCES

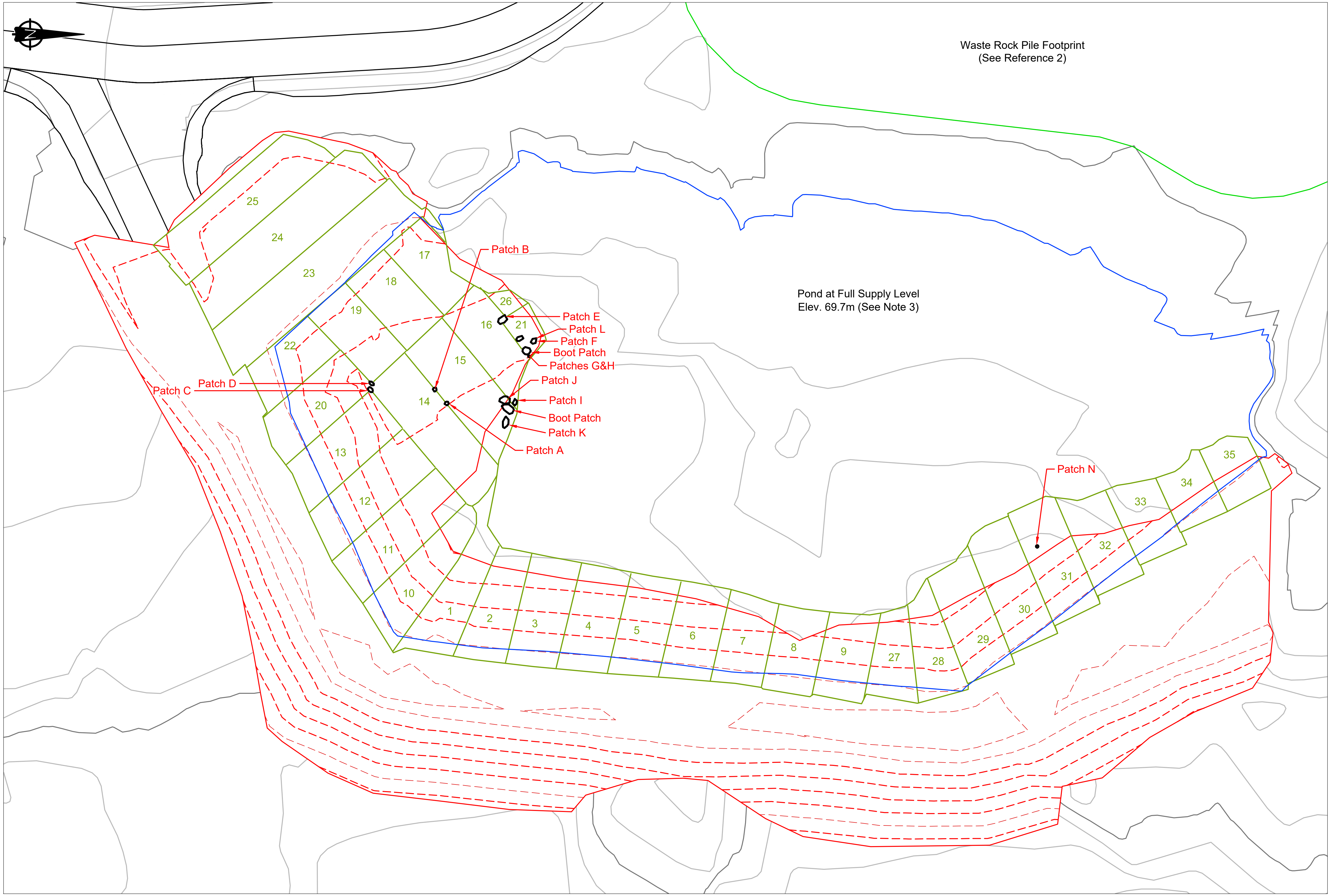
Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Instrumentation Plan

DRAWING NO.: MN-CWP-09
SHEET 9 OF 10
REVISION NO.: AB1



LEGEND

🟩 As-Built Liner Panel

⬛ As-Built Patch Panel

🟥 As-Built Contact Water Pond Berm

🟩 Maximum Proposed Waste Rock Pile Footprint

🟦 Contact Water Pond

NOTES

1. Contours shown at 1.0m intervals.
2. All dimension shown in meters unless otherwise stated.
3. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
4. Liner installation and quality control provided by A&A Technical Services.
5. Construction access 'tote' road (MN-CWP01 & 02) is not shown on this drawing.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid North Waste Rock Pile, Hope Bay Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources Inc. Project Number: 1CT022.043. August 2019.
3. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated May 2019 - September 2019.

0m 5 10 15 20

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DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

- -	- -	- -	- -	- -	AB1	As-Built	RW	JBK	20/03/24
NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE

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CHECKED: RW
APPROVED: JBK
DATE: March 24, 2020
FILE NAME: 1CT022.043 - Liner Layout.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

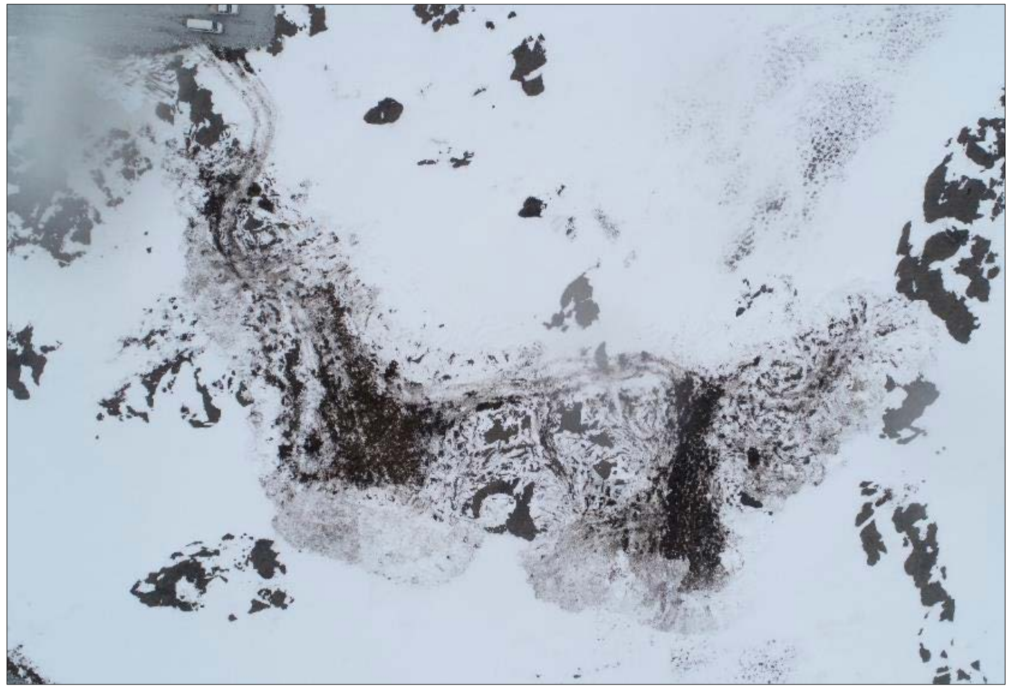
DRAWING TITLE:
As-Built Liner Panel Layout

DRAWING NO. MN-CWP-10
SHEET 10 OF 10
REVISION NO. AB1

Appendix B – Construction Photo Log

Aerial drone photo of snow clearing. May 25, 2019

Aerial drone photo of snow clearing. May 25, 2019



Aerial drone photo of snow clearing. May 27, 2019

Snow clearing. Looking south from north abutment. May 27, 2019

Snow clearing. May 30, 2019

Notes: Photos provided by TMAC site personnel.

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Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

TMAC RESOURCES

Hope Bay Project

Madrid CWP Construction Photo Log

Snow Clearing and Foundation Preparation

Date:	Approved:	Figure:
March 2020	RW	1

Aerial drone photo of ROQ placement. May 30, 2019

Note: Photo provided by TMAC site personnel.

ROQ placement. May 30, 2019

Note: Photo provided by TMAC site personnel.

ROQ placement. June 3, 2019

ROQ placement and roller compaction. June 3, 2019

ROQ placement and roller compaction. June 3, 2019

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TMAC RESOURCES

Madrid CWP Construction Photo Log

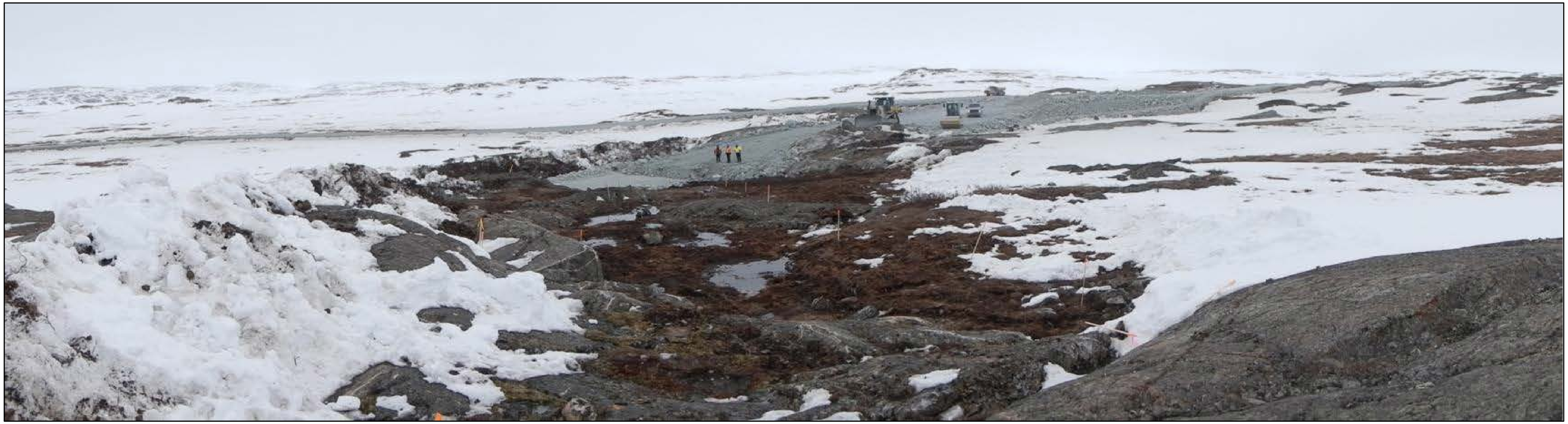
Placement of ROQ Berm Fill – 1 of 2

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	2



ROQ placement. June 3, 2019

ROQ placement. June 4, 2019

ROQ placement. 0+075 to 0+160 complete June 13, 2019

ROQ placement 0+160 to 0+225 complete June 13, 2019

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Madrid CWP Construction Photo Log

Placement of ROQ Berm Fill – 2 of 2

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

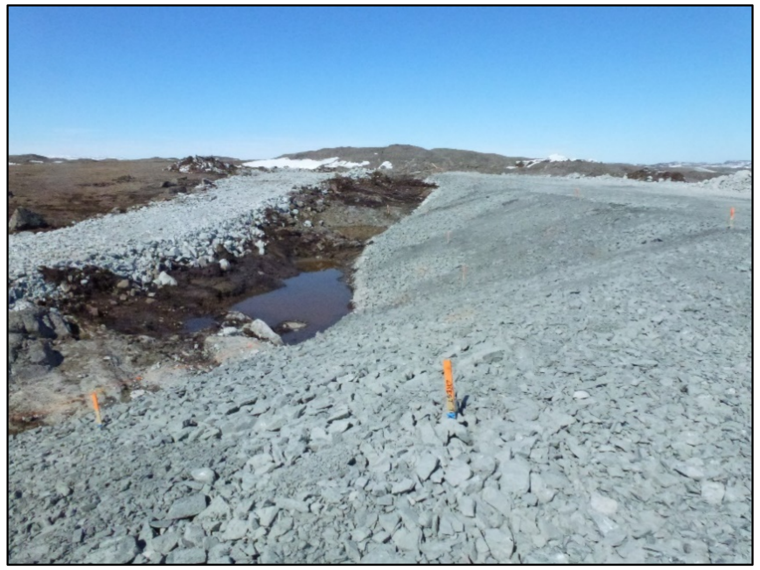
Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	3

Upstream excavation 0+100 to 0+160. June 4, 2019

Excavation of overburden at upstream toe to expose Bedrock 0+000 to 0+100. June 13, 2019

Excavation of overburden at upstream toe to expose Bedrock 0+100 to 0+160. June 13, 2019



Excavation of overburden at upstream toe to expose Bedrock 0+160 to 0+225. June 13, 2019

Excavation of overburden at upstream toe to expose Bedrock 0+100 to 0+0+160. June 13, 2019

Excavation of overburden at upstream toe to expose Bedrock 0+160 to 0+225. June 15, 2019

Excavation of overburden at upstream toe to expose Bedrock 0+160 to 0+225. June 17, 2019

Excavation of overburden at upstream toe to expose Bedrock 0+100 to 0+160. June 17, 2019

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TMAC RESOURCES

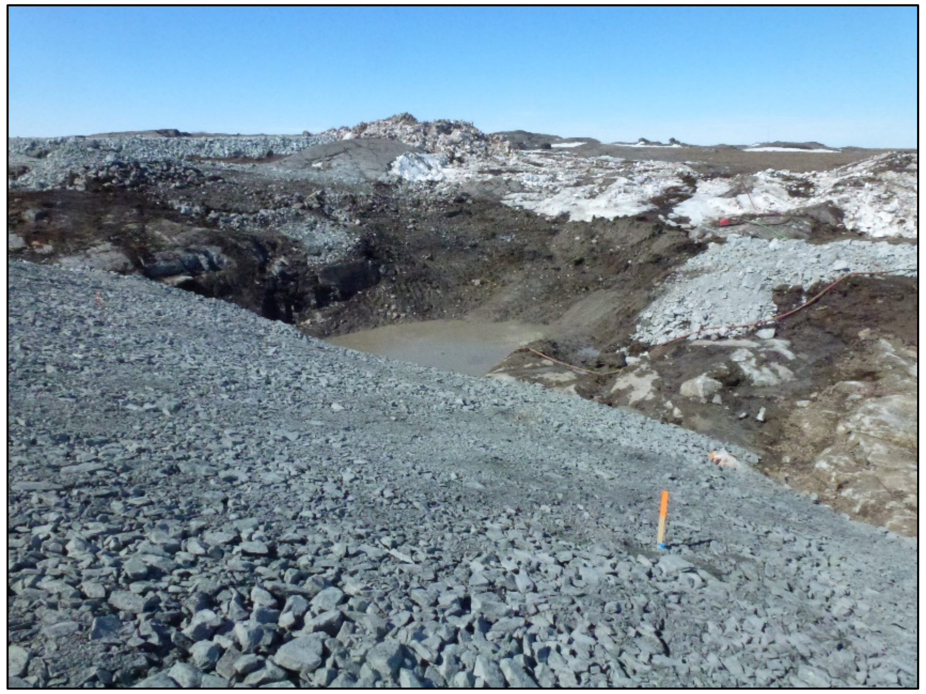
Madrid CWP Construction Photo Log

Upstream Excavation (to expose bedrock for liner tie-in)

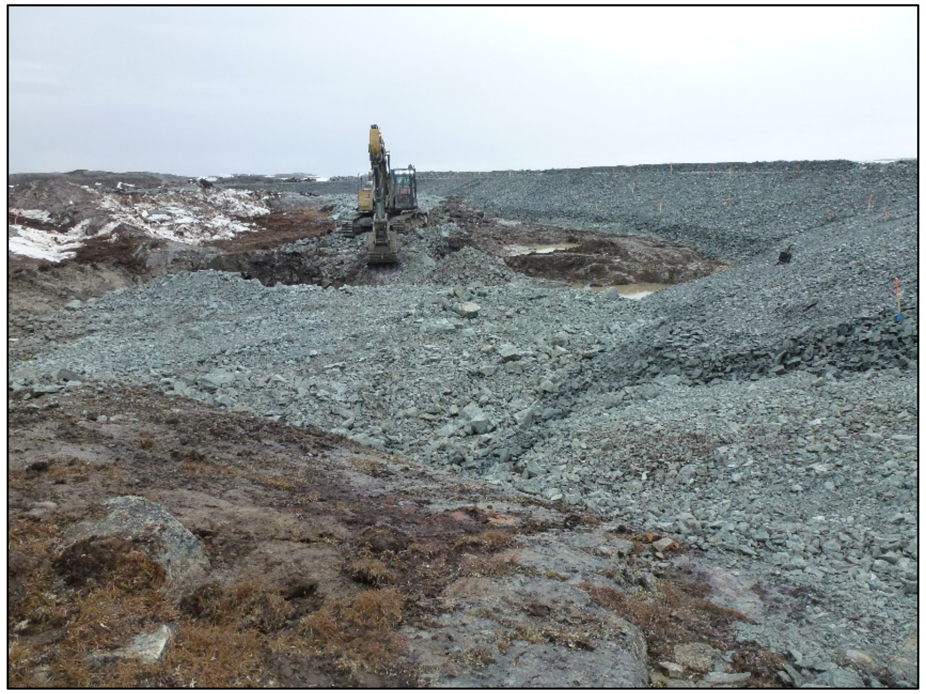
Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date: March 2020
Approved: RW
Figure: 4



Deeper than expected overburden 0+050 to 0+075. June 13, 2019



Placement of additional ROQ to fill deeper than expected overburden 0+050 to 0+075. June 14, 2019

Placement of additional ROQ to fill deeper than expected overburden 0+050 to 0+075. June 14, 2019

Placement of additional ROQ to fill deeper than expected overburden 0+050 to 0+075. June 15, 2019

Placement of additional ROQ and bedding material to fill deeper than expected overburden 0+050 to 0+075. June 26, 2019

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Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Madrid CWP Construction Photo Log

Placement of Additional ROQ (due to excess overburden)

Date:	Approved:	Figure:
March 2020	RW	5


Placement of transition material 0+000 to 0+100. June 16, 2019


Placement of transition material 0+100 to 0+160. June 16, 2019


Placement of transition material 0+160 to 0+225. June 16, 2019


Placement of bedding material 0+000 to 0+050. June 25, 2019


Placement of bedding material 0+100 to 0+160. June 25, 2019


Placement of bedding material 0+160 to 0+225. June 25, 2019


Placement of bedding material 0+000 to 0+160. June 26, 2019


Placement of bedding material 0+160 to 0+225. June 26, 2019


Placement of bedding material 0+050 to 0+075 over additional ROQ. June 26, 2019

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MAC RESOURCES

Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

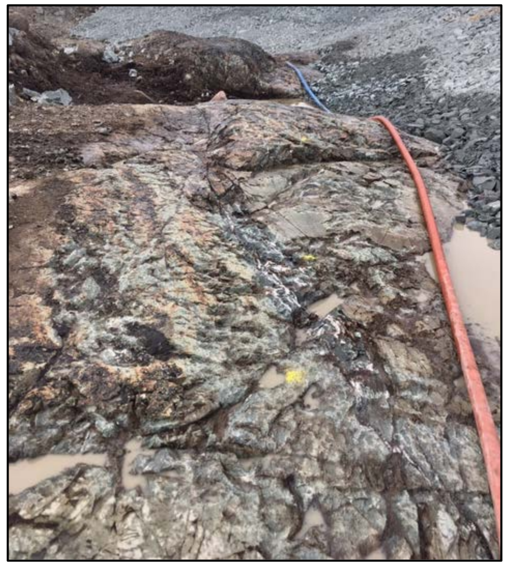
Hope Bay Project

Madrid CWP Construction Photo Log

Transition and Bedding Material Placement on Upstream Slope

Date:	Approved:	Figure:
March 2020	RW	6

Cleaning of bedrock at liner tie-in or plinth contact 0+100 to 0+160. June 20, 2019



Cleaning of bedrock at liner tie-in or plinth contact 0+100 to 0+160. June 20, 2019

Cleaning of bedrock at liner tie-in or plinth contact 0+050 to 0+100. June 25, 2019

Cleaning of bedrock at liner tie-in or plinth contact 0+160 to 0+225. June 26, 2019

Cleaning of bedrock at liner tie-in or plinth contact 0+100 to 0+160. June 26, 2019

Cleaning of bedrock at liner tie-in or plinth contact 0+000 to 0+050. June 26, 2019

Cleaning of bedrock at liner tie-in or plinth contact 0+000 to 0+050. June 27, 2019

Cleaning of bedrock at liner tie-in or plinth contact 0+160 to 0+225. June 27, 2019

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Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Madrid CWP Construction Photo Log

Cleaning of Bedrock (for plinth construction & liner tie-in)

Date:	Approved:	Figure:
March 2020	RW	7

Formwork for plinth contact. June 29, 2019

Formwork and steel reinforcing for plinth 1. June 30, 2019

Steel reinforcing secured in bedrock. June 30, 2019

Concrete being cast for plinth 1 June 30, 2019

Formwork stripped plinth 1 July 1 , 2019

Concrete containing Sikaset Plug cast. July 17, 2019

Placement of bentonite crush. July 17, 2019

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MAC RESOURCES

Madrid CWP Construction Photo Log

Construction of Plinth 1

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	8

Formwork and reinforcing plinth 2 June 30, 2019

Concrete being cast from plinth to plinth 2 June 30, 2019

Formwork stripped plinth 2 and plinth 3 July 1 , 2019

Drying surfaces prior to applying patch material.
July 16, 2019

Placement of Sikaset Plug within void. July 16, 2019

Sikaset Plug used for minor voids

Sopramastic and bentonite crush placed
July 17, 2019

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MAC RESOURCES

Madrid CWP Construction Photo Log

Construction of Plinth 2

Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date: March 2020
Approved: RW
Figure: 9


Formwork for plinth 2 & 3 contact. June 29, 2019


Formwork and steel reinforcing for plinth 3. June 30, 2019


Concrete being floated plinth 2 and plinth 3 June 30, 2019


Formwork stripped plinth 2 and plinth 3 July 1 , 2019


Void cleaned below plinth 3. July 15, 2019


Dye testing plinth 3. July 16. 2019


Bentonite crush placed July 17, 2019

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Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

MAC RESOURCES

Hope Bay Project

Madrid CWP Construction Photo Log

Construction of Plinth 3

Date:	Approved:	Figure:
March 2020	RW	10


Formwork and reinforcing for plinth 4. July 1, 2019


Concrete casting plinth 4. July 2, 2019


Void cleaned below plinth 4 July 13, 2019


Concrete grouting cast. July 13, 2019


Seal al joints with Sika Sikaset Plug plinth 4. July 14, 2019


Dye testing plinth 4. July 16, 2019


Placement bentonite crush July 17, 2019


Bentonite crush. July 25, 2019

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MAC RESOURCES

Madrid CWP Construction Photo Log

Construction of Plinth 4

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	11


Formwork for plinth 5 contact. June 30, 2019


Formwork and reinforcing for plinth 5. July 1, 2019


Concrete casting plinth 4 and plinth 5. July 2, 2019


Formwork removed July 3, 2019


Sikaset Plug and Sopramastic along join July 17, 2019


Bentonite crush placed. July 17, 2019


Bentonite crush. July 25, 2019

srk consulting

MAC RESOURCES

Job No: 1CT022.43

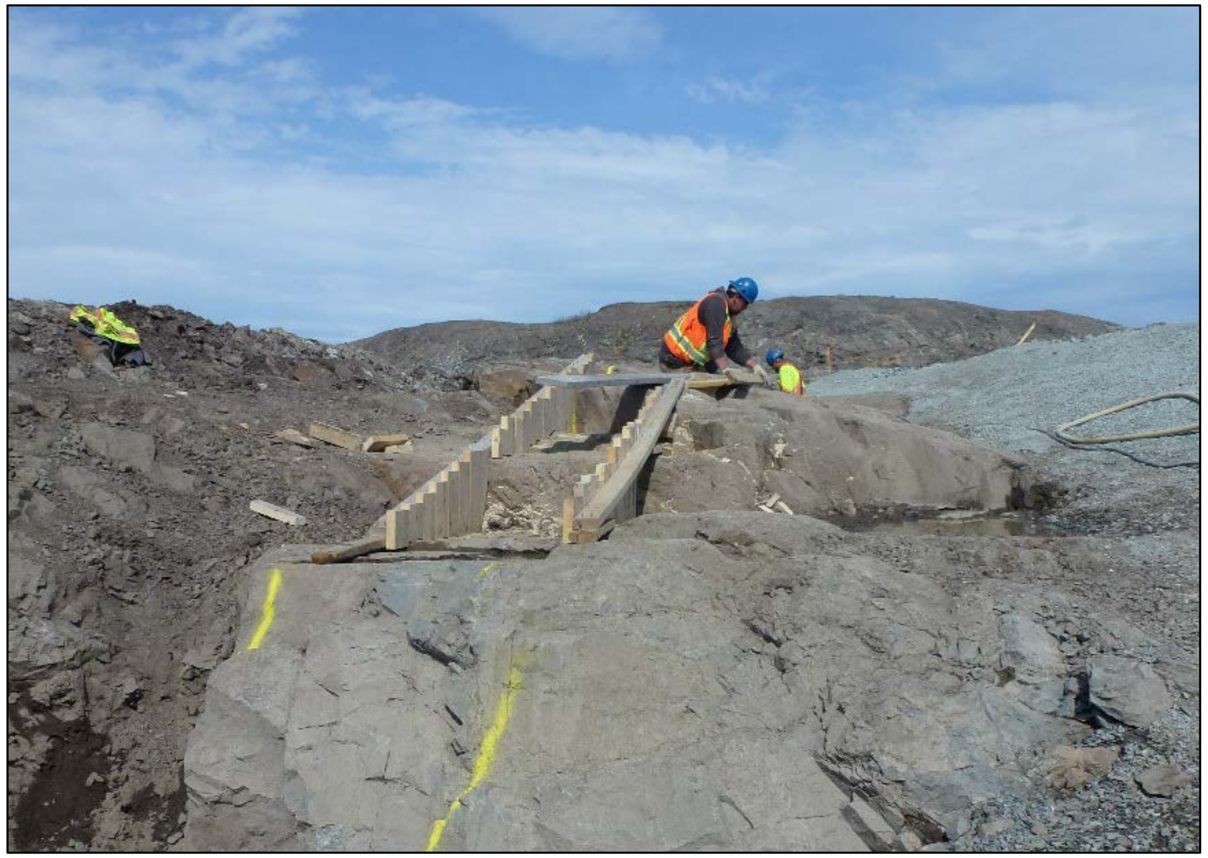
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Madrid CWP Construction Photo Log

Construction of Plinth 5

Date:	Approved:	Figure:
March 2020	RW	12



Formwork plinth 6 June 29, 2019

Concrete casting plinth 6 June 30, 2019

Sopramastic placed for voids plinth 6 July 16, 2019

srk consulting	MAC RESOURCES	Madrid CWP Construction Photo Log **Construction of Plinth 6**
Job No: 1CT022.43 Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined	Hope Bay Project	Date: March 2020 Approved: RW Figure: 13

Cleaning and formwork for plinth 7. June 29, 2019

Formwork and steel reinforcing for plinth 7. June 30, 2019

Steel reinforcing secured in bedrock plinth 7. June 30, 2019

Casting of concrete plinth 7 June 30, 2019

Concrete cast plinth 7 June 30, 2019

Voids below plinth. July 14, 2019.

Bentonite crush. July 25, 2019

srk consulting

MAC RESOURCES

Madrid CWP Construction Photo Log

Construction of Plinth 7

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date: March 2020

Approved: RW

Figure: 14


Formwork for plinth 8. June 29, 2019


Concrete casting plinth 8 July 2, 2019


Concrete cast plinth 8 July 2, 2019


Formwork removed leak testing plinth 8. July 4, 2019


Void exposed plinth 8. July 13, 2019


Voids cleaned and formwork for concrete grouting. July 15, 2019

Concrete grout cast, dye test conducted. July 15, 2019

Concrete cast, Sopramastic placed along joins with bentonite crush. July 25, 2019

srk consulting

MAC RESOURCES

Madrid CWP Construction Photo Log

Construction of Plinth 8

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	15

Contact rock cleaned and formwork placed plinth 9. July 2, 2019

Contact rock cleaned and formwork placed plinth 10. July 2, 2019

Plinth 9 and 10 cast July 2, 2019

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MAC RESOURCES

Madrid CWP Construction Photo Log

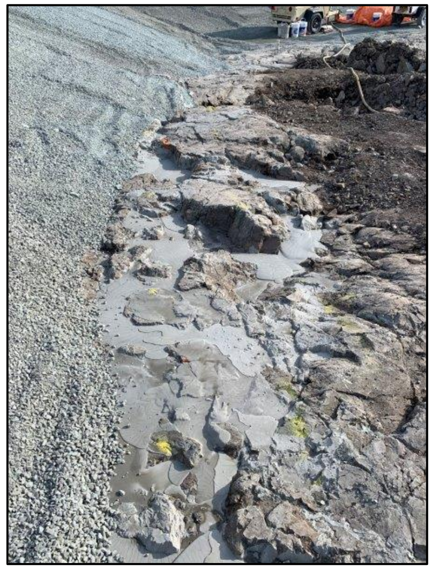
Construction of Plinth 9 and 10

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	16



Grouting cracks. June 24, 2019

Grouting cracks. June 24, 2019

Grouting cracks. June 24, 2019

Concrete liner tie-in 0+050 to 0+100. June 24, 2019

Concrete liner tie-in 0+100 to 0+160. June 24, 2019

Concrete liner tie-in 0+120 to 0+160. June 24, 2019

Void grouted. June 25, 2019

Void grouted. June 25, 2019

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Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

TMAC RESOURCES

Hope Bay Project

Madrid CWP Construction Photo Log

Void Grouting and Dental Concrete for Liner Tie-In – 1 of 2

Date:	Approved:	Figure:
March 2020	RW	17

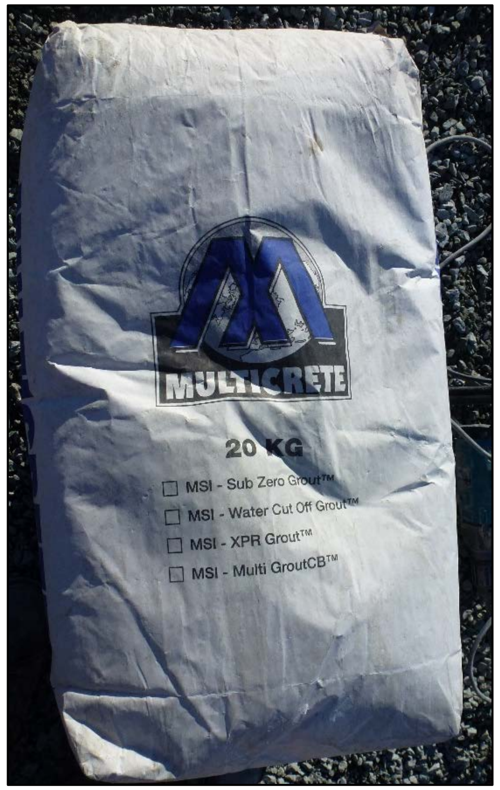
Concrete grouting 0+050 to 0+075. July 2, 2019

Concrete grouting for liner tie-in 0+000 to 0+50. July 3, 2019

Concrete grouting for liner tie-in 0+160 to 0+225. July 3, 2019

Crack/void identified. July 14, 2019

Crack/void grouted. July 25, 2019



Multicrete sub-zero grout used

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MAC RESOURCES

Madrid CWP Construction Photo Log

Void Grouting and Dental Concrete for Liner Tie-In – 2 of 2

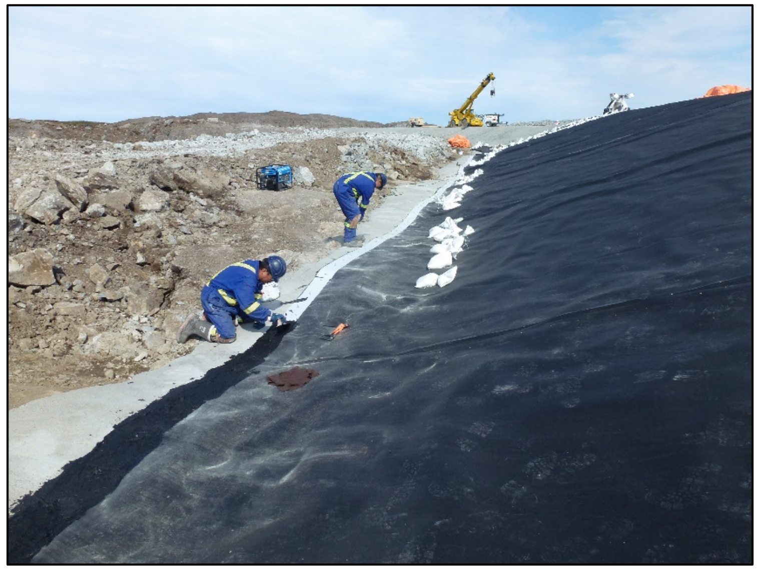
Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date:	Approved:	Figure:
March 2020	RW	18

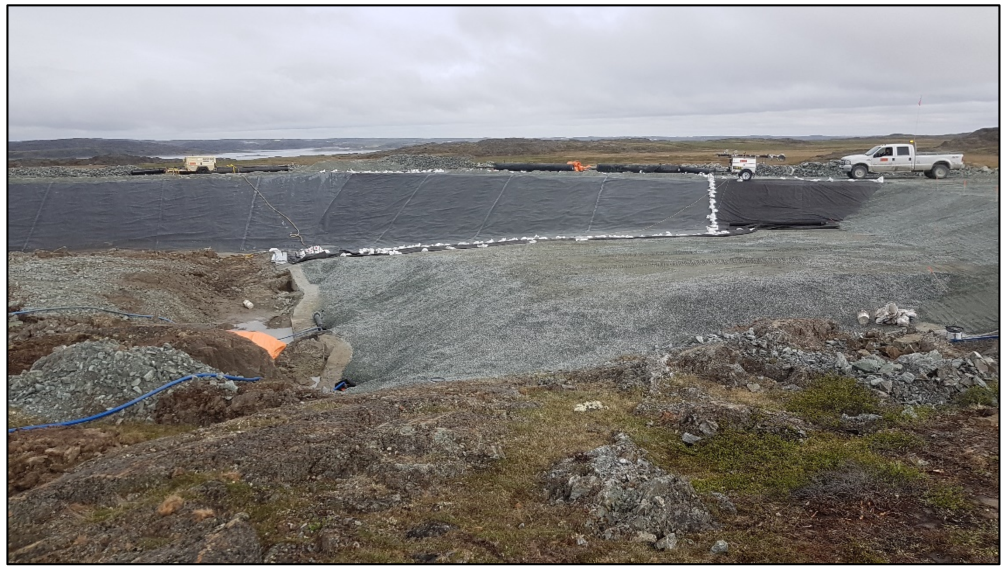
Geotextile and liner placement 0+050 to 0+100. June 28, 2019

Geotextile and liner placement 0+050 to 0+100. June 28, 2019



Liner tie-in 0+040 to 0+160. June 29, 2019

Geotextile and liner placement 0+100 to 0+160. July 6, 2019



Geotextile and liner placement 0+000 to 0+100. July 6, 2019

Liner specification

Sopramastic liner sealant

srk consulting

MAC RESOURCES

Job No: 1CT022.43

Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Madrid CWP Construction Photo Log

Geotextile and Liner Installation – 1 of 3

Date: March 2020

Approved: RW

Figure: 19

Geotextile placement 0+000 to 0+100. July 8, 2019

Liner join 0+050 . July 8, 2019

Liner placement and tie-in 0+000 to 0+100. July 8, 2019

Geotextile placement 0+160 to 0+225. July 25, 2019

Geotextile and liner placement 0+160 to 0+225. July 25, 2019

Liner tie-in 0+160 to 0+225. July 25, 2019

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Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

TMAC RESOURCES

Hope Bay Project

Madrid CWP Construction Photo Log

Geotextile and Liner Installation – 2 of 3

Date:	Approved:	Figure:
March 2020	RW	20

Well installation panel. July 8, 2019

Liner pushed up by water 0+000 to 0+050 July 11, 2019

Geotextile and crush placed over liner due to ground water below liner 0+000 to 0+050. July 25, 2019

Liner anchor material 0+050 to 0+160. July 28, 2019

Liner anchor material 0+000 to 0+225. July 28, 2019

srk consulting

MAC RESOURCES

Madrid CWP Construction Photo Log

Geotextile and Liner Installation – 3 of 3

Job No: 1CT022.43
Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined

Hope Bay Project

Date: March 2020
Approved: RW
Figure: 21

Downstream slope prior to final shaping. July 6, 2019

Downstream slope final shaping. July 28, 2019

Downstream slope final shaping. July 28, 2019

Downstream slope final shaping. July 28, 2019

srk consulting	MAC RESOURCES	Madrid CWP Construction Photo Log **Final ROQ Berm Shaping**
Job No: 1CT022.43 Filename: 1CT022.043_HB_MadridCWP_PhotoLog_Combined	Hope Bay Project	Date: March 2020 Approved: RW Figure: 22

Appendix C – Issued for Construction Drawings

Engineering Drawings for the Madrid North Contact Water Pond

Hope Bay Project, Nunavut, Canada

Active Drawing Status

Drawing Number	**Drawing Title**	**Issue**	**Date**	Revision
MN-CWP-01	General Arrangement (With Orthophoto)	Issued for Construction	March 19, 2019	0
MN-CWP-02	General Arrangement	Issued for Construction	March 19, 2019	0
MN-CWP-03	Contact Water Pond Anticipated Foundation Conditions Plan and Profile	Issued for Construction	March 19, 2019	0
MN-CWP-04	Contact Water Pond Plan and Profile	Issued for Construction	March 19, 2019	0
MN-CWP-05	Contact Water Pond Typical Sections	Issued for Construction	March 19, 2019	0
MN-CWP-06	Contact Water Pond Typical Details	Issued for Construction	March 19, 2019	0
MN-CWP-07	Liner Tie-in Typical Details	Issued for Construction	March 19, 2019	0

TMAC RESOURCES

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2019/04/02

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Project Number: 1CT022.043

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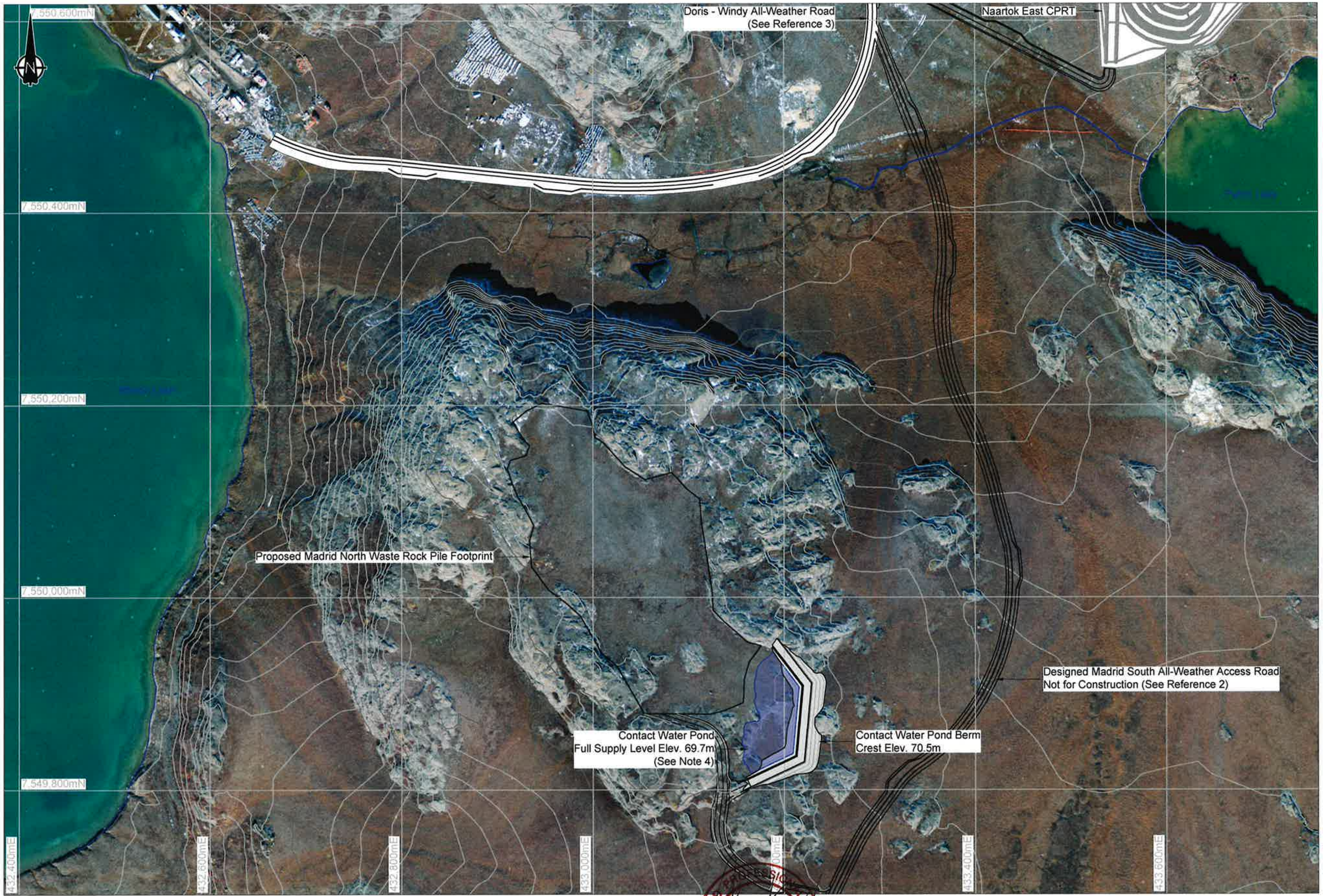

LEGEND

═	Proposed Road
🟦	Proposed Contact Water Pond

NOTES

1. Contours shown at 2.0m intervals.
2. All units shown in meters unless otherwise specified.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
4. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen day) residence time for water in the pond.
5. Imagery provided by client.

REFERENCES

1. NAD83 UTM Zone 13.
2. Details found in "Engineering Drawings for the Madrid South All-Weather Road, Hope Bay Project, Nunavut, Canada". Revision E Issued for Discussion drawings prepared for TMAC Resources. Project Number: 1CT022.043. March 2019.
3. Engineering Drawings for the Doris-Windy All-Weather Road, Doris Infrastructure Project, Nunavut, Canada. Revision AB1. As-Built drawings prepared for Hope Bay Mining Ltd. Project Number: 1CH008.033/058. May 11, 2012.
4. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
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REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	RW	EMR	19/03/19
A	Issued for Discussion	RW	EMR	19/03/05
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FILE NAME: 1CT022.043 - GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
General Arrangement
(With Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
MN-CWP-01	1 OF 7	0

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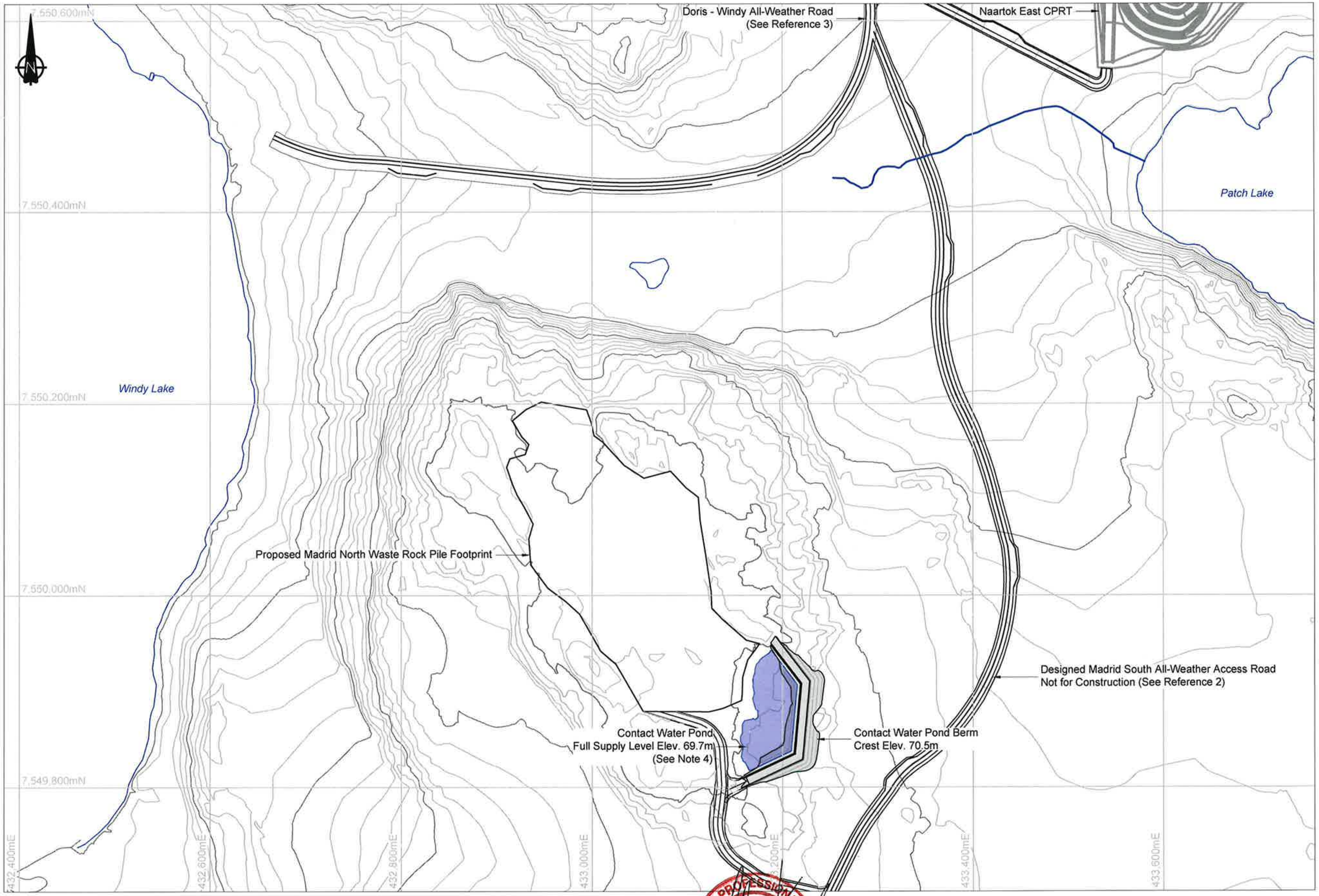


LEGEND

═	Proposed Road
🟦	Proposed Contact Water Pond

NOTES

1. Contours shown at 2.0m intervals.
2. All units shown in meters unless otherwise specified.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018)
4. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.

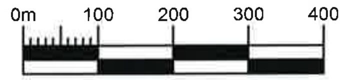
REFERENCES

1. NAD83 UTM Zone 13.
2. Details found in "Engineering Drawings for the Madrid South All-Weather Road, Hope Bay Project, Nunavut, Canada". Revision E Issued for Discussion drawings prepared for TMAC Resources. Project Number: 1CT022.043. March 2019.
3. Engineering Drawings for the Doris-Windy All-Weather Road, Doris Infrastructure Project, Nunavut, Canada. Revision AB1. As-Built drawings prepared for Hope Bay Mining Ltd. Project Number: 1CH008.033/058. May 11, 2012.
4. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.

MATERIAL LIST AND QUANTITIES

Overburden Excavation: 250m³
ROQ / ROM Material: 13,450m³
Transition Material: 1,705m³
Bedding Material: 450m³
Surfacing Material: 2,80m³
HDPE Geomembrane Liner: 2,005m²
Non-woven Geotextile: 2,005m²

*All volumes reported are calculated to neat lines. No bulking / shrinking factors have been utilized in volume determination. Losses into the Tundra are not accounted for.



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FILE NAME: 1CT022.043 - GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
General Arrangement

DRAWING NO. MN-CWP-02
SHEET 2 OF 7
REVISION NO. 0

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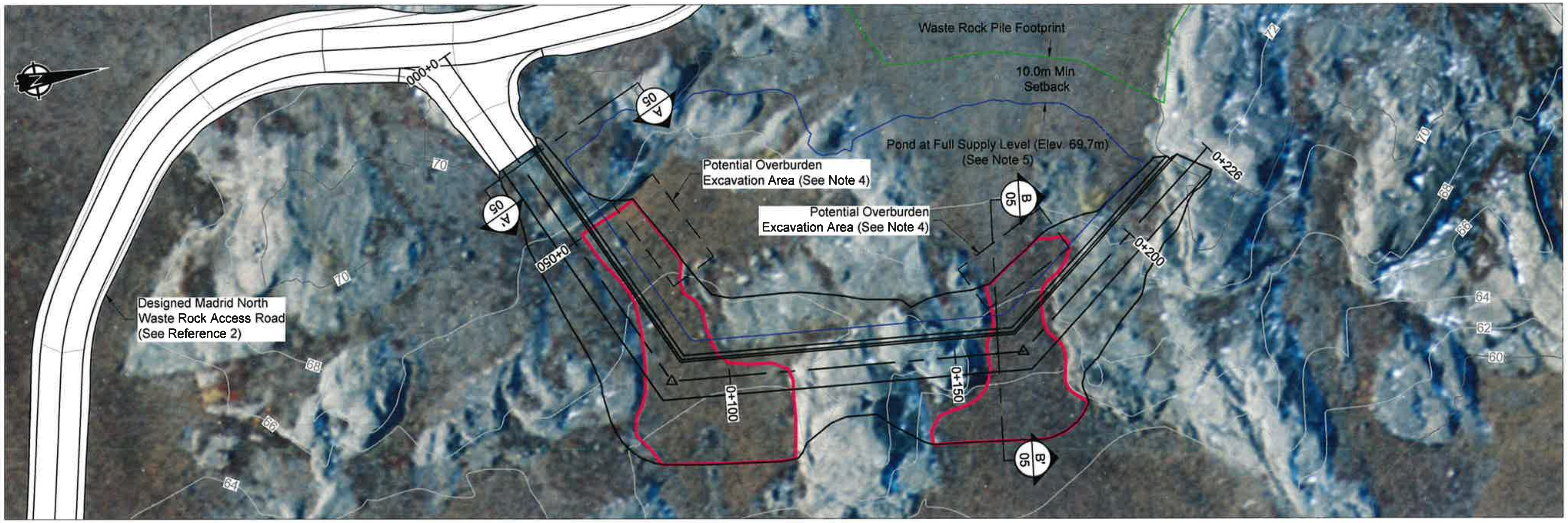
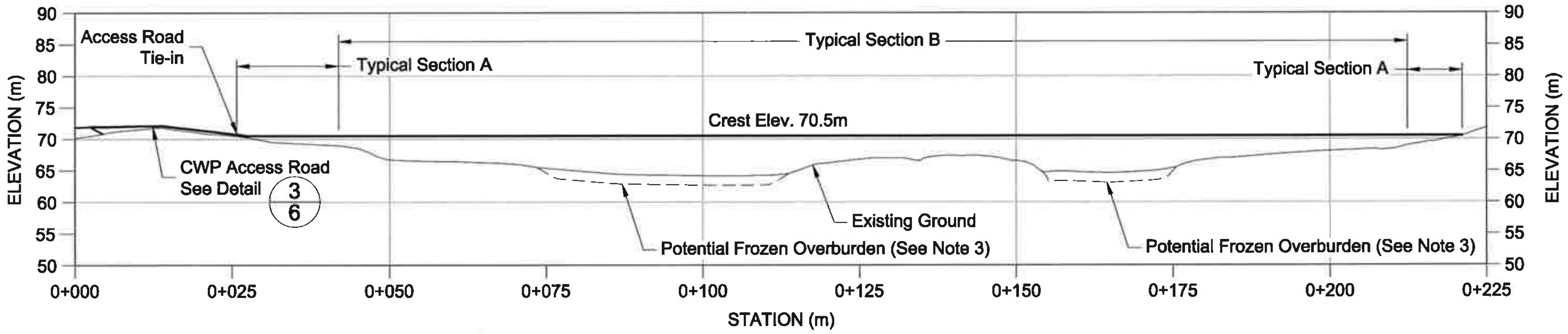


Contact Water Pond Berm Plan View



Contact Water Pond Berm Profile View

LEGEND

🟥	Anticipated Overburden
🟦	Contact Water Pond
⬛	Contact Water Pond Berm
🟩	Waste Rock Pile Footprint

NOTES

1. Contours shown at 2.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. The majority of the CWP berm footprint is expected to encounter bedrock outcrop. However, based on aerial imagery overburden may be encountered in low-lying areas.
4. If overburden including tundra matt or organics ~~is~~ encountered at the upstream toe, it will be excavated to bedrock to allow liner to tie-in to the bedrock foundation.
5. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
6. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.

0m 10 20 30 40

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A	Issued for Discussion	RW	EMR	19/03/05

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FILE NAME: 1CT022.043 - OB.dwg		

TMAC RESOURCES

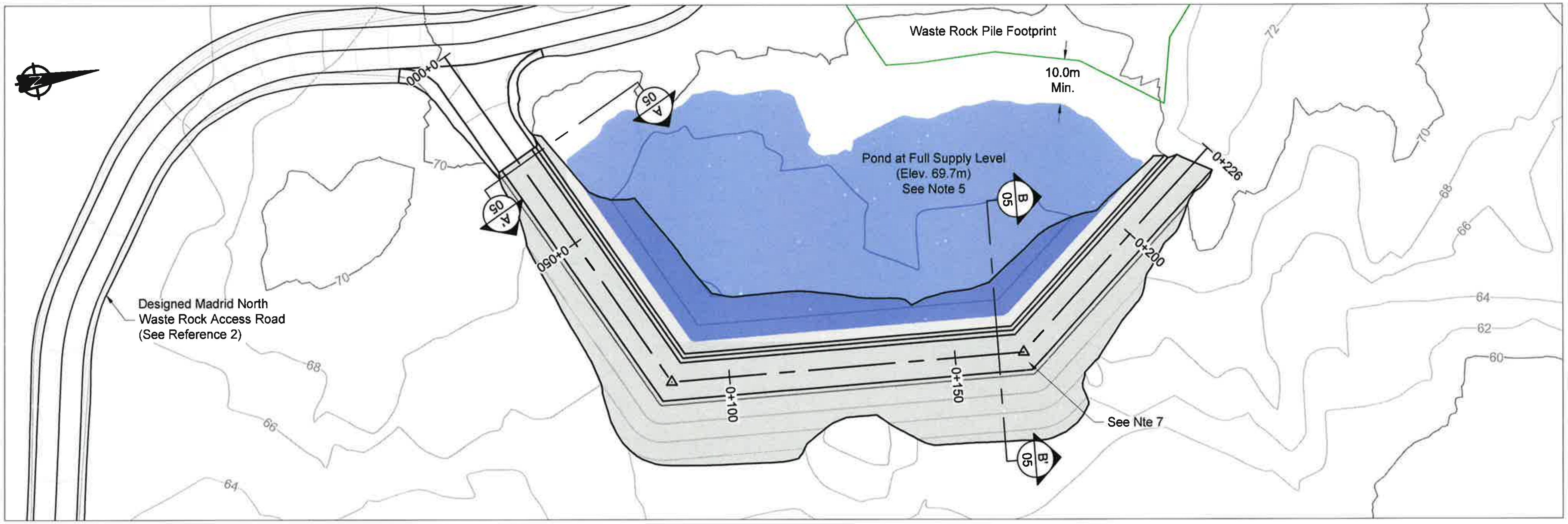
Hope Bay Project

SRK JOB NO.: 1CT022.043

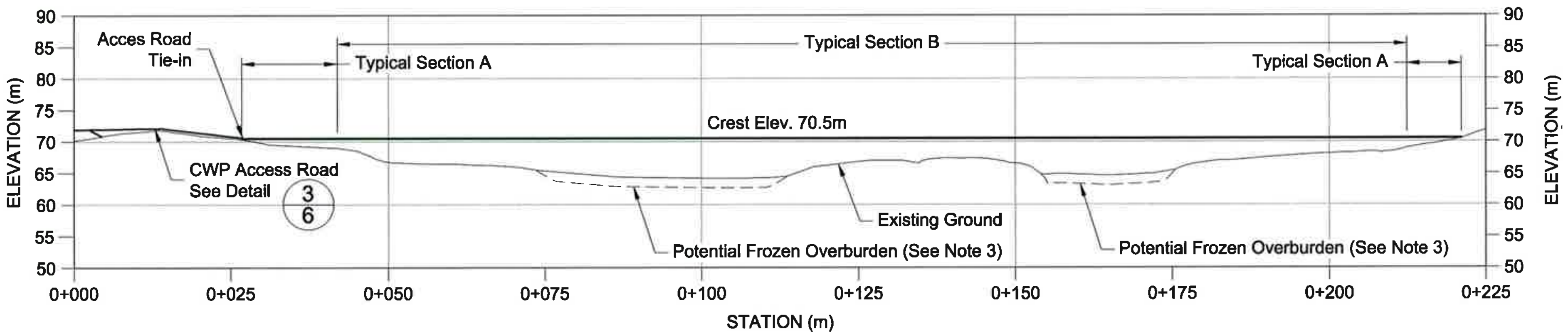
Madrid North Contact Water Pond

DRAWING TITLE: Contact Water Pond
Anticipated Foundation Conditions
Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
MN-CWP-03	3 OF 7	0



Contact Water Pond Berm Plan View



Contact Water Pond Berm Profile View

LEGEND

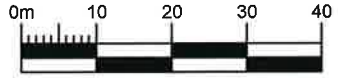
🟦	Contact Water Pond
▨	Contact Water Pond Berm
🟩	Waste Rock Pile Footprint

NOTES

1. Contours shown at 2.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. The majority of the CWP berm footprint is expected to encounter bedrock outcrop. However, based on aerial imagery overburden may be encountered in low-lying areas.
4. If overburden is encountered at the upstream toe, it will be excavated to bedrock to allow liner to tie-in to the bedrock foundation.
5. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
6. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
7. Where the height of the berm exceeds 3.0m, safety berms or barries are required on the crest. See Typical Berm Barrier Options on drawing MN-CWP-06.

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.



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A	Issued for Discussion	RW	EMR	19/03/05

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MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Plan and Profile

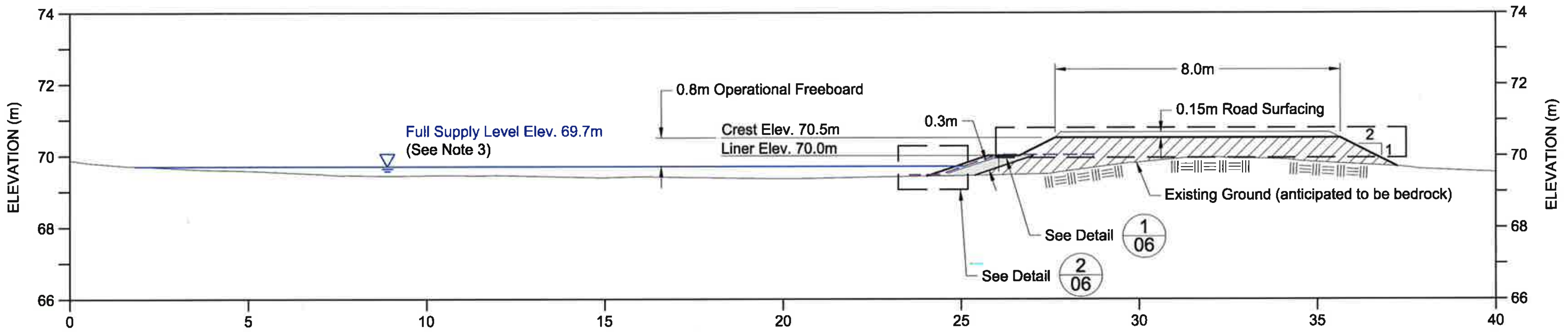
DRAWING NO.	SHEET	REVISION NO.
MN-CWP-04	4 OF 7	0

LEGEND

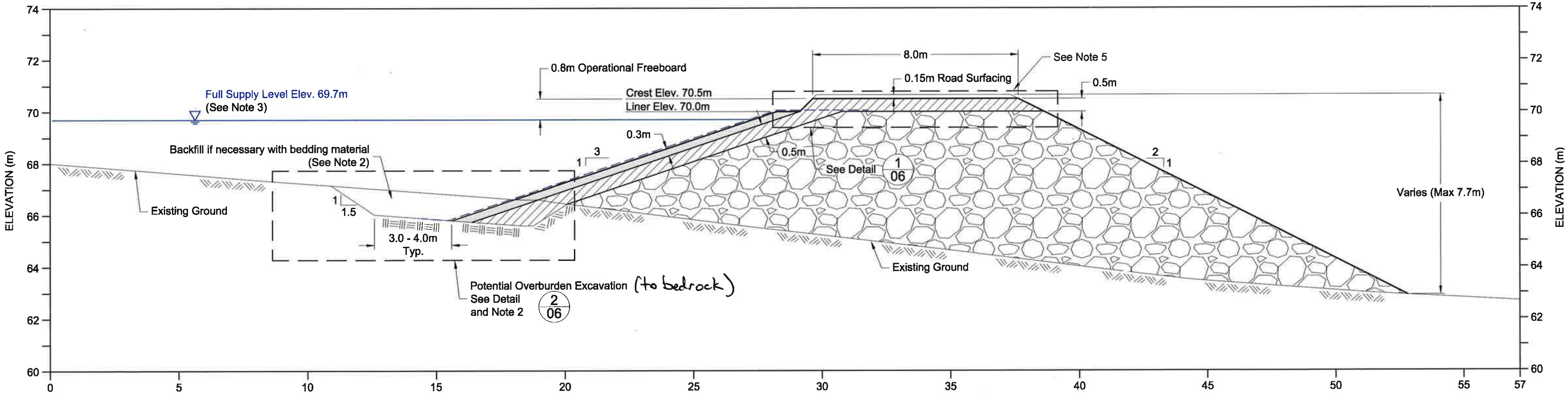
- – – – Liner System
- ▭ Bedding Material
- ▨ Transition Material
- ⬭ Run of Quarry (ROQ) or Run of Mine (ROM) Material

NOTES

1. All dimensions shown in meters unless otherwise stated.
2. If overburden or organics is encountered at the upstream toe, it will be excavated to bedrock to tie-in to the bedrock foundation. Thickness of excavation will vary and will depend on conditions encountered. Excavation to be backfilled with bedding material if necessary to protect the liner tie-in.
3. The CWP will normally be kept in a dry state with a maximum two-week (i.e. fourteen-day) residence time for water in the pond.
4. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
5. Where the height of the berm exceeds 3.0m, safety berms or barriers are required on the crest. See Typical Berm Barrier Options on drawing MN-CWP-06.



A/03 **Cross Section A-A' - Berm Sections less than 1.5m**



B/03 **Cross Section B-B' - Berm Sections 1.5m or higher**

0m 1 2 3 4 5 6

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							0	Issued for Construction	RW	EMR	19/03/19
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CHECKED: RW	APPROVED: EMR	DATE: March 19, 2019

FILE NAME: 1CT022.043 - PP.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:
Contact Water Pond
Typical Sections

DRAWING NO. MN-CWP-05
SHEET 5 OF 7
REVISION NO. 0

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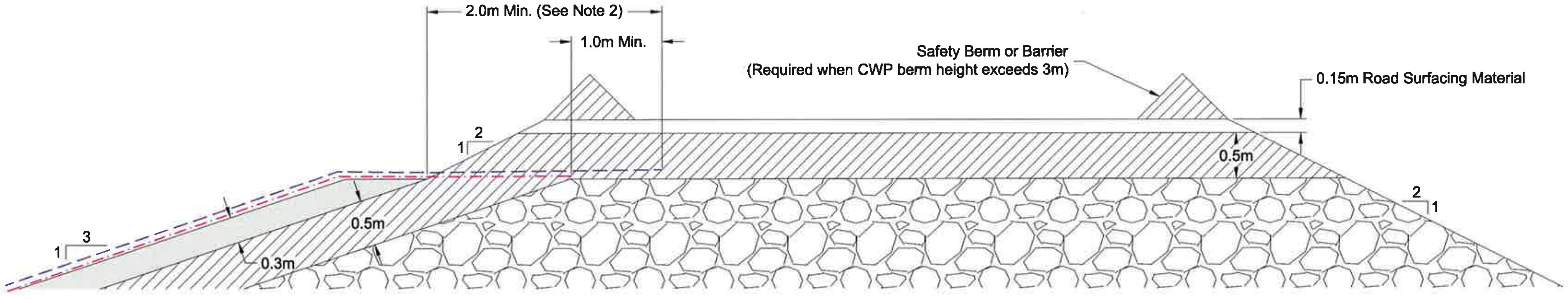


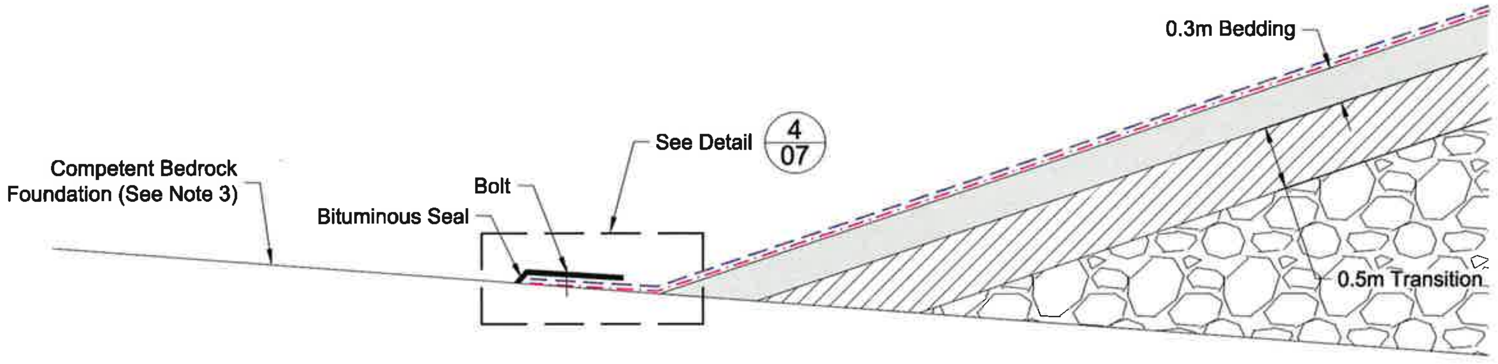
1 / 05 **Typical Liner Anchor Detail**

LEGEND

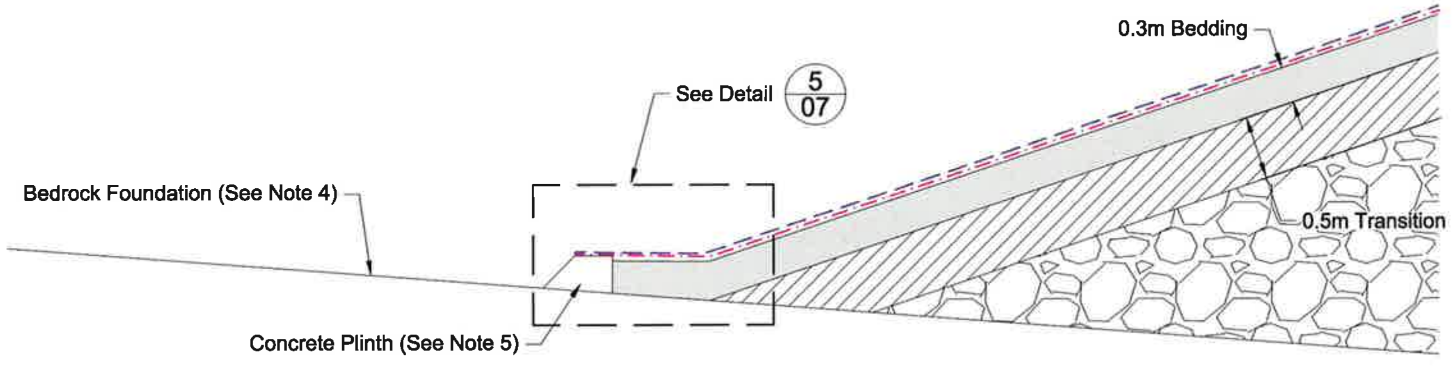
– – –	Liner	▨	Transition Material
– · –	Non-woven Geotextile	⬭	Run of Quarry (ROQ) or Run of Mine (ROM) Material
▭	Bedding Material	■	Bituminous Seal

NOTES

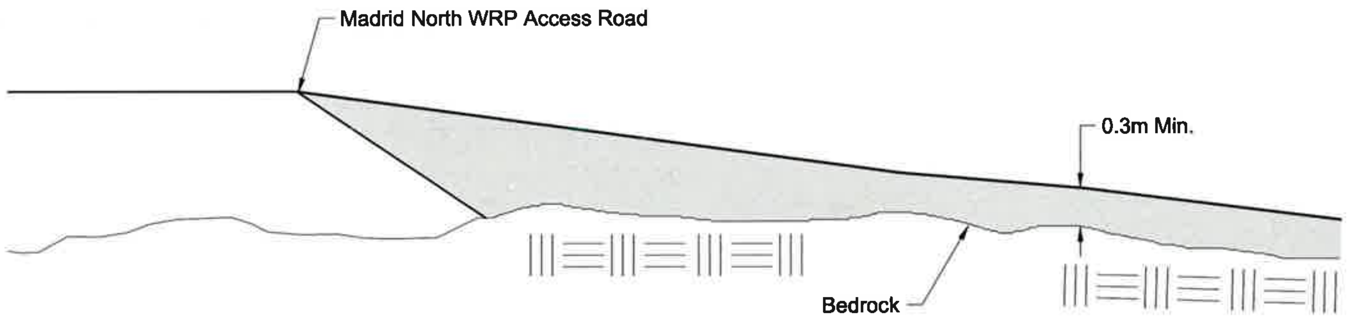
1. All dimensions shown in meters unless otherwise stated.
2. Minimum 1.0m liner overlap with ROQ/ROM material. Total covered liner overlap must be a minimum of 2.0m. Non-woven geotextile to terminate at ROQ/ROM.
3. If competent bedrock conditions are encountered, liner can be mechanically tied in to bedrock. A bituminous seal may also be applied. Bedrock conditions to be inspected and approved by field engineer.
4. If bedrock conditions are unfavourable (e.g. weathered, highly fractured) or the bedrock surface is highly irregular, a concrete plinth may be required to facilitate liner tie-in. Bedrock conditions to be inspected and approved by the field engineer.
5. Liner to be affixed to top of concrete plinth with GSE Polylock Concrete Embedment Strip or Approved Alterative. Steel reinforcement bars also required and should be typically drilled and grouted a minimum 450mm into bedrock.
6. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).



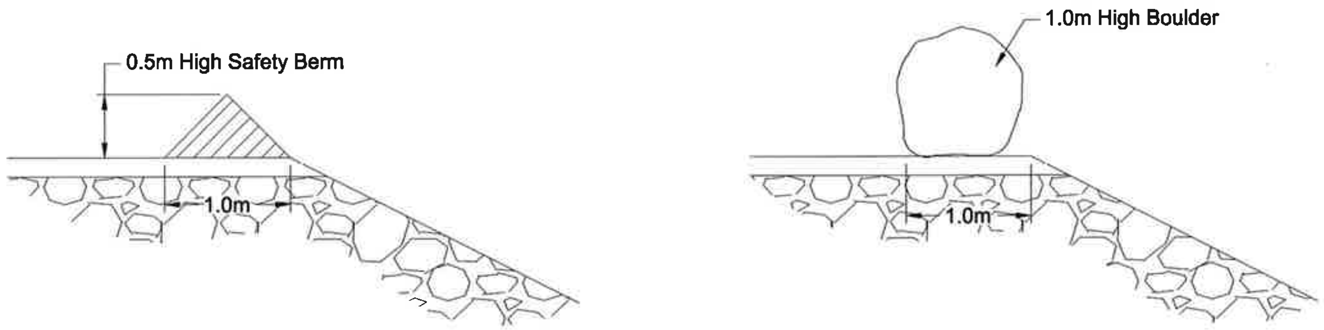
2 / 05 **Typical Liner Anchor at Bedrock - Mechanical Tie-down Option**



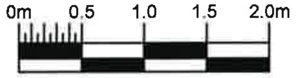
2 / 05 **Typical Liner Anchor at Bedrock - Concrete Plinth Option**



3 / 04,05 **CWP Access Road Detail**



Typical Safety Berm or Barrier Options



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DATE: March 19, 2019
FILE NAME: 1CT022.043 - PP.dwg

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SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond
DRAWING TITLE: Contact Water Pond Typical Details
DRAWING NO. MN-CWP-06
SHEET 6 OF 7
REVISION NO. 0

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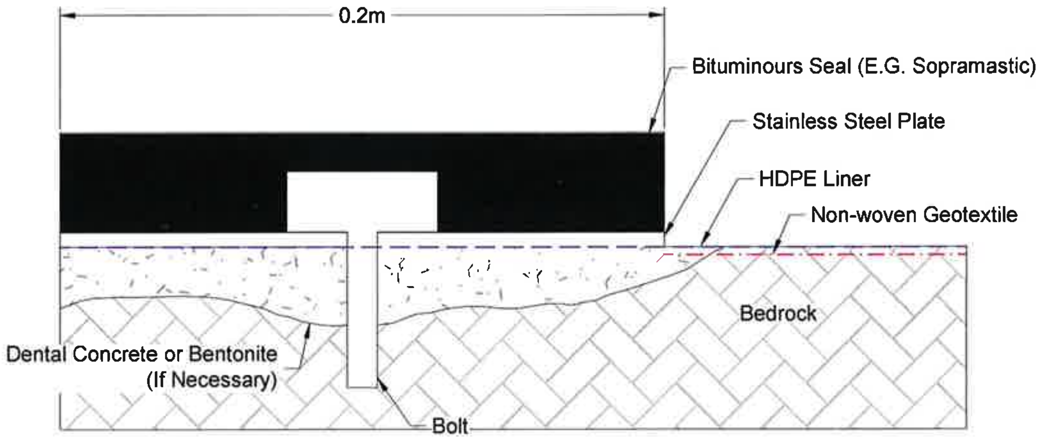
LEGEND

– – –	HDPE Liner	▨	HDPE Liner
–·–	Non-woven Geotextile	▭	Run of Quarry (ROQ) or Run of Mine (ROM) Material
▭	Bedding Material	▨	Bedrock
▭	Concrete	■	Bituminous Seal

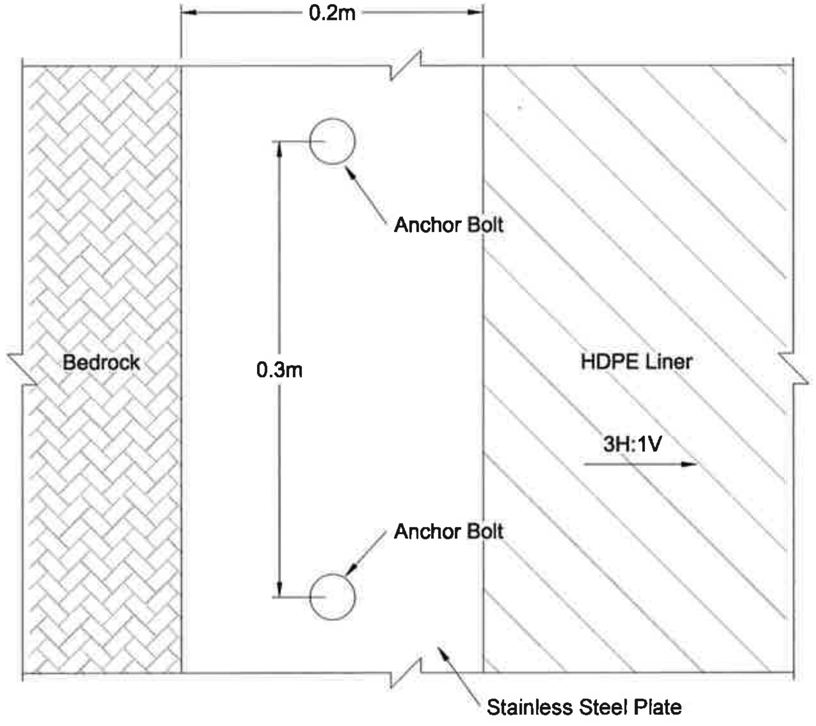
NOTES

1. All dimensions shown in meters unless otherwise stated.
2. Bedrock conditions and contact point for the liner will be inspected in the field by the engineer. The engineer will make a final decision for the required adhesion method.
3. Typical details shown may vary and additional details will be provided if required.
4. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).
5. In cold (~<0°c) ambient air temperature periods, the area where concrete is placed or poured, may be required to be heated and horded, or a polymer added to the mix. This would be done to ensure the concrete cures appropriately and maintains its strength and integrity (i.e. does not excessively crack).



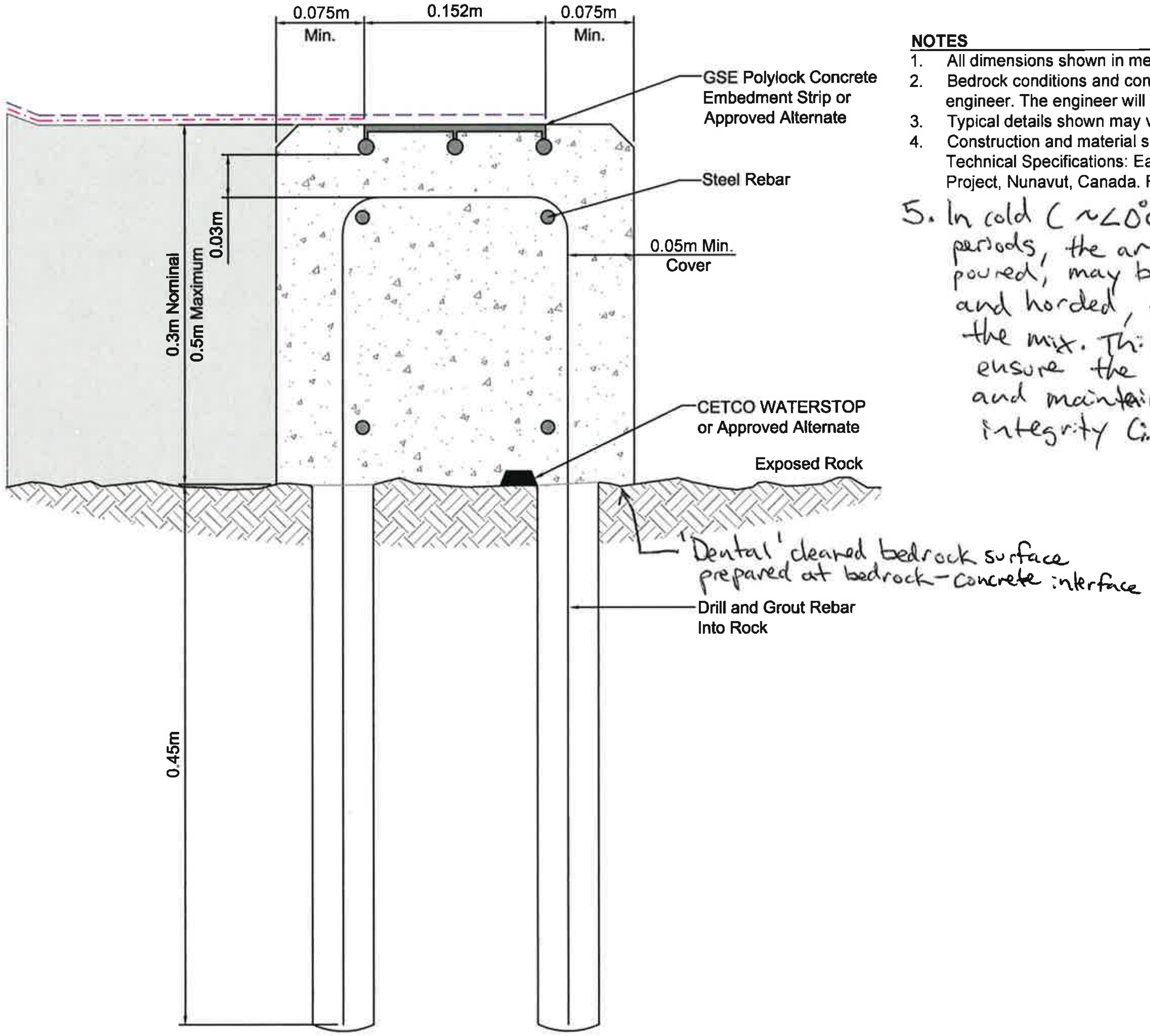
4/06 **Liner Anchored to Bedrock - Side View Typical Detail**

NOT TO SCALE



4/06 **Liner Anchored to Bedrock - Plan View Typical Detail**

NOT TO SCALE



5/06 **Liner Anchored to Concrete Plinth - Typical Detail**

0m 50 100 150 200

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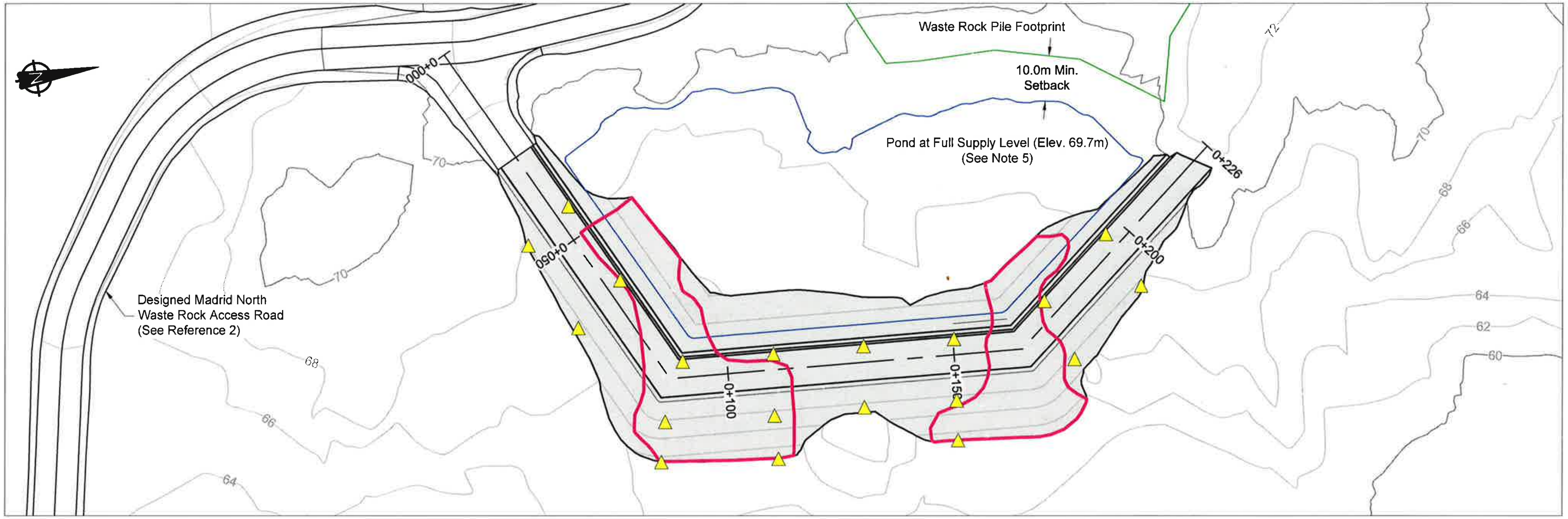
SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond

DRAWING TITLE:

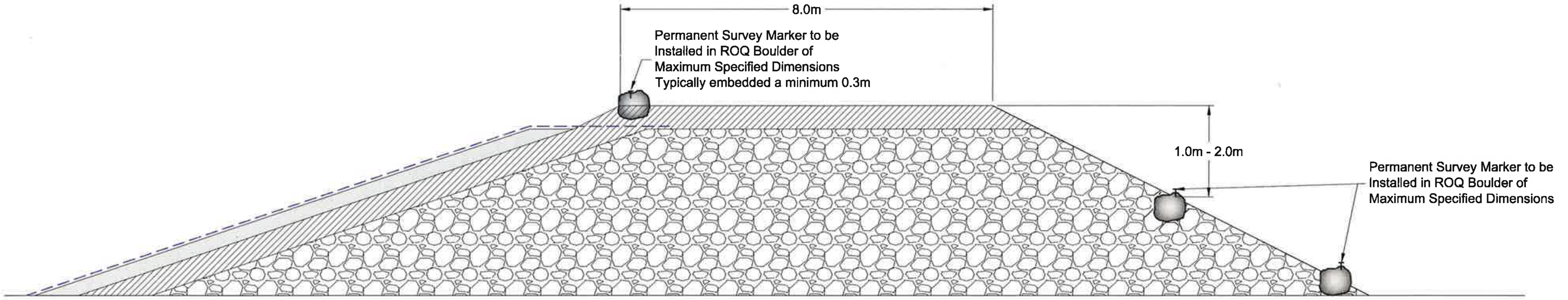
Liner Tie-in Typical Details

DRAWING NO.	SHEET	REVISION NO.
MN-CWP-07	7 OF 7	0



Contact Water Pond Berm Instrumentation Plan

0m 10 20 30 40



Surficial Survey Point Installation

0m 1 2 3 4

LEGEND

△	Surficial Survey Monitoring Point
– –	Liner System
🟥	Anticipated Overburden
☐	Contact Water Pond
☐	Contact Water Pond Berm
🟩	Waste Rock Pile Footprint
▭	Bedding Material
▨	Transition Material
▭	Run of Quarry (ROQ) or Run of Mine (ROM) Material

NOTES

1. Contours shown at 2.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.

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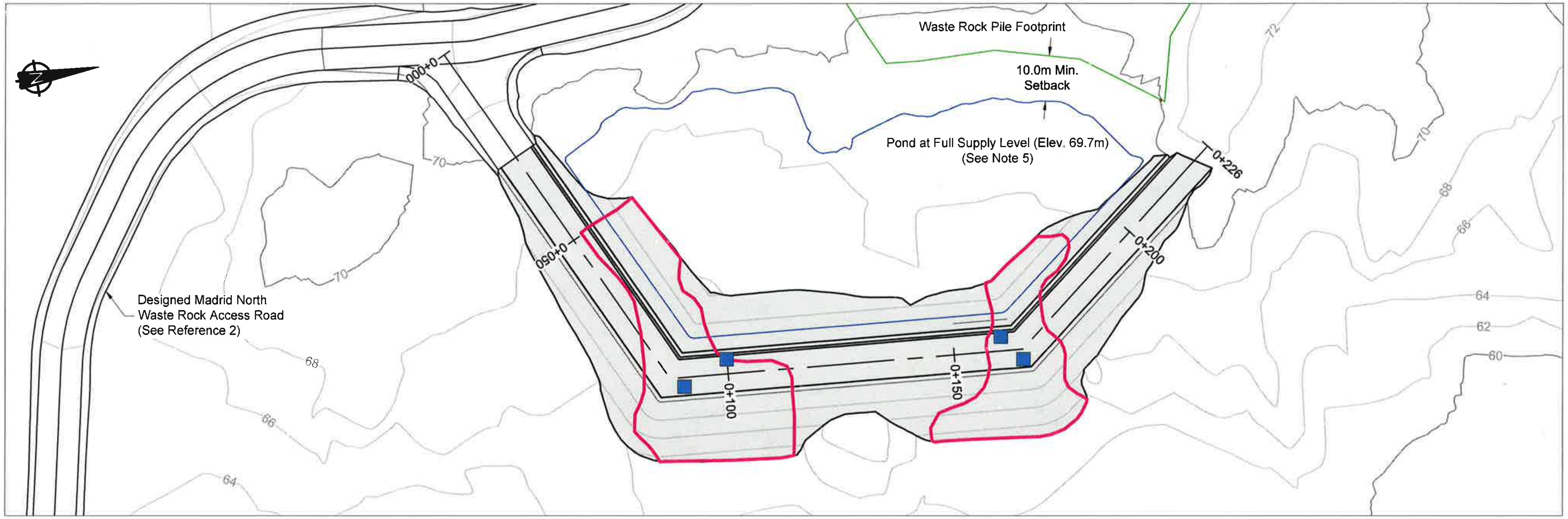
Madrid North Contact Water Pond

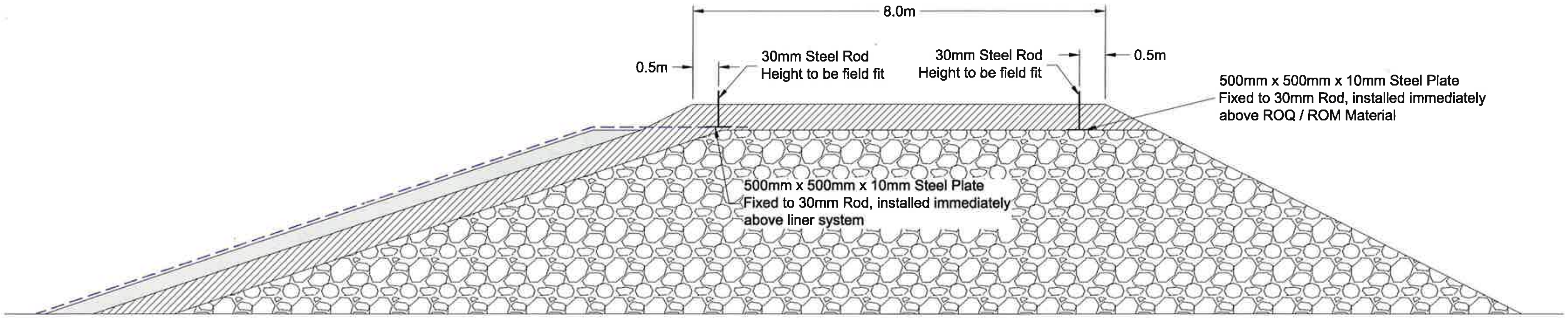
DRAWING TITLE:
Contact Water Pond
Instrumentation Plan - 1 of 2

DRAWING NO. MN-CWP-08
SHEET 8 OF 9
REVISION NO. A



Contact Water Pond Berm Instrumentation Plan

0m 10 20 30 40



Settlement Monitoring Plate Installation

0m 1 2 3 4

LEGEND

■	Settlement Monitoring Plate
– – –	Liner System
🟥	Anticipated Overburden
🟦	Contact Water Pond
☐	Contact Water Pond Berm
🟩	Waste Rock Pile Footprint
▭	Bedding Material
▨	Transition Material
▭	Run of Quarry (ROQ) or Run of Mine (ROM) Material

NOTES

1. Contours shown at 2.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. Construction and material specifications shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction. SRK (2018).

REFERENCES

1. NAD83 UTM Zone 13.
2. Engineering Drawings for the Madrid South All-Weather Road, Hope ay Project, Nunavut, Canada. Issued for Discussion. Revision A. Project No. 1CT022.043. March 2019.
3. Geochemical Characterization of Quarry Materials for the Doris-Windy All-Weather Road, Hope Bay Project. Report prepared for Hope Bay Mining Ltd., 1CH008.000. August 2008.

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SRK JOB NO.: 1CT022.043

Madrid North Contact Water Pond
DRAWING TITLE:
Contact Water Pond
Instrumentation Plan - 2 of 2
DRAWING NO.: MN-CWP-09
SHEET: 9 OF 9
REVISION NO.: A

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Appendix D – CWP Berm Stability Analysis

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Memo

To:	File	**Client:**	TMAC Resources Inc.
From:	Raul Norambuena	**Project No:**	1CT022.043
Reviewed:	Ryan Williams, PEng John Kurylo, PEng	**Date:**	November, 2019
Subject:	Hope Bay Project – Slope Stability Verification of the As-built CWP Berm at Madrid North		

1 Introduction

1.1 General

As part of the development at Madrid, a contact water pond (CWP) is required at the Madrid North site to intercept and manage contact water runoff from the Madrid North waste rock pile (WRP). The design of the CWP incorporates a run-of-quarry (ROQ) berm with a geomembrane liner on the upstream face to contain contact water. The CWP liner is anchored and sealed to bedrock at the toe of the berm's upstream slope. The berm was founded on exposed bedrock and areas of frozen overburden soil. Permafrost present within the berm foundation will be maintained due to the thermal protection of the berm fill. The CWP design is presented in SRK (2019).

The CWP berm was constructed between May and September 2019. The berm design considers an upstream slope of 3H:1V and a downstream slope of 2H:1V. After the specified height of the berm was reached, the downstream slopes were found to be steeper than the design. The as-built downstream slopes varied between 1.7H:1V to 1.9H:1V, with some sections as steep as 1.65H:1V (see Figure 1).

SRK instructed TMAC to place additional fill or regrade the slopes to achieve the design slope of 2H:1V. Instead, TMAC requested SRK to complete a stability analysis to determine if the steeper than design slopes were stable and met minimum required factors of safety.

1.2 Objectives

SRK completed a stability analysis to assess the risk of geotechnical instability of the CWP berm in its as-built condition. The objectives of the analysis are to assess if best practice design criteria in terms of factors of safety are met for the final (as-built) condition of the CWP berm. This memo presents the methods, assumptions and results for the stability analyses, as well as SRK's recommendations.

2 CWP Design Overview

2.1 Design Criteria Summary

The general design criteria of the CWP are listed below:

- Berm constructed from geochemically suitable run-of-quarry (ROQ) rock or run-of-mine (ROM) waste rock;
- Upstream side slopes of 3H:1V (18.4°) and downstream side slopes of 2H:1V (26.5°);
- Maximum residence time for ponded water is two weeks (i.e., the pond will be normally kept in a dry state);
- 20-year design life;
- The berm crest will be used as a light vehicle access road, with minimum crest width of 8 m;
- 0.3 m thick layer of bedding material underneath the HDPE liner; and

0.5 m thick layer of transition material between the bedding layer and bulk ROQ/ROM fill.

2.2 Geotechnical Design

A stability and thermal analysis were completed previously in an earlier revision of a pond design for both Madrid and Boston. The analysis and results are presented in a separate memo (SRK 2017a).

The previous stability analysis found that the CWP berm design is stable and meets minimum factor of safety (FoS) criteria as per CDA (2014) under both long-term static and pseudo-static loading conditions. Both the upstream and downstream slopes of the previous design were 2H:1V and the analysis only considered overburden (thawed and frozen) for the foundation conditions. The design of the Madrid North CWP incorporates a flatter upstream slope (3H:1V) and will be founded on a combination of bedrock and frozen overburden.

2.3 Thermal and Hydrotechnical Design

The design considered a minimum bulk fill thickness of 4.0 m for thermal protection of the overburden, limiting the thawing potential in the foundation. The impermeabilization system design consists of a single HDPE geomembrane (textured) underlain by a heavy duty non-woven geotextile (12 oz/yd^2) anchored to the top of the slope and into the upstream slope. The CWP has been designed to contain a 1:100-year, 24-hour storm event, together with the maximum daily snowmelt.

The specific aspects of the thermal design are included in the previous CWP design memorandum (SRK 2017a) and the site specific hydrotechnical design are included in the Madrid Water Management Engineering Report (SRK 2017b).

3 Stability Analysis

3.1 As-built Model

Three scenarios were considered for a representative cross-section to assess the stability of the as-built configuration of the CWP berm. The scenarios consider different conditions of the overburden soils in the berm foundation. Scenario 1 assumes that overburden will remain fully frozen, Scenario 2 assumes thawing of the 1-m thick active layer, and Scenario 3 assumes the complete thawing of the overburden. The cross-sections representing each scenario are shown in Figure 2 in the attachments.

In addition to the foundation conditions, four different downstream slopes were assessed considering the variability measured after construction of the downstream slopes (as-built). The slopes (H:V) considered in the analyses are 2.0:1.0 (26.5°), 1.7:1.0 (30.5°), and 1.65:1.0 (31.2°). A sensitivity case was considered with slopes at 1.5:1.0 (33.7°).

The model includes the pond surcharge over the liner at the upstream face of the berm. The water table was assumed constant (steady state) at the foundation level, relying on the performance of the geosynthetic liner, the high hydraulic conductivity of the ROQ material, and the short residence time of the pond. The thickness of overburden in the foundation was assumed to be a maximum of 4 m based on observations during construction activities.

3.2 Method of Analysis

The two-dimensional (2D) stability analyses on the representative cross-sections were assessed using the slope stability software Slide 2018 (Rocscience, 2018). The limit equilibrium analysis used the Morgenstern-Price and Spencer method of slices. The slip surface search method used was the Cuckoo Search, and the Block Search for the thawed overburden scenario to confirm the minimum factor of safety between different mechanisms of failure.

3.3 Factor of Safety Criteria

Design factors of safety (FoS) are generally defined through various industry best practice standards and guidelines. For dams, the Canadian Dam Association (CDA) Guidelines (CDA 2014) are considered best practice. Table 1 summarizes the recommended minimum design FoS in accordance with the CDA (2014). These values were part of the design criteria assumed for the previous stability analyses of the CWP berm (SRK 2017a) and still apply for this analysis.

Table 1: Minimum Factors of Safety Used for Slope Stability Analysis (CDA 2014)

Loading Condition	Minimum Factor of Safety	Slope
During or at end of construction	>1.3 depending on risk assessment during construction	Typically downstream
Long term (steady state seepage, normal reservoir level)	1.5	Downstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream slope where applicable
Pseudo-static	1.0	Downstream

Post-earthquake	1.2	Downstream

For this analysis, the most conservative design values were used; i.e., 1.5 for long-term static stability, and of 1.0 for pseudo-static stability.

3.4 Seismic Design Parameters

The CDA (2014) provides recommended minimum seismic design criteria based on the hazard classification assigned to the structure. Assuming a hazard classification for the CWP of Low, the CDA (2014) specifies the design earthquake with an annual exceedance probability (AEP) of 1/100 for the construction and operations stage. For long-term scenarios, i.e., post-closure, the design seismic event must be increased to 1/1,000-year event. The stability analysis was conservatively undertaken using an earthquake with an AEP of 1/2,475.

Based on previous assessments (SRK 2016), the horizontal pseudo-static coefficient resulting from a 1/2,475-year return period earthquake was determined to be 0.018, on firm ground. The CWP berm will experience amplification based on the foundation soil (Type E) and its geometry (NBCC, 2015), resulting in a pseudo-static coefficient of 0.025.

3.5 Material Properties

The geotechnical material parameters selected for the stability analyses are summarized in Table 2. Material properties for the analyses were based on the site wide geotechnical design properties (SRK 2017c) as well as SRK's engineering judgment.

Table 2: Material Properties

Material	Unit weight, γ [kN/m³]	Cohesion, c' [kPa]	Angle of Shear Resistance, φ' [º]
ROQ (Thawed)	20	Indraratna et al (1993) – lower-strength bound	
Overburden Marine Clay (Frozen)	17	100	26
Overburden Marine Clay (Thawed)	17	6	26
Bedrock	24	Infinite Strength (Impenetrable)	
Pond (Water)	10	No Strength	

3.5.1 ROQ Material

Indraratna et al (1993), following the work of Leps (1970) and other authors, compiles and describes the results of large scale triaxial tests performed in rockfill materials. The tests are performed under low to high confining stresses (0.04 to 3.5 MPa) in order to relate the findings to the stability of rockfill dams. The shear strength of rockfill is studied in detail, defining lower and upper bounds envelopes of strength. Figure 3 in the attachments presents the rockfill resistance bounds from high-strength to lower-strength (Indraratna et al, 1993 modified from Leps, 1970).

Figure 4 and 5 in the attachments contain photographs from the construction showing qualitatively the characteristics of the ROQ material used for berm fill. The strength of the ROQ has been conservatively assumed to be the lower-strength bound presented in Figure 3 (in red), despite the soundness and angularity shown in Figure 4 and 5. This assumption is considered reasonable given that no specific shear resistance testing was performed on the ROQ material, since it would be impractical to do so.

4 Results

The results of the stability analysis are summarized in Table 3 and Table 4. Complete details are presented in Attachment 1 and 2 for long-term and pseudo-static conditions, respectively. Values highlighted in red indicate they do not meet the minimum required values for factor of safety.

Table 3: Slope Stability Analysis Results – Long-Term Steady State (Target FoS 1.5)

Slope H:V	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Frozen OB	Thawed Act Layer	Thawed OB	Thawed OB*
2.00:1.0	1.9	1.7	1.6	1.6
1.70:1.0	1.6	1.6	1.5	1.5
1.65:1.0	1.6	1.6	1.5	1.5
1.50:1.0	1.4	1.4	1.4	1.4

(*) Block Search method to verify if different failure mechanism with lower FoS exists

Table 4: Slope Stability Analysis Results – Pseudo-Static (Target FoS 1.0)

Slope H:V	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Frozen OB	Thawed Act Layer	Thawed OB	Thawed OB*
2.00:1.0	1.8	1.6	1.5	1.5
1.70:1.0	1.6	1.5	1.4	1.4
1.65:1.0	1.5	1.5	1.4	1.4
1.50:1.0	1.4	1.4	1.4	1.3

(*) Block Search method to verify if different failure mechanism with lower FoS exists

The results shown in the tables above correspond to the most critical slip surfaces, which are associated with shallow (low depth) slip surfaces with no significant impact on the overall stability of the berm. Deeper slip surfaces (i.e. those that would impact the overall stability of the berm) would have higher FoS.

The results show that the CWP berm in its current configuration meets the stability FoS criteria of 1.5 for long-term conditions and 1.0 for pseudo-static stability.

5 Conclusions and Recommendations

The results of the stability analysis indicate the following:

1. The current most critical slope (average 1.65H:1V) is stable and meets FoS criteria even if the overburden foundation fully thaws.

2. If the overburden completely thaws, the FoS is close to 1.5. The risk of failure is very low, and only local slip surfaces could be expected, without any significant impact on the serviceability and performance of the CWP.

SRK recommends the following:

1. Install settlement monitoring pins in the downstream slope as per the CWP instrumentation plan to monitor slope performance. Pins should be surveyed every 2 weeks immediately prior to and during freshet (May and June) and every 4 weeks before winter (July to November). Note settlement monitoring is not required during winter months.
   a) Pins should be installed prior to winter 2019/2020 so that a first set of readings can be taken to establish a baseline for the 2020 freshet.
2. It is recommended a ground temperature cable be installed at the downstream toe of the CWP berm if settlement instruments indicate movements are occurring. This would allow the assumptions for the thermal models on the foundation (SRK 2017a) to be verified and to correlate ground temperature changes with measured displacements.
3. If at any time excessive movements are observed, a small rockfill buttress at the toe, or flattening of the slope to 2H:1V, will likely be required. Both options can be assessed to determine the optimal solution that meets FoS criteria and minimizes fill.

6 References

Canadian Dam Association (CDA). 2014. Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams. 2014.

Indraratna, B.; Wijewardena, L. S. S.; Balasubramaniam, A. S. (1993) Large-scale triaxial testing of grey waste rockfill. Géotechnique 1993 43:1, 37-51.

Leps, T.M. (1970) Review of the shearing strength of rockfill. J. of Soil Mech. and Found. Div., ASCE, Vol.96, No. SM4, Proc. Paper 7394, July 1970, 1159-1170.

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SRK Consulting (Canada) Inc., 2016. Hope Bay Project – Horizontal Seismic Parameters for Pseudo-Static Modelling. Memo Prepared for TMAC Resources Inc., 1CT022.004. November 2016.

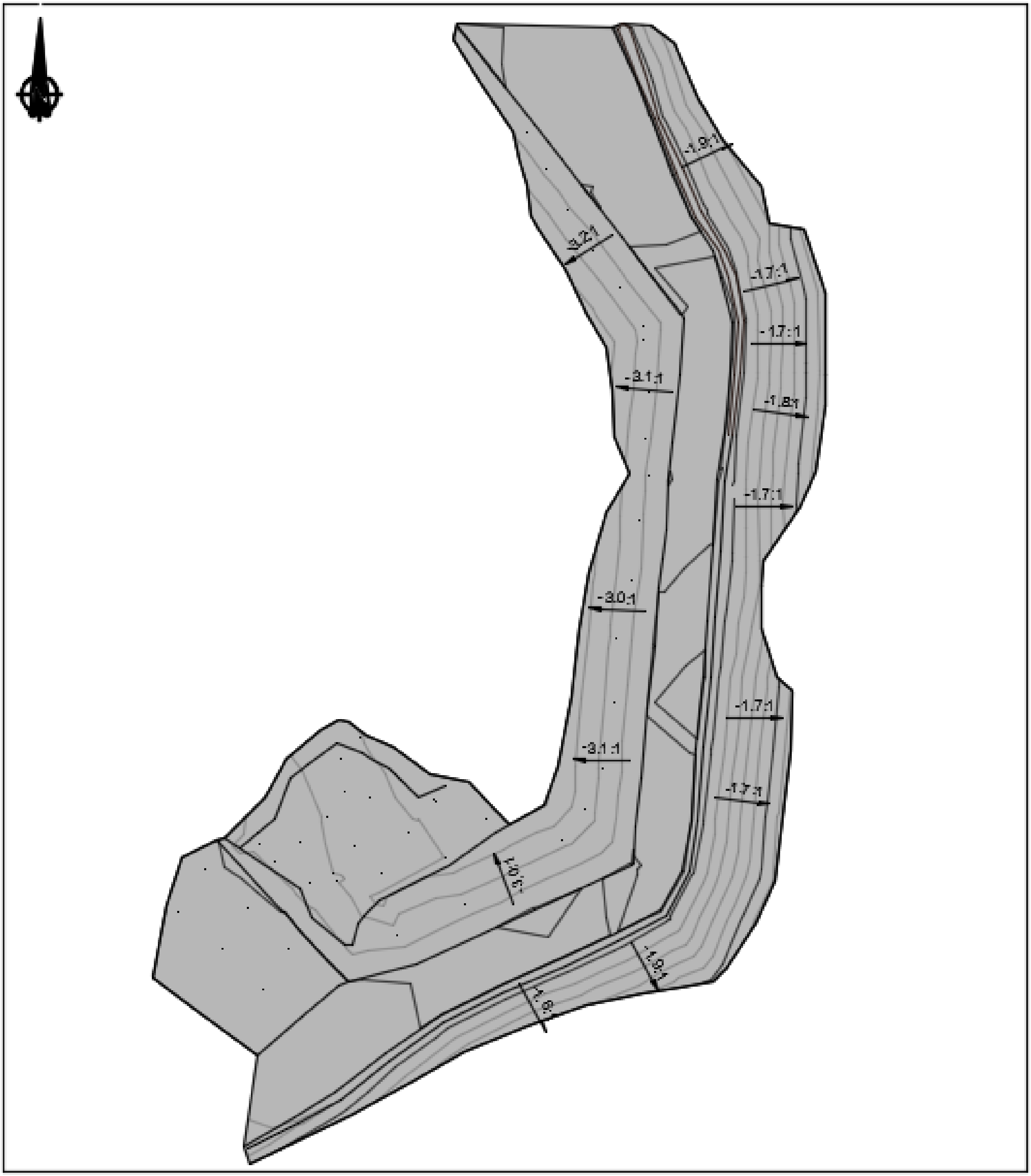
SRK Consulting (Canada) Inc., 2017a. Hope Bay Project – Contact Water Pond Design. Memo Prepared for TMAC Resources Inc., 1CT022.013. November 2017.

SRK Consulting (Canada) Inc., 2017b. Madrid Water Management Engineering Report, Hope Bay Project. Report Prepared for TMAC Resources Inc., 1CT022.013. November 2017.

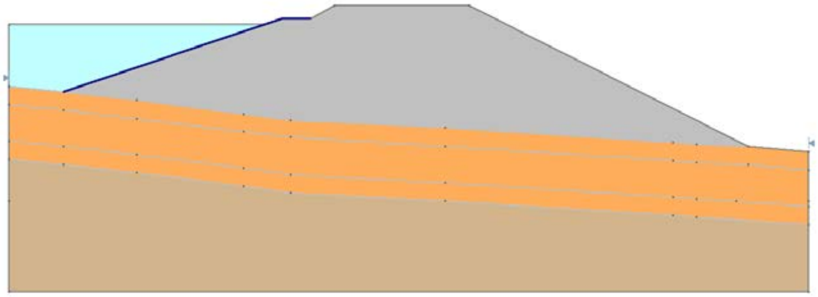
SRK Consulting (Canada) Inc., 2017c. Geotechnical Design Parameters and Overburden Summary Report, Hope Bay Project. Report Prepared for TMAC Resources Inc., 1CT022.013. November 2017.

SRK Consulting (Canada) Inc., 2019. Detailed Design of the Contact Water Pond Berm at Madrid North, Hope Bay Project. Report Prepared for TMAC Resources Inc., 1CT022.043. March 2019.

Figures

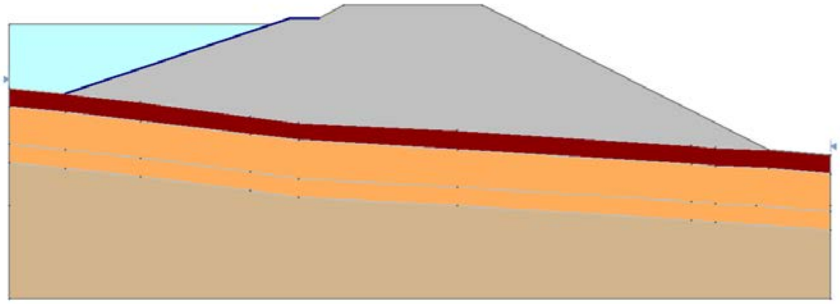


srk consulting	TMAC RESOURCES	Madrid CWP Berm – As Built Slope Stability **As built Plan View of CWP Berm**
Job No: 1CT022.43 Filename: CWP_Stability_Figures.pptx	Hope Bay Project	Date: November 2019 Approved: RW Figure: 1



Scenario 1

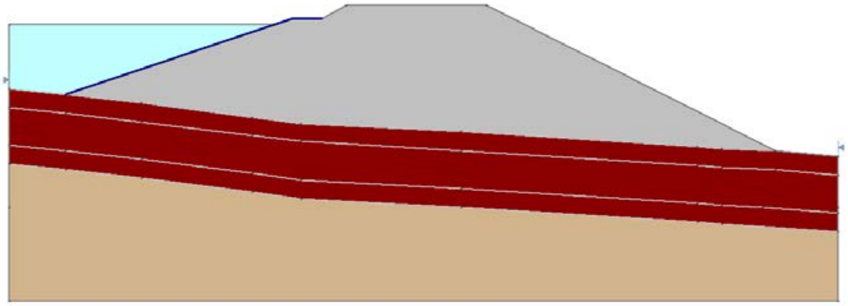
Frozen Overburden



Scenario 2

Thawed Overburden

Active Zone



Scenario 3

Overburden Fully

Thawed

srk consulting

TMAC RESOURCES

Madrid CWP Berm – As Built Slope Stability

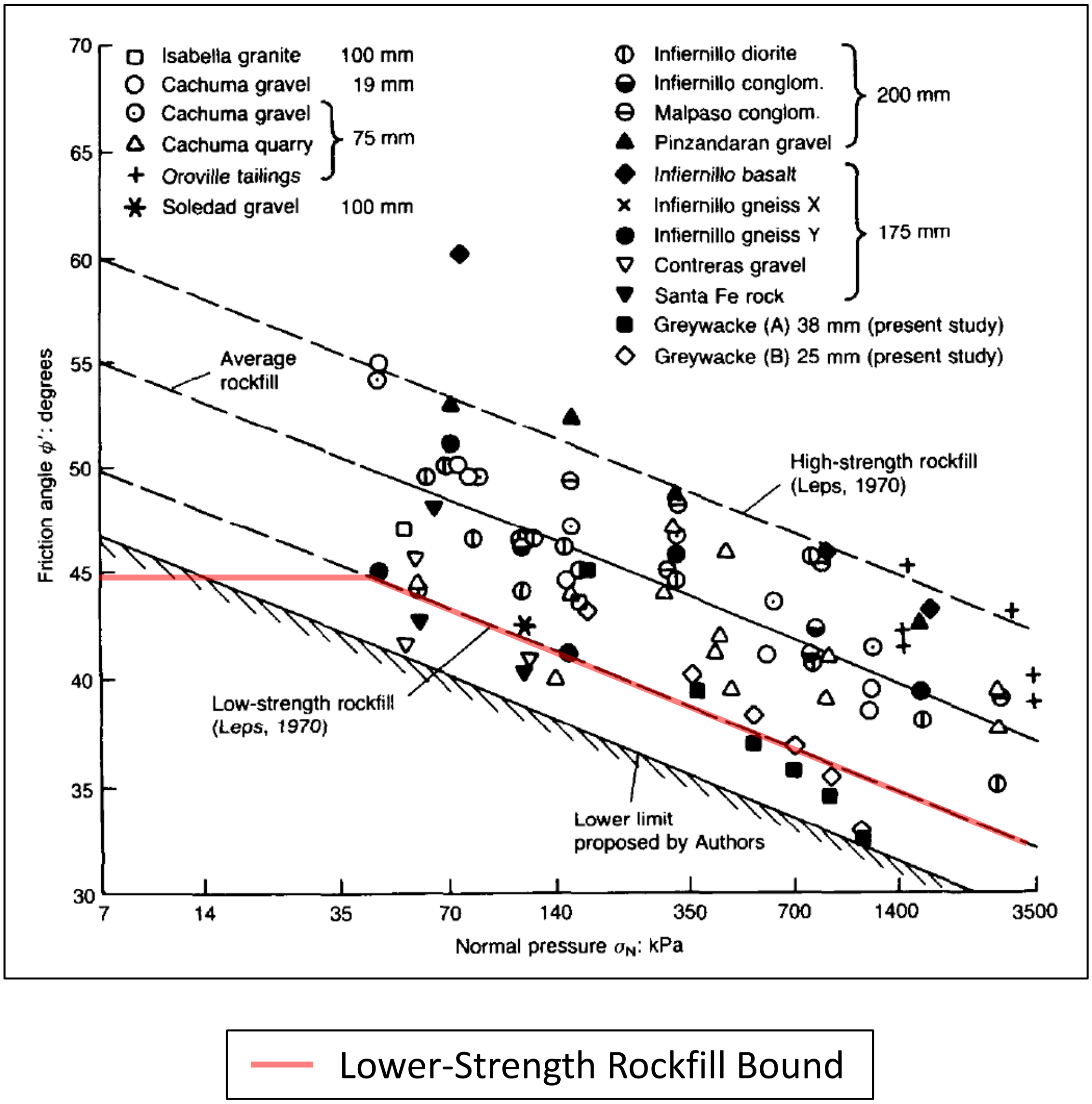
Model Cross Sections of the CWP Berm

Job No: 1CT022.43

Filename: CWP_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	2



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TMAC RESOURCES

Madrid CWP Berm – As Built Slope Stability

Rockfill Shear Resistance Parameters

Indraratna et al (1993)

Job No: 1CT022.43

Filename: CWP_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 3

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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

ROQ Placement June 2019

Job No: 1CT022.43 Filename: CWP_Stability_Figures.pptx	Hope Bay Project	Date: November 2019	Approved: RW	Figure: 4

srk consulting

TMAC RESOURCES

Madrid CWP – As Built Slope Stability

Slope Regrading July 2019

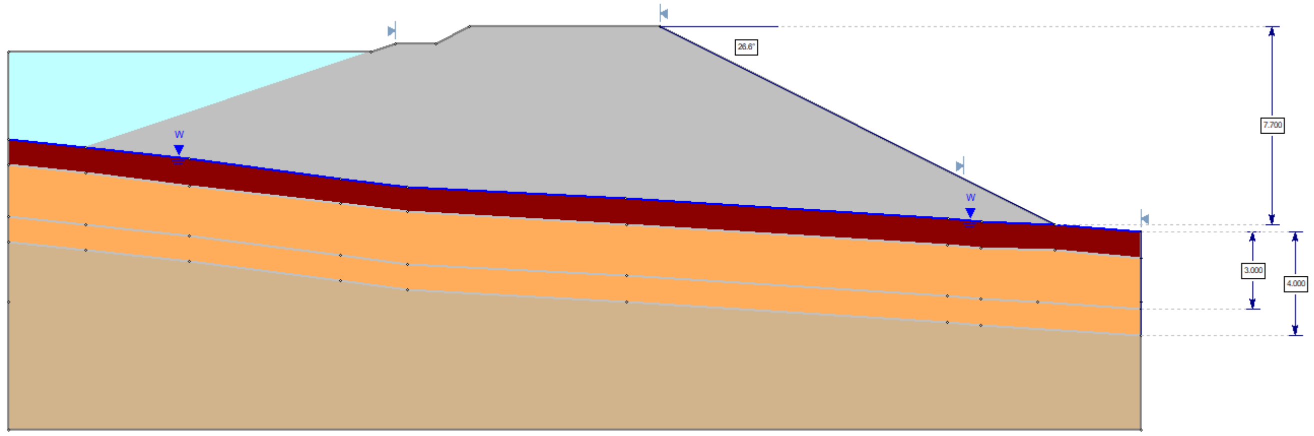
Job No: 1CT022.43
Filename: CWP_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	5

Attachment 1: Long-Term Stability Results

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Shear Normal Function	Allow Sliding	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26			Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function			Lower Bound		Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength				No	Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26			Water Surface	Custom	0
Pond	🟦	10	No strength					Water Surface	Custom	0



srk consulting

TMAC RESOURCES

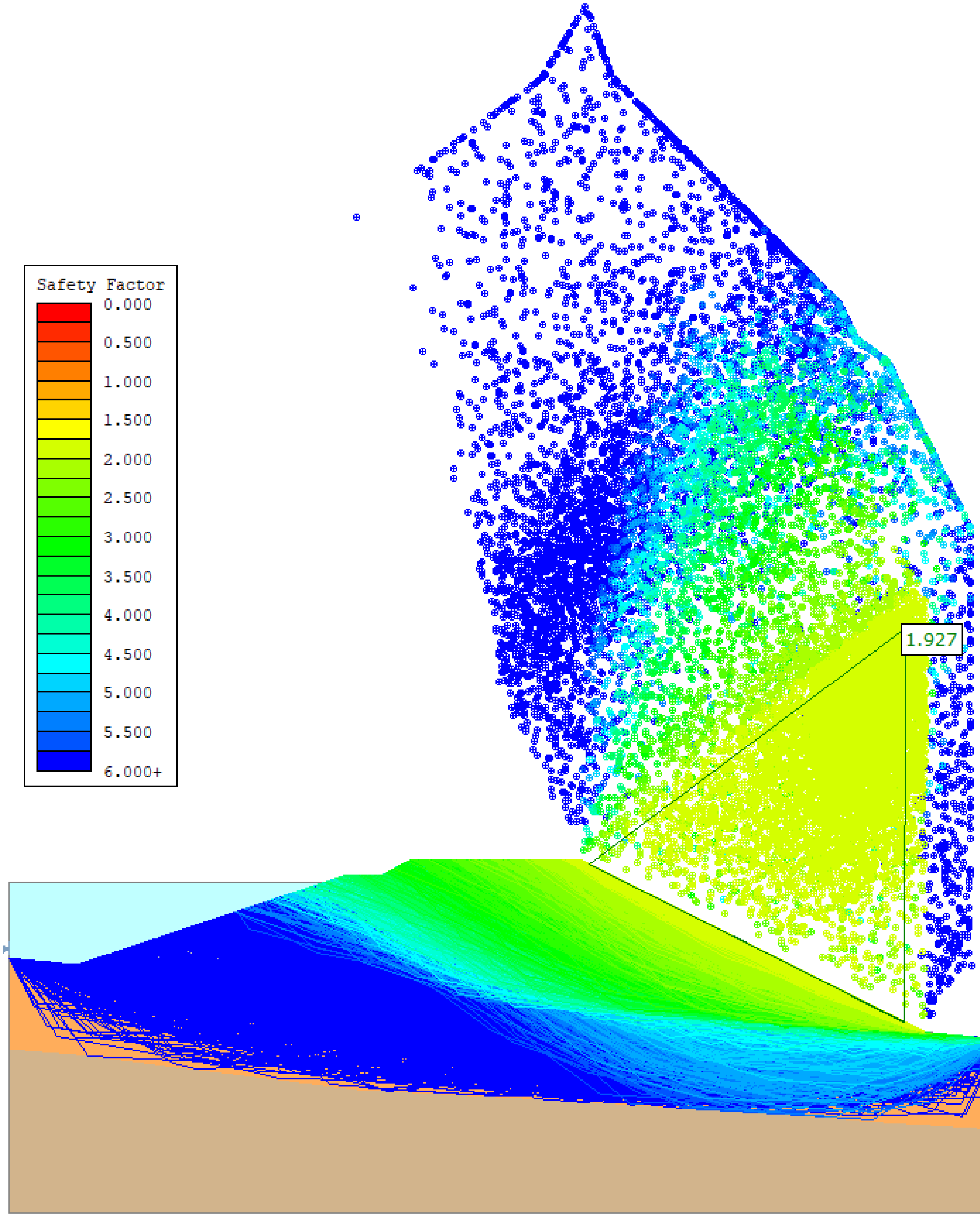
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) - Geometry

Job No:	1CT022.43
Filename:	LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	1



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TMAC RESOURCES

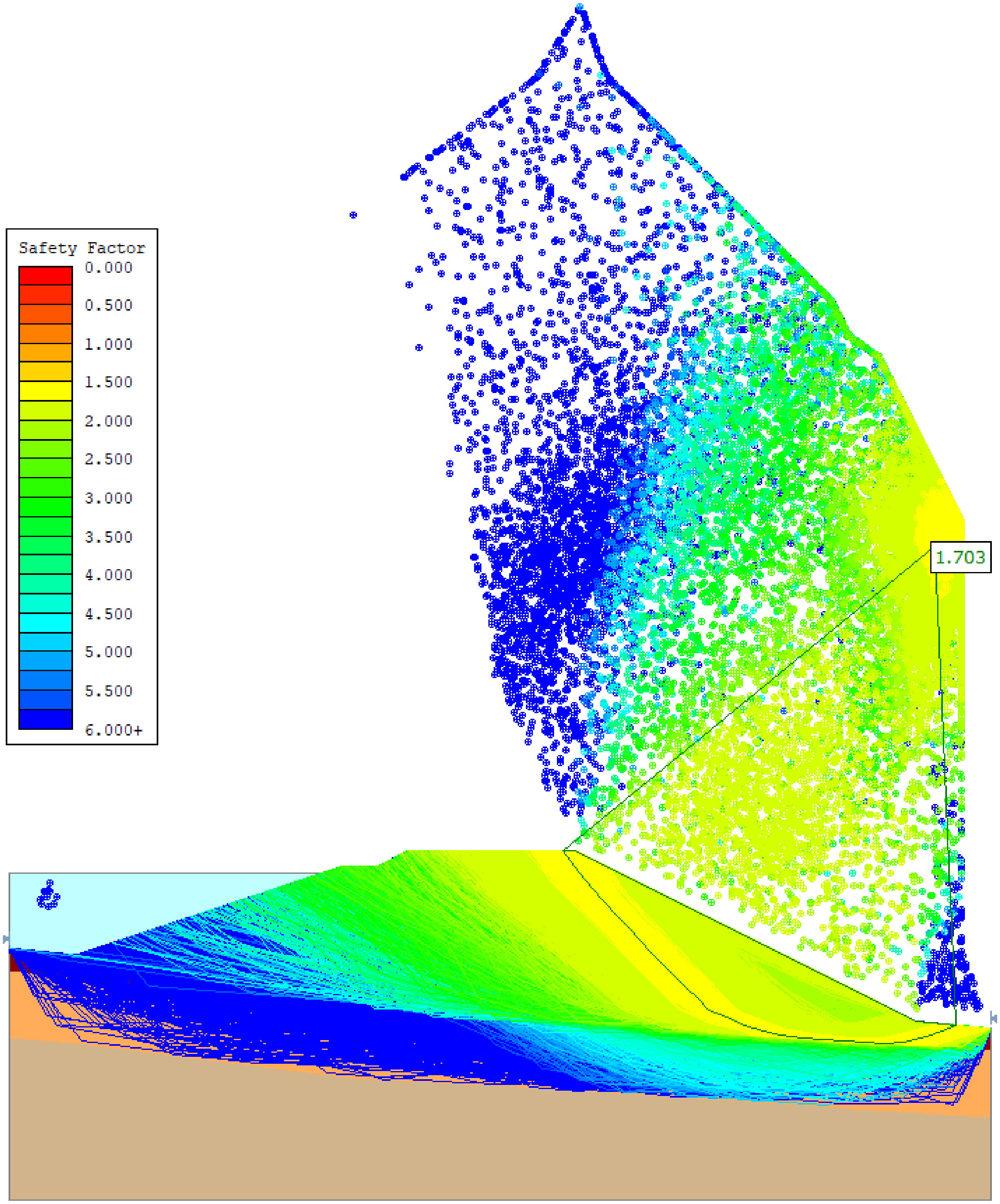
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) – Frozen OB

Job No:	1CT022.43
Filename:	LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	2



srk consulting

MAC RESOURCES

Madrid CWP – As Built Slope Stability

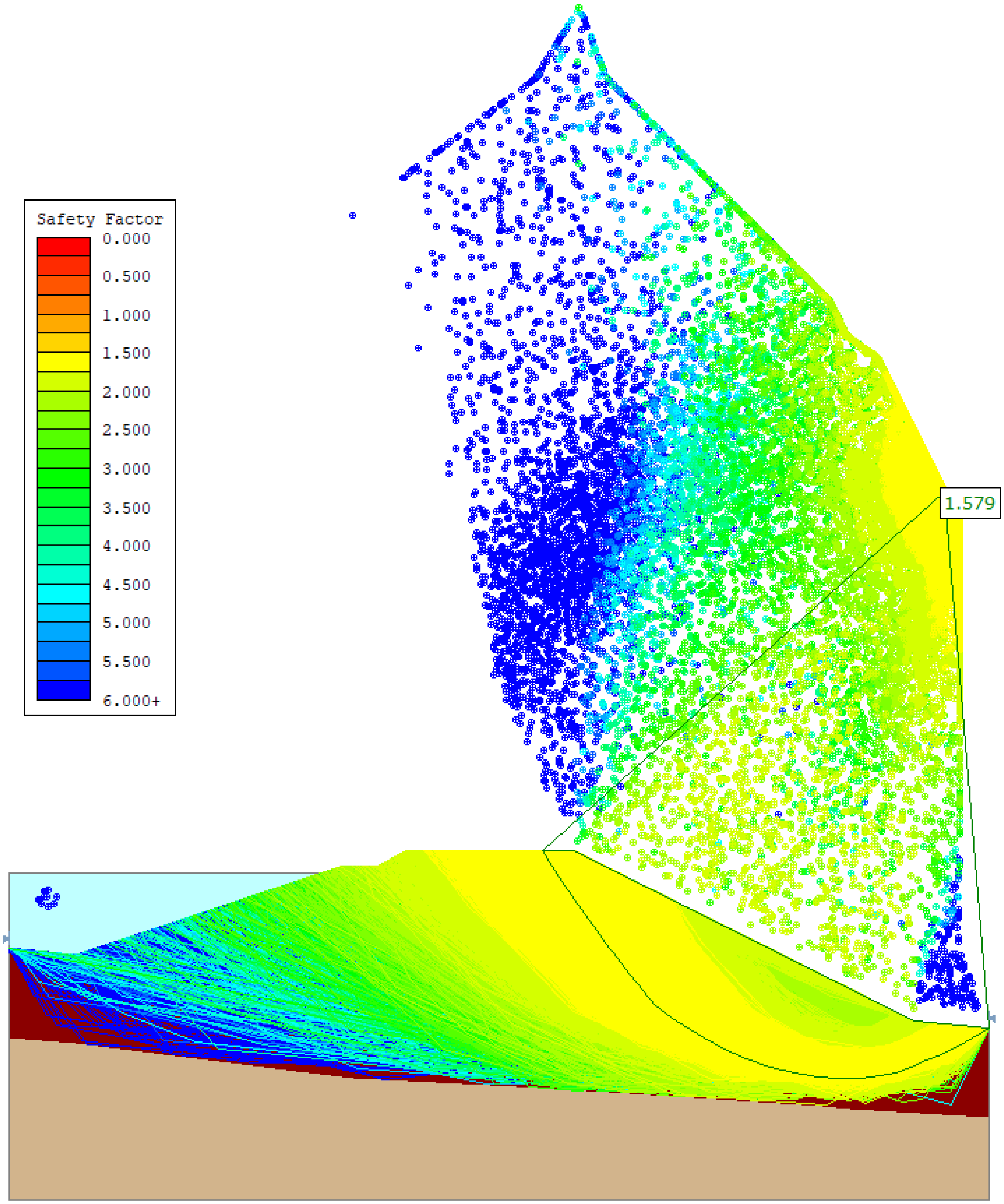
2.0:1.0 (H:V) – Thawed Active Layer

Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	3



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TMAC RESOURCES

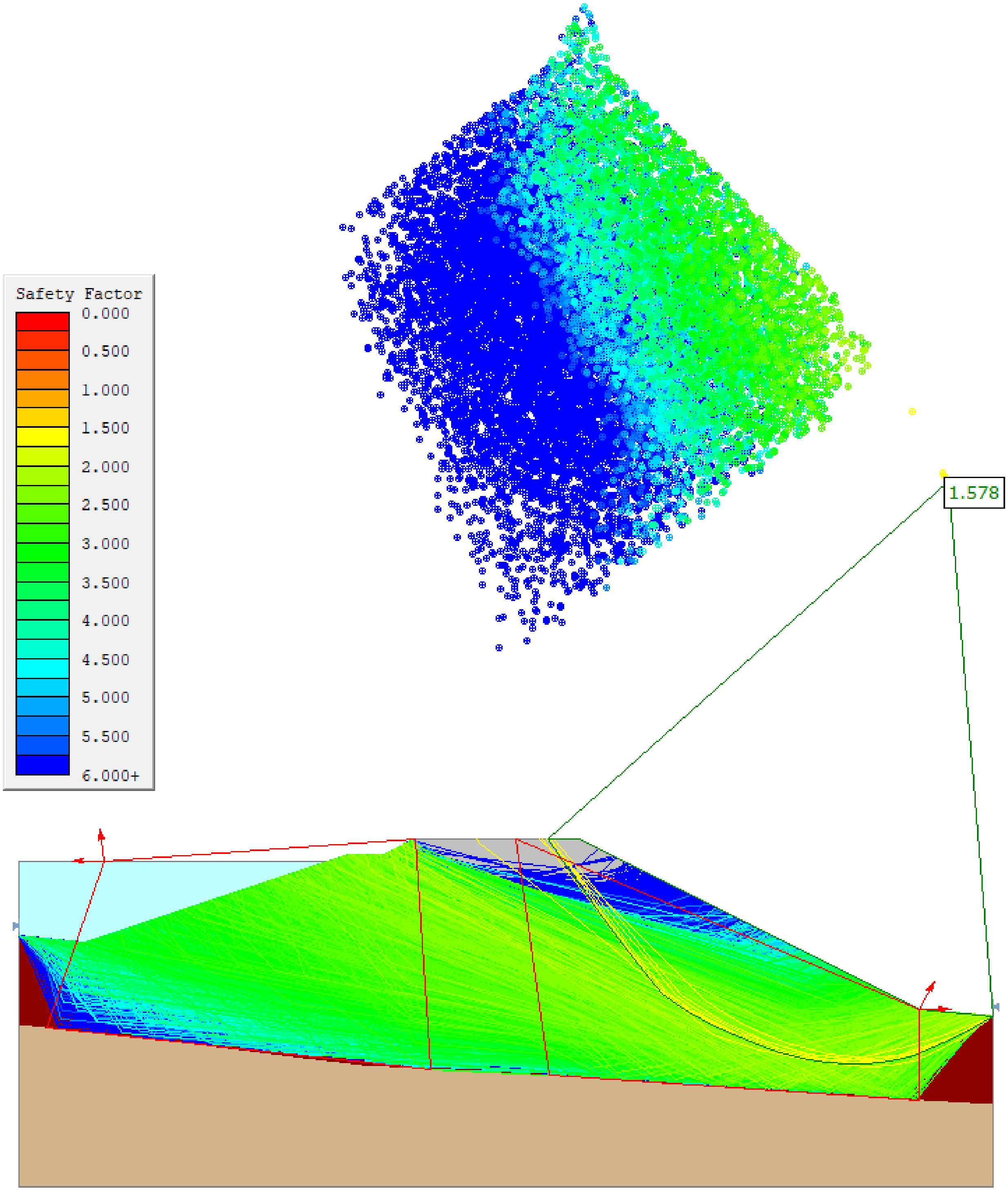
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) – Thawed OB

Job No:	1CT022.43
Filename:	LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	4



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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) – Thawed OB (Block Search)

Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

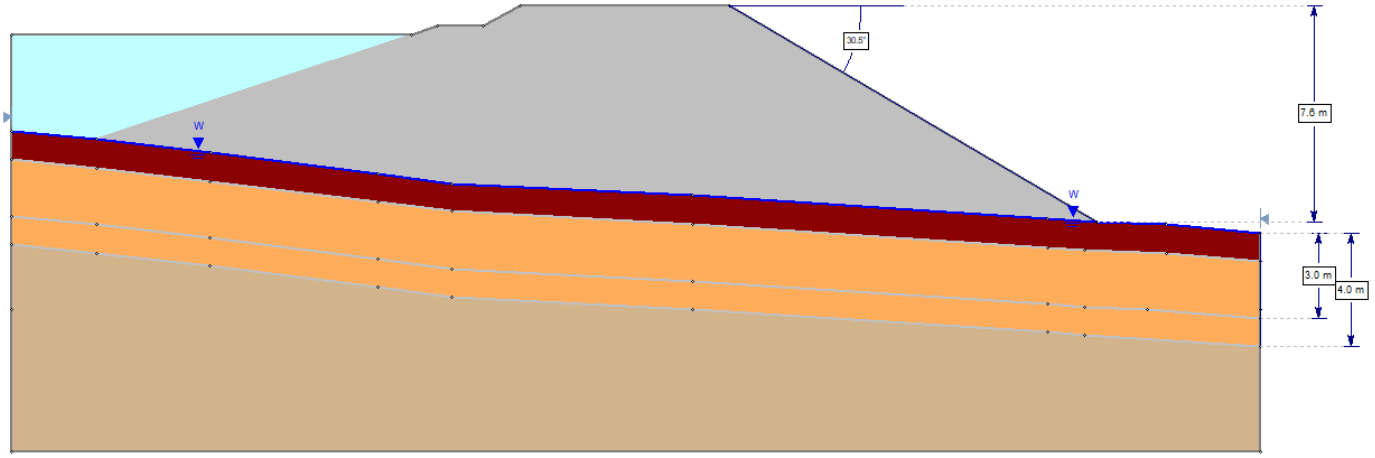
Hope Bay Project

Date: November 2019

Approved: RW

Figure: 5

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26	Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function			Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength			Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26	Water Surface	Custom	0
Pond	🟦	10	No strength			Water Surface	Custom	0



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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) - Geometry

Job No: 1CT022.43

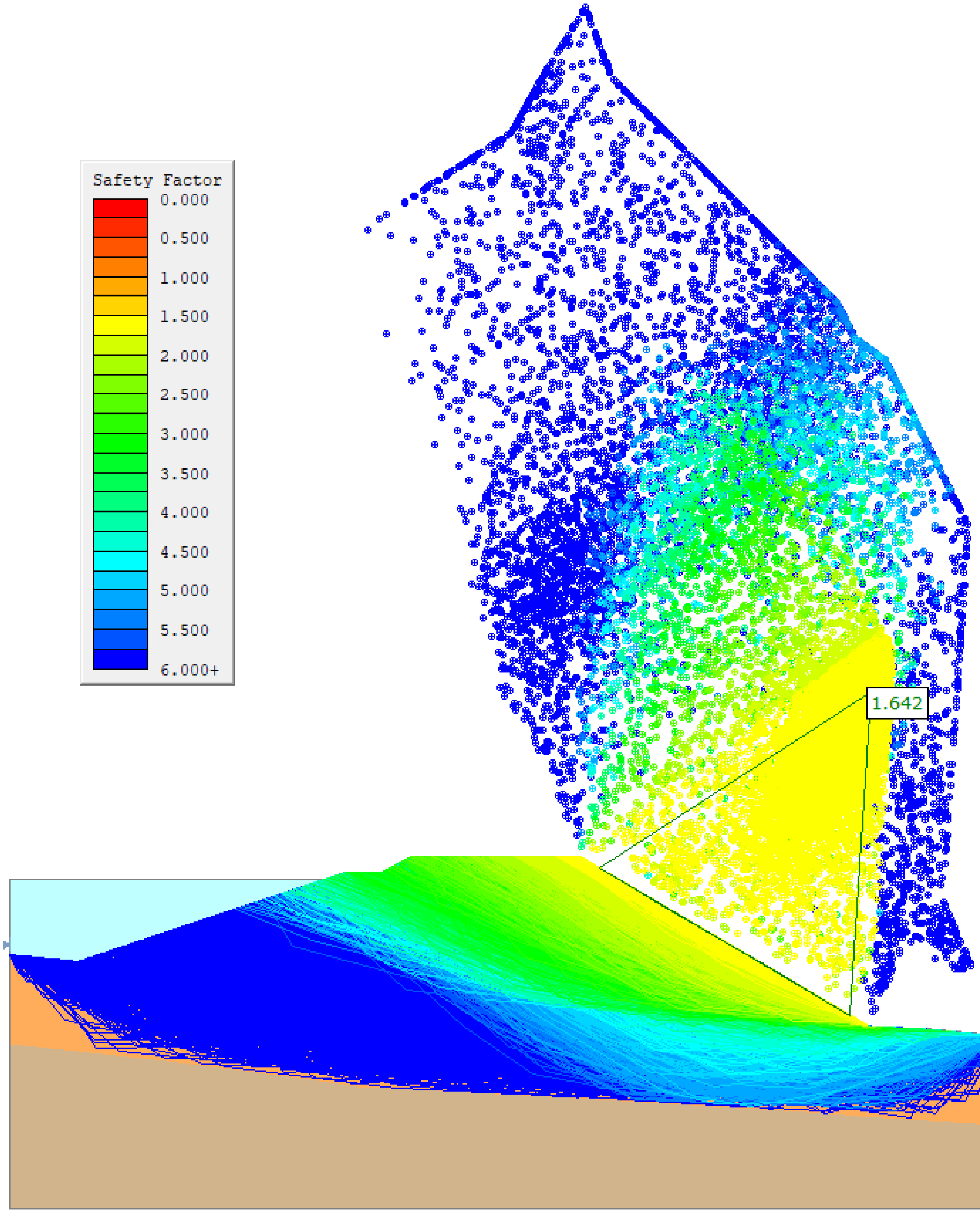
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: **6**



Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) – Frozen OB

Job No: 1CT022.43

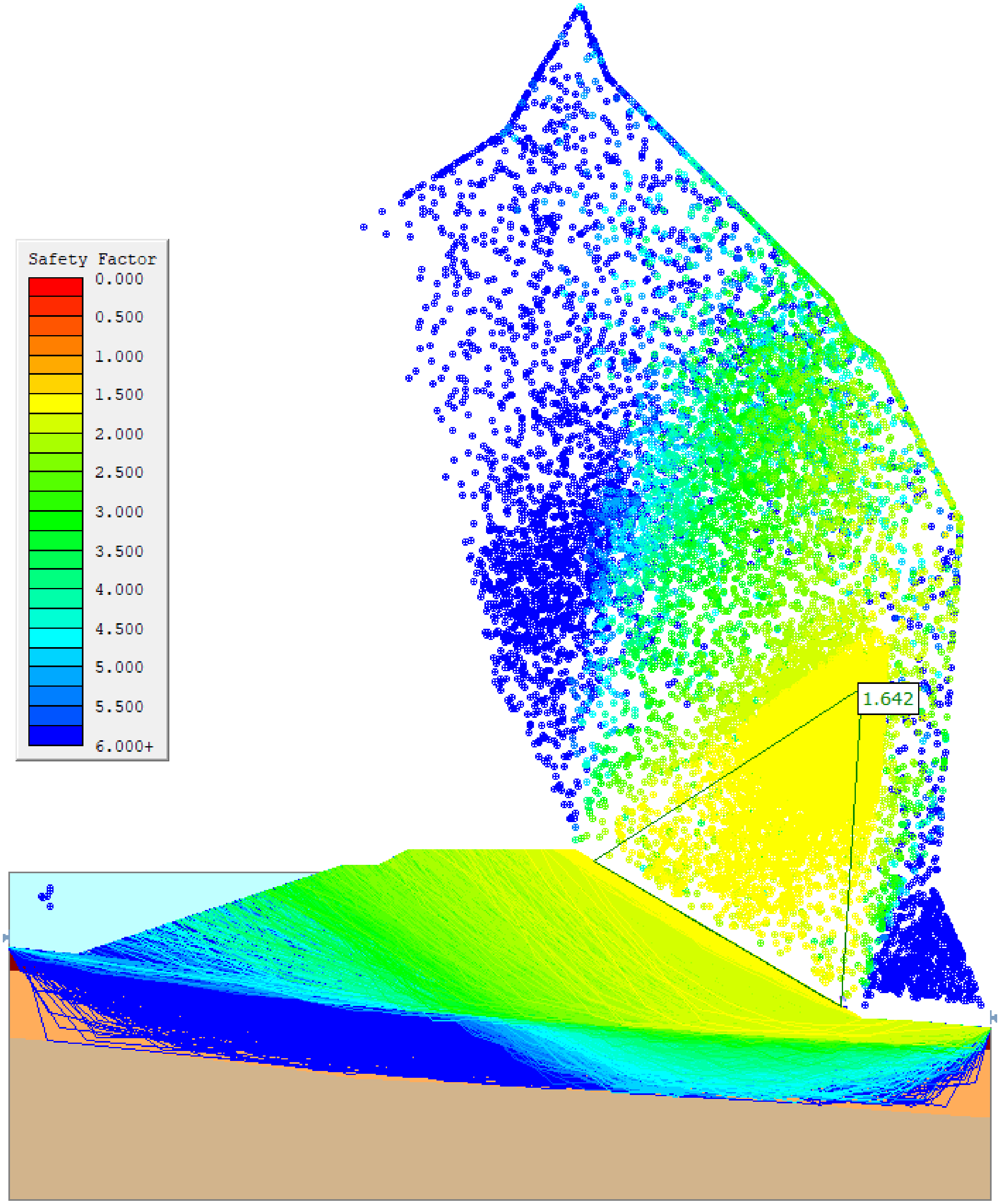
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

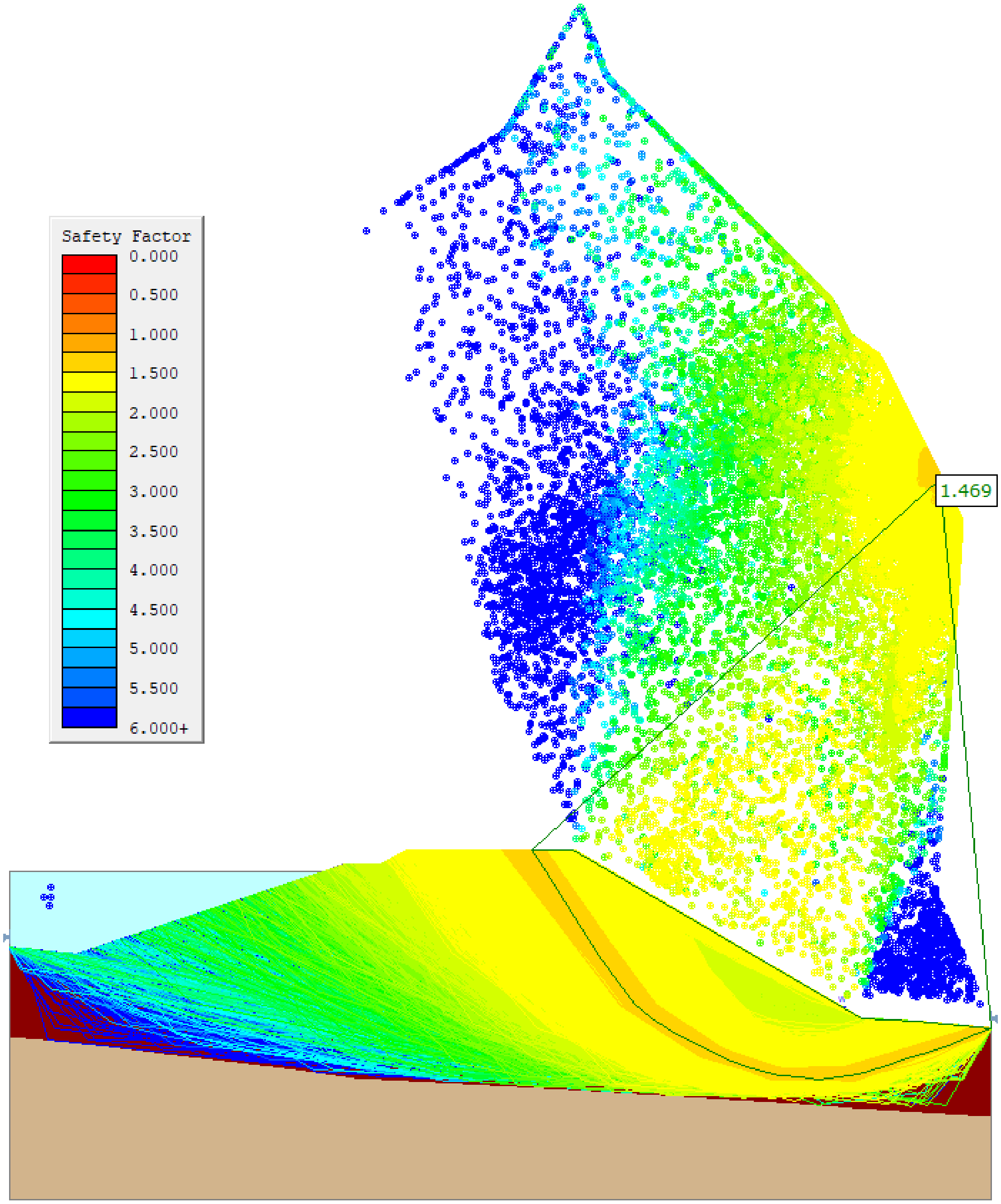
Date: November 2019

Approved: RW

Figure: 7



srk consulting	TMAC RESOURCES	Madrid CWP – As Built Slope Stability **1.7:1.0 (H:V) – Thawed Active Layer**
Job No: 1CT022.43 Filename: LongTerm_Stability_Figures.pptx	Hope Bay Project	Date: November 2019 Approved: RW Figure: **8**



Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) – Thawed OB

Job No: 1CT022.43

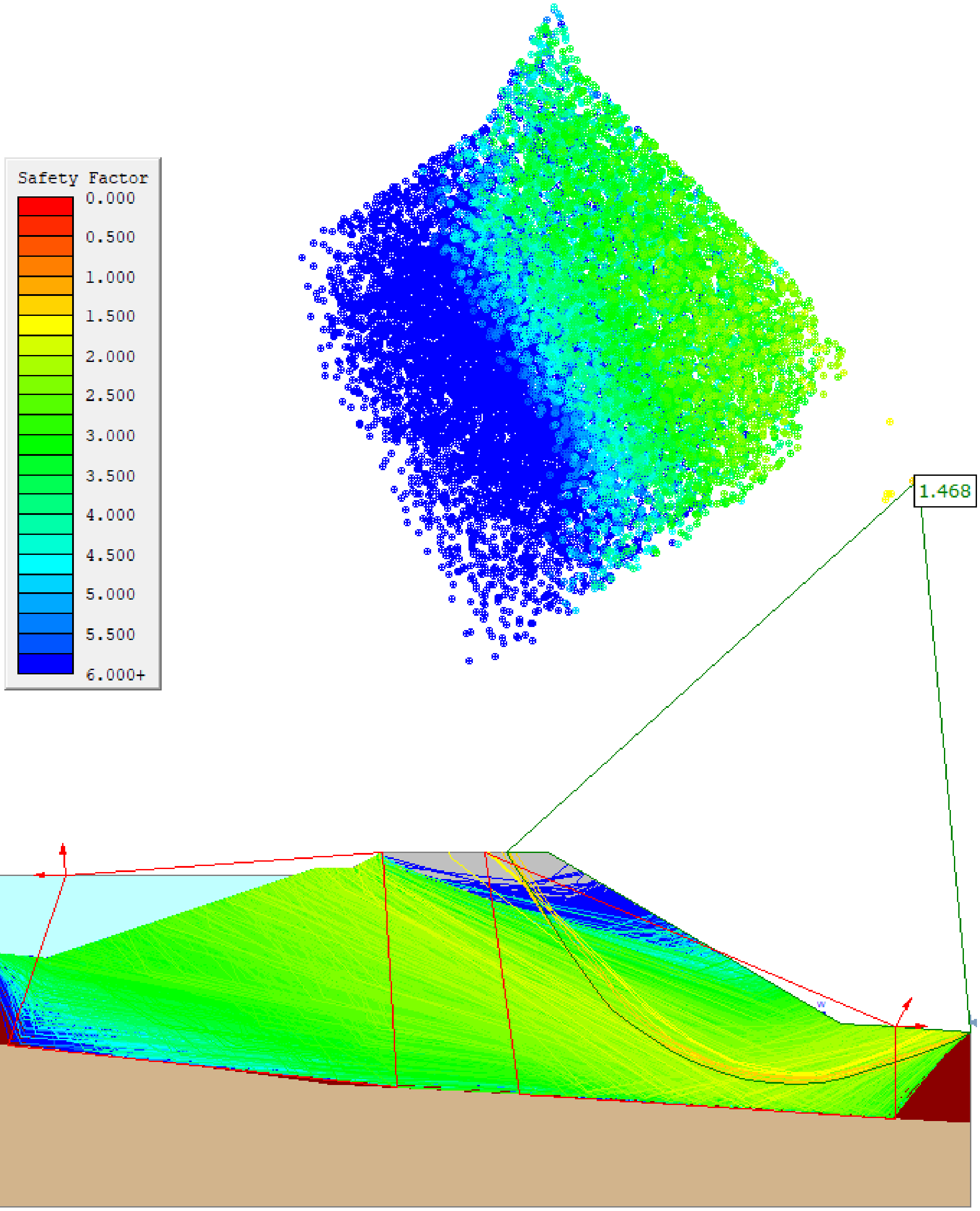
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 9



Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) – Thawed OB (Block Search)

Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

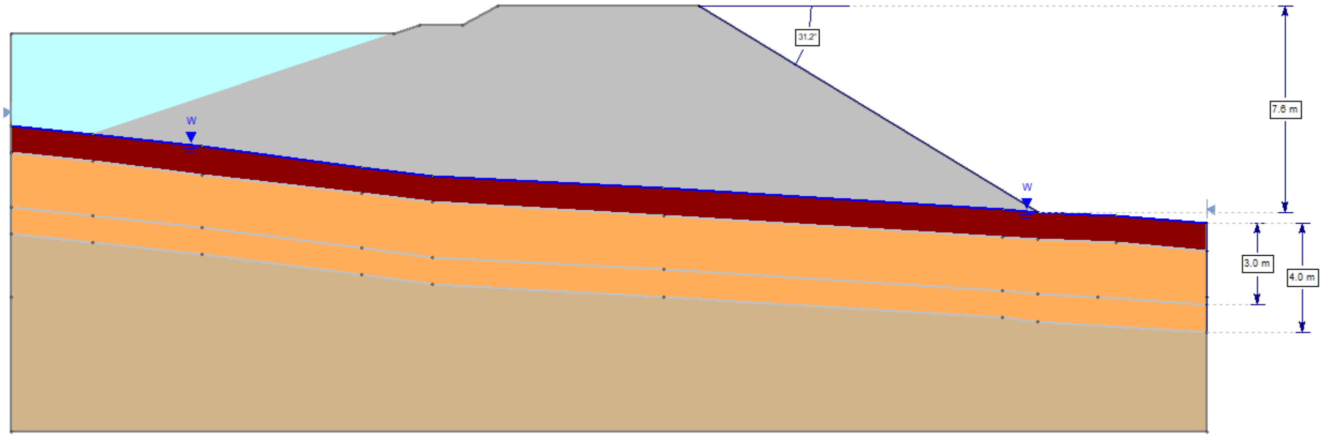
Hope Bay Project

Date: November 2019

Approved: RW

Figure: 10

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26	Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function			Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength			Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26	Water Surface	Custom	0
Pond	🟦	10	No strength			Water Surface	Custom	0



Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

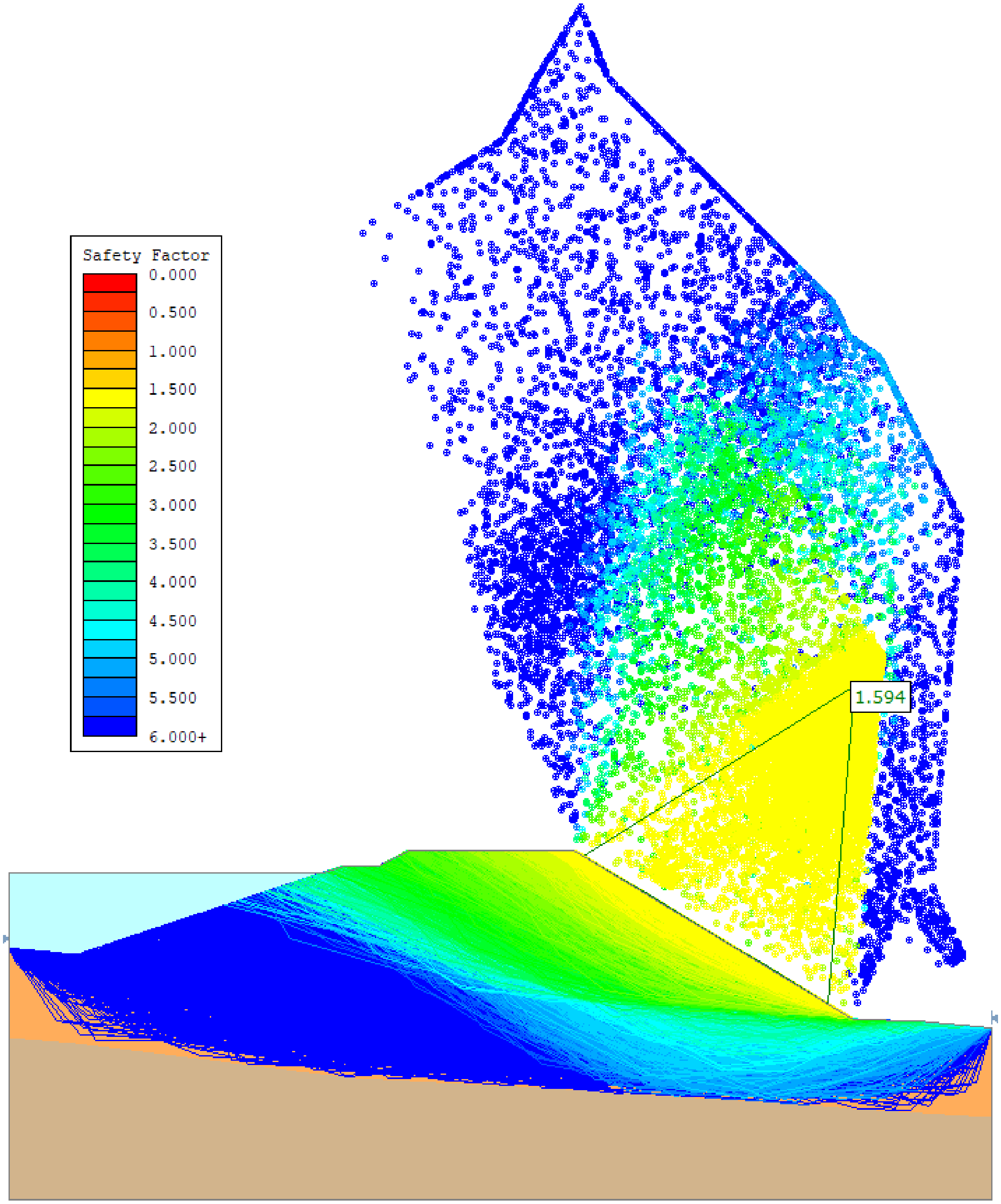
Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) - Geometry

Date: November 2019

Approved: RW

Figure: 11



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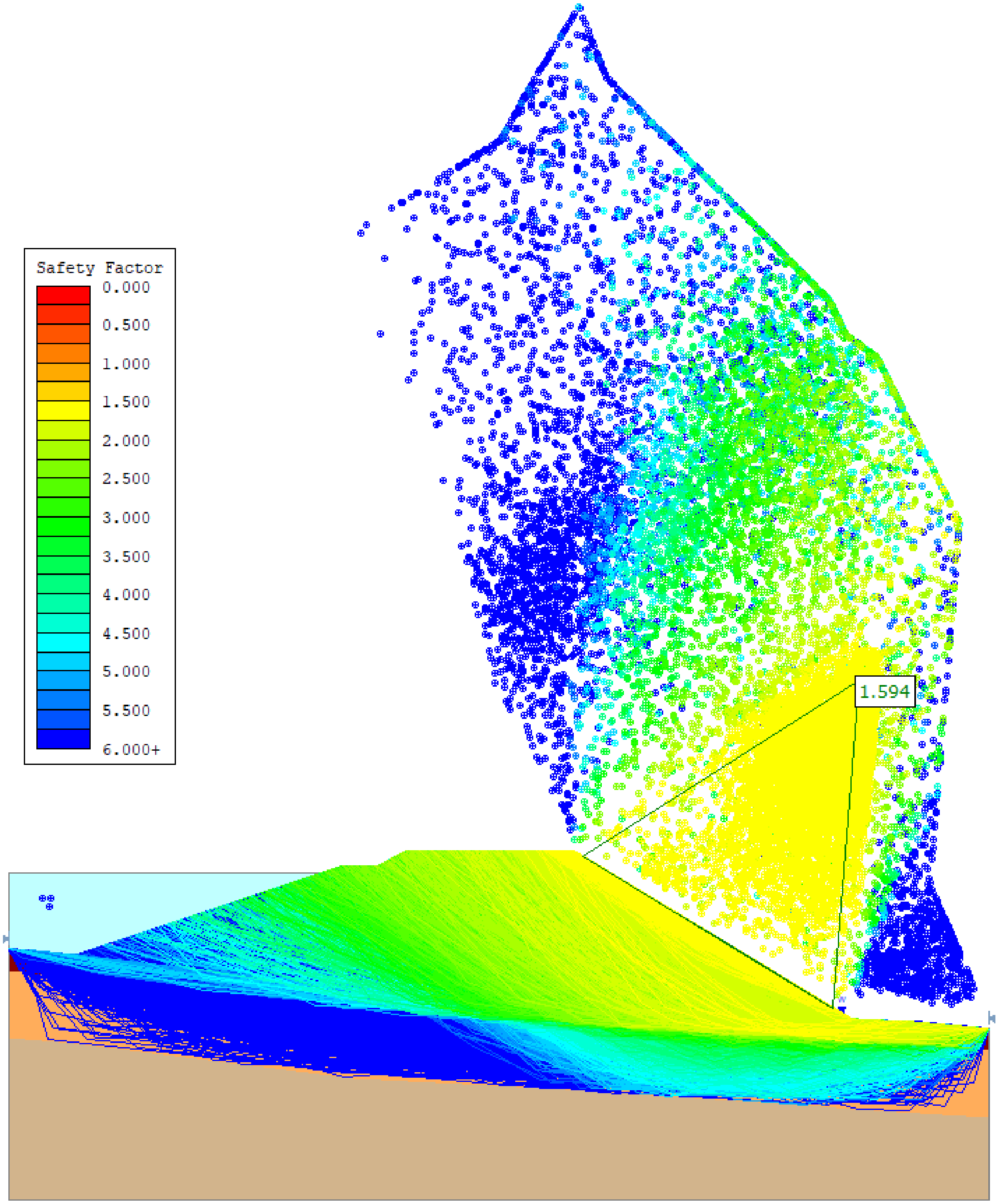
MAC RESOURCES

Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Frozen OB

Job No: 1CT022.43 Filename: LongTerm_Stability_Figures.pptx	Hope Bay Project	Date: November 2019	Approved: RW

Figure: 12



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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Thawed Active Layer

Job No: 1CT022.43

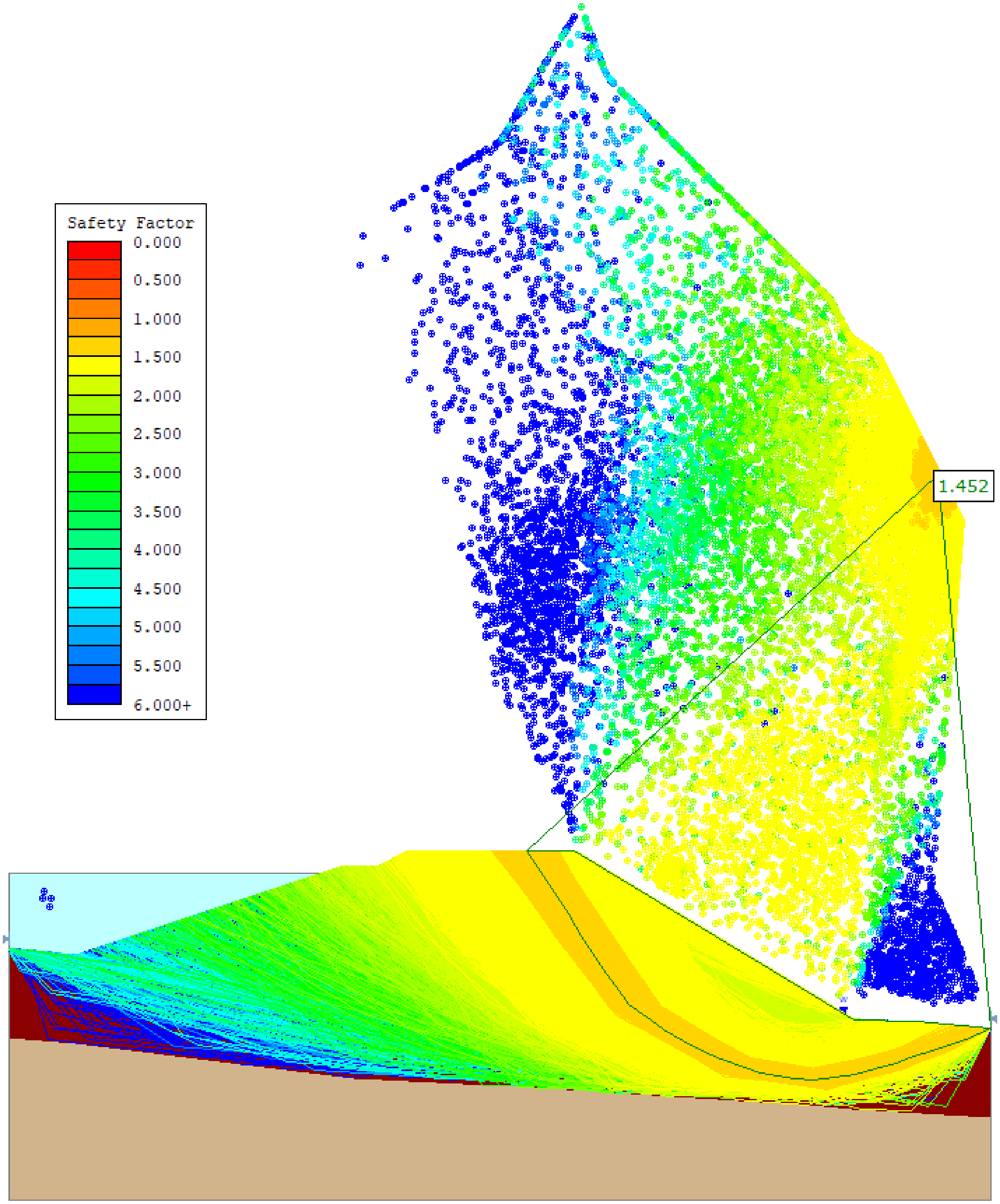
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 13



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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Thawed OB

Job No: 1CT022.43

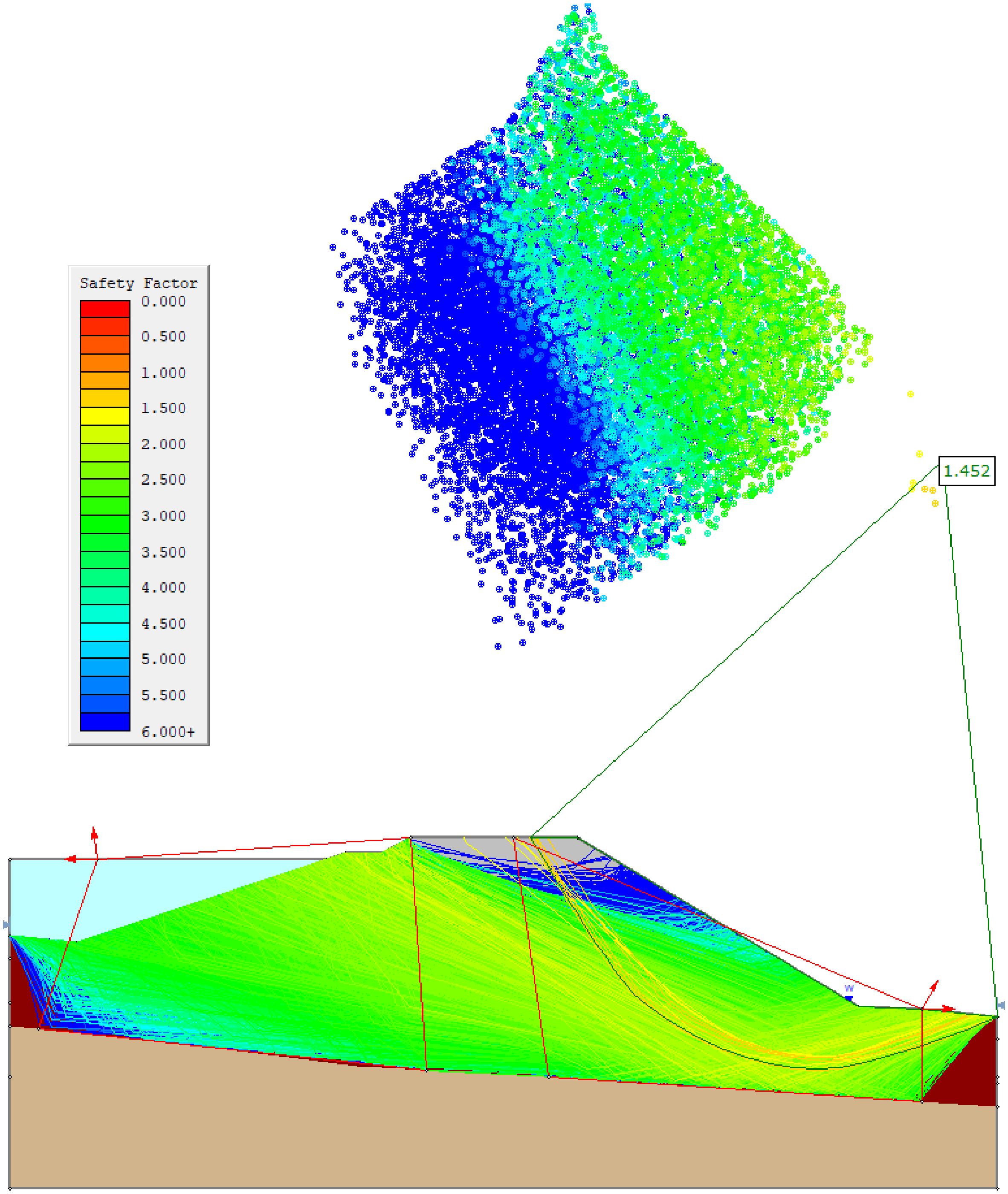
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 14



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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Thawed OB (Block Search)

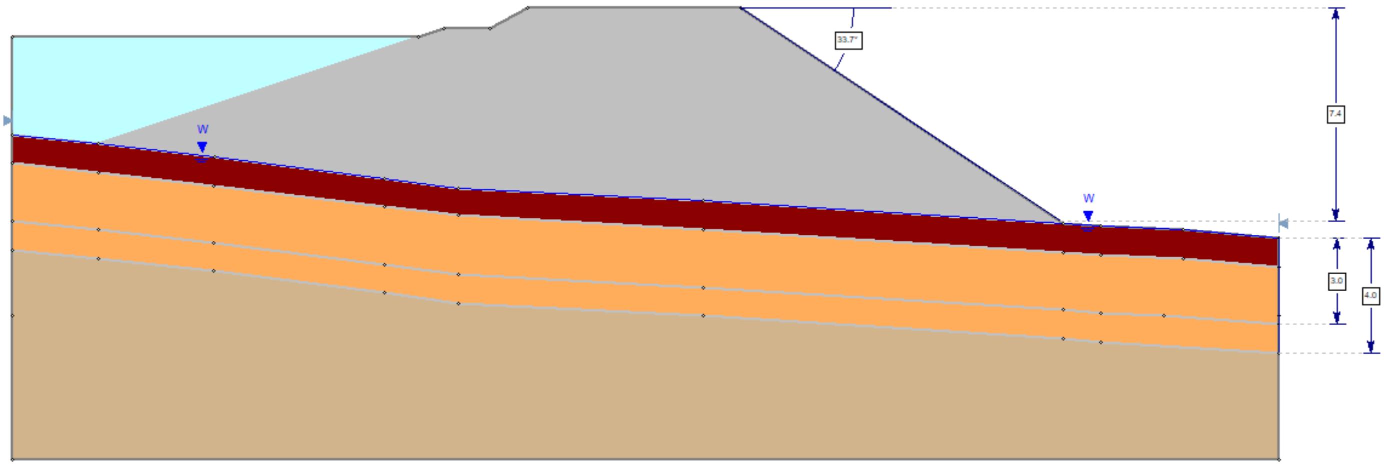
Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	15

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26		Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function				Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength			No	Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26		Water Surface	Custom	0
Pond	🟦	10	No strength				Water Surface	Custom	0



Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) - Geometry

Job No: 1CT022.43

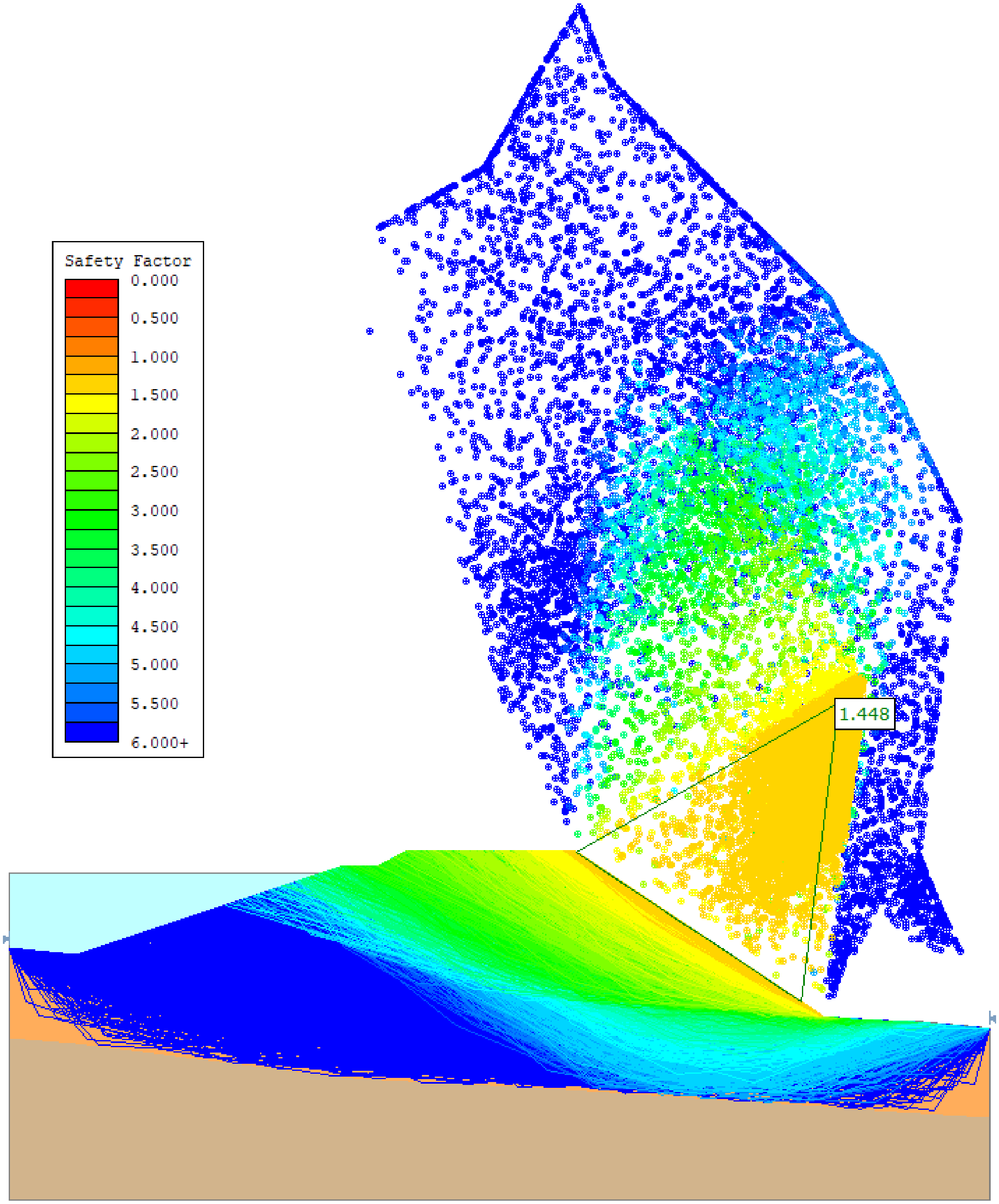
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 16



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MAC RESOURCES

Madrid CWP – As Built Slope Stability

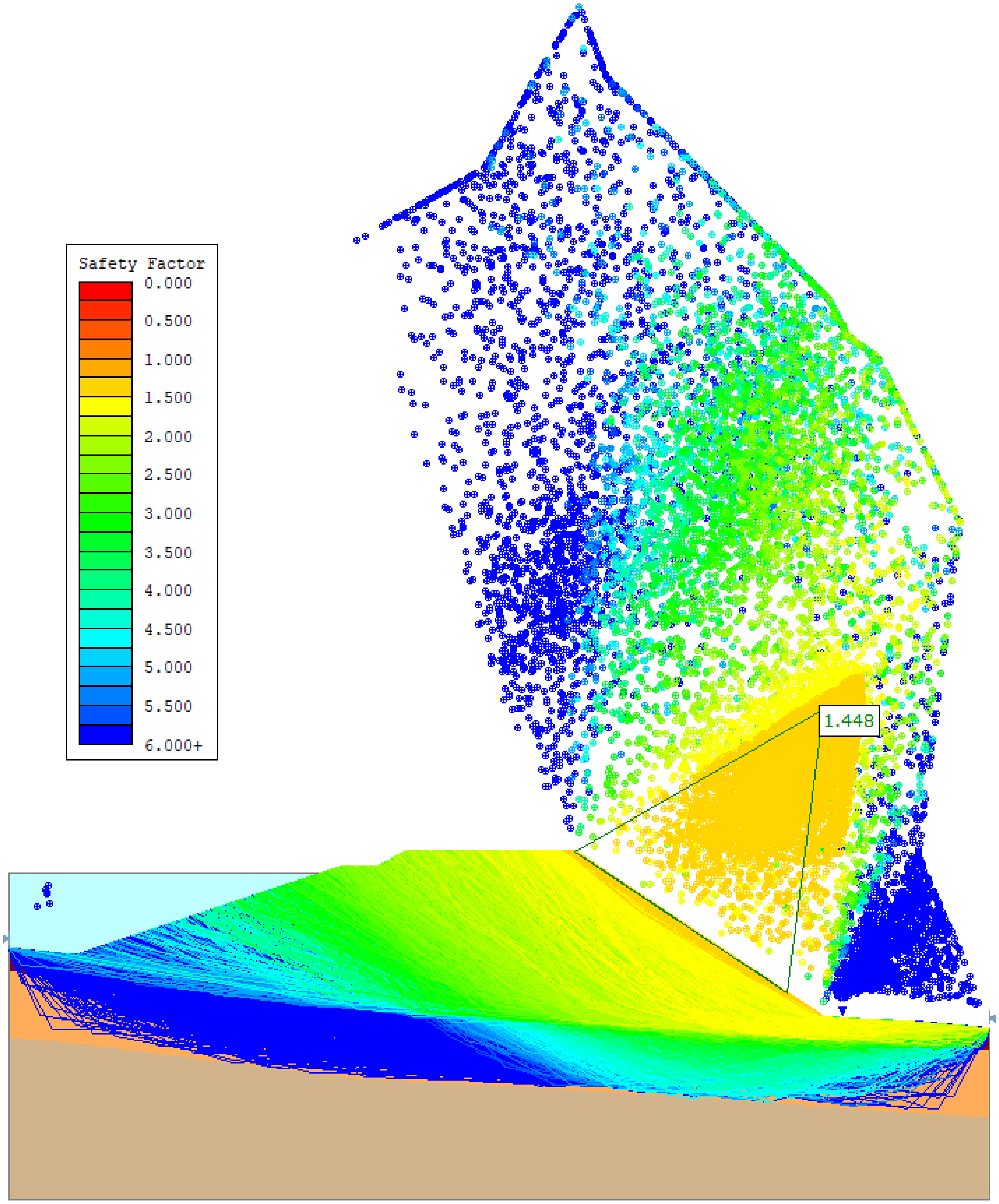
1.5:1.0 (H:V) – Frozen OB

Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	17



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Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

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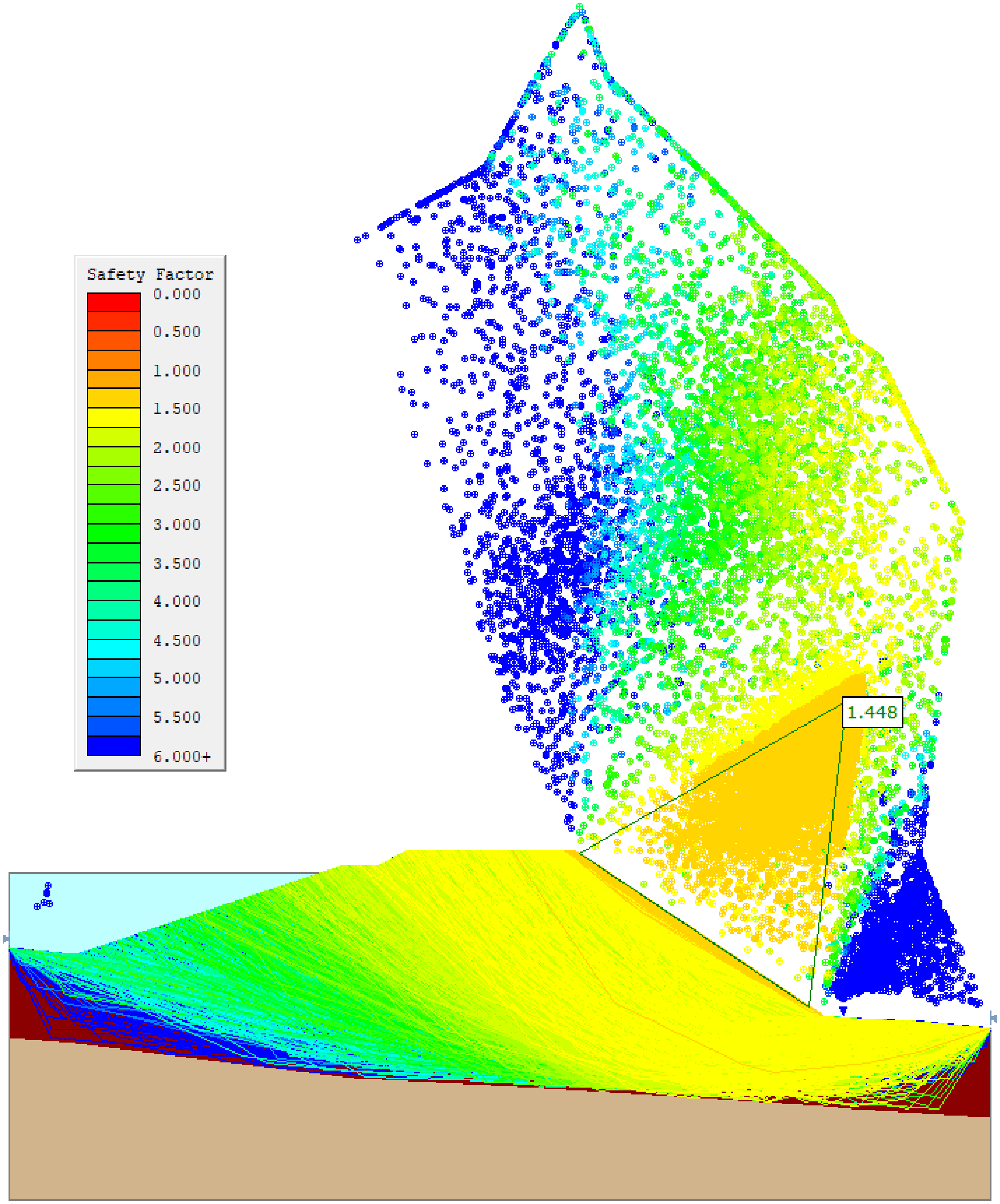
Hope Bay Project

Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) – Thawed Active Layer

Date:	Approved:	Figure:
November 2019	RW	18



Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) – Thawed OB

Job No: 1CT022.43

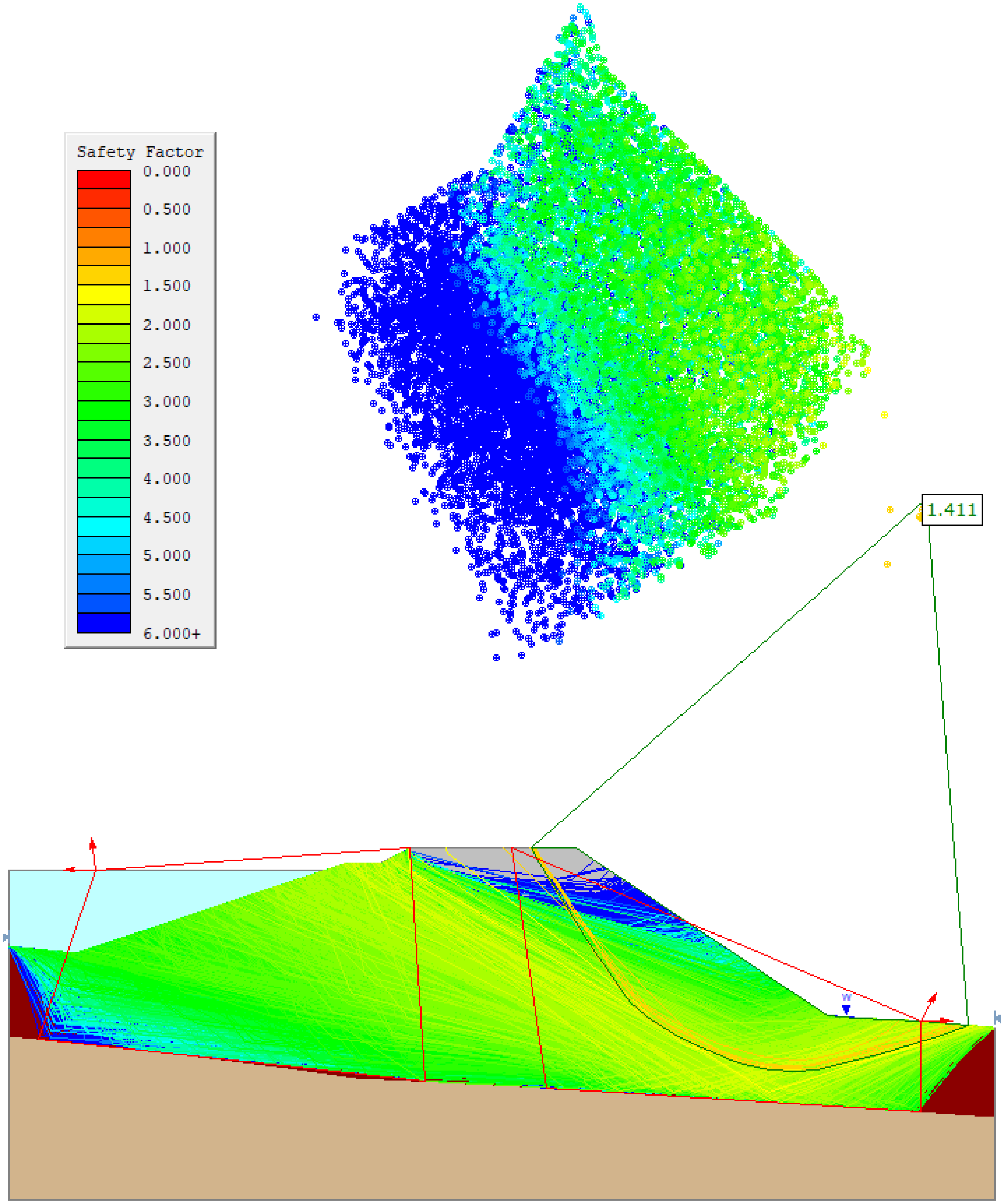
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 19



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MAC RESOURCES

Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) – Thawed OB
(Block Search)

Job No: 1CT022.43
Filename: LongTerm_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	20

Slope H:V	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Frozen OB	Thawed Act. Layer	Thawed OB	Thawed OB*
2.00:1.0	1.9	1.7	1.6	1.6
1.70:1.0	1.6	1.6	1.5	1.5
1.65:1.0	1.6	1.6	1.5	1.5
1.50:1.0	1.4	1.4	1.4	1.4

(*) Block Search method to verify if different failure mechanism with lower FoS exists.

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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

Slope Stability Results Summary

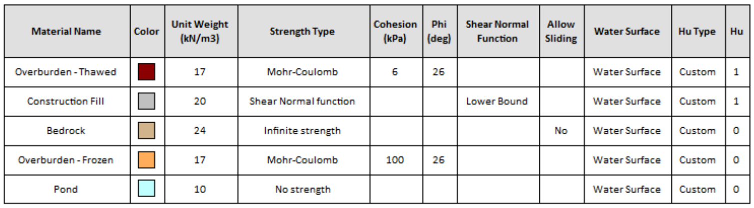
Job No: 1CT022.43

Filename: LongTerm_Stability_Figures.pptx

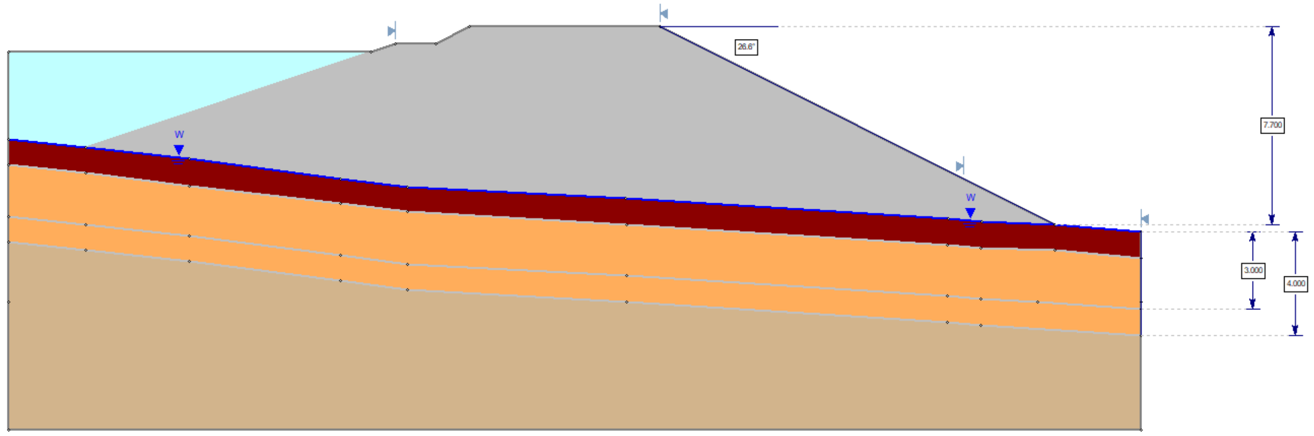
Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	**21**

Attachment 2: Pseudo-Static Stability Results



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Shear Normal Function	Allow Sliding	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26			Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function			Lower Bound		Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength				No	Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26			Water Surface	Custom	0
Pond	🟦	10	No strength					Water Surface	Custom	0



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TMAC RESOURCES

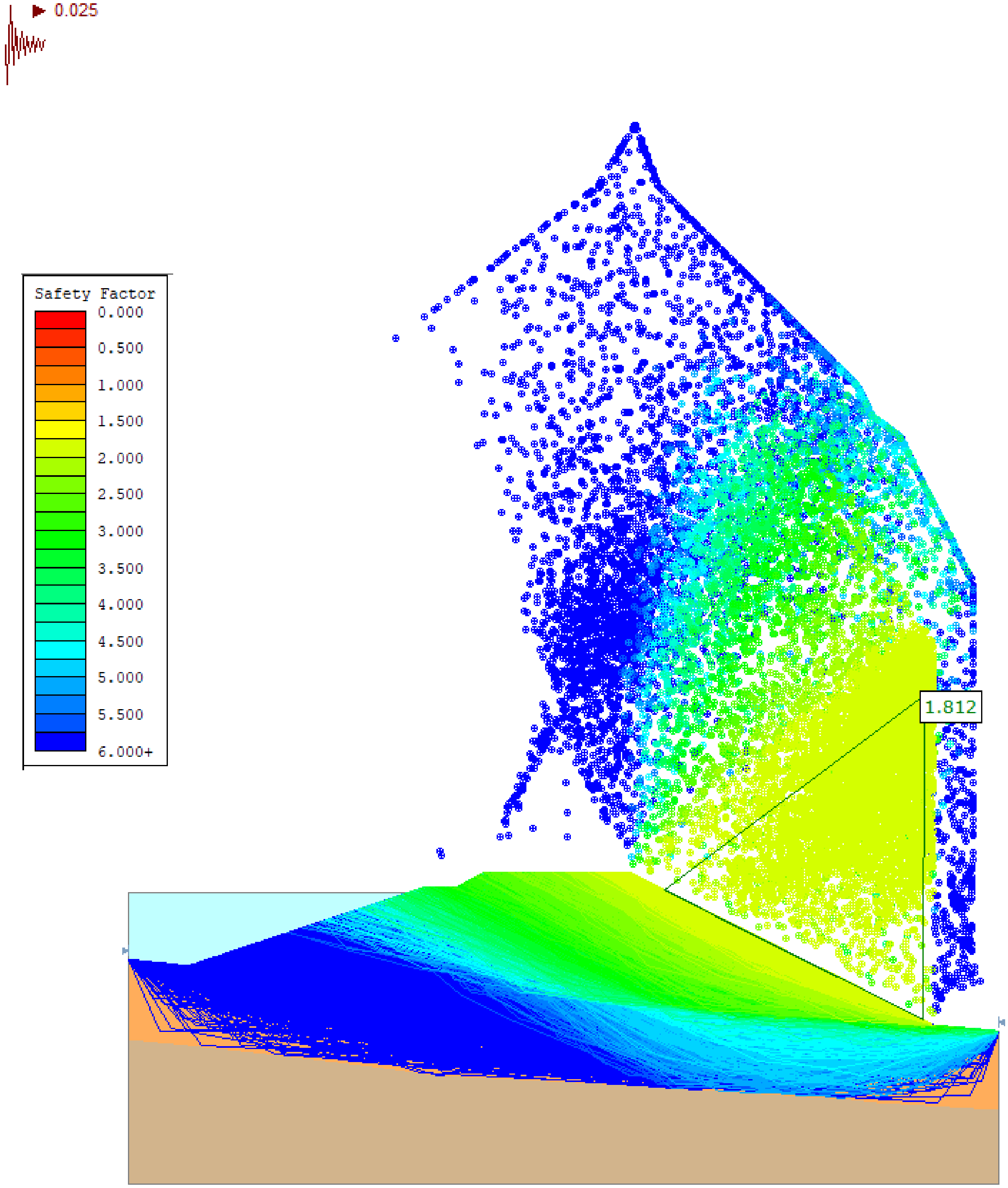
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) - Geometry

Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019
Approved: RW
Figure: 1



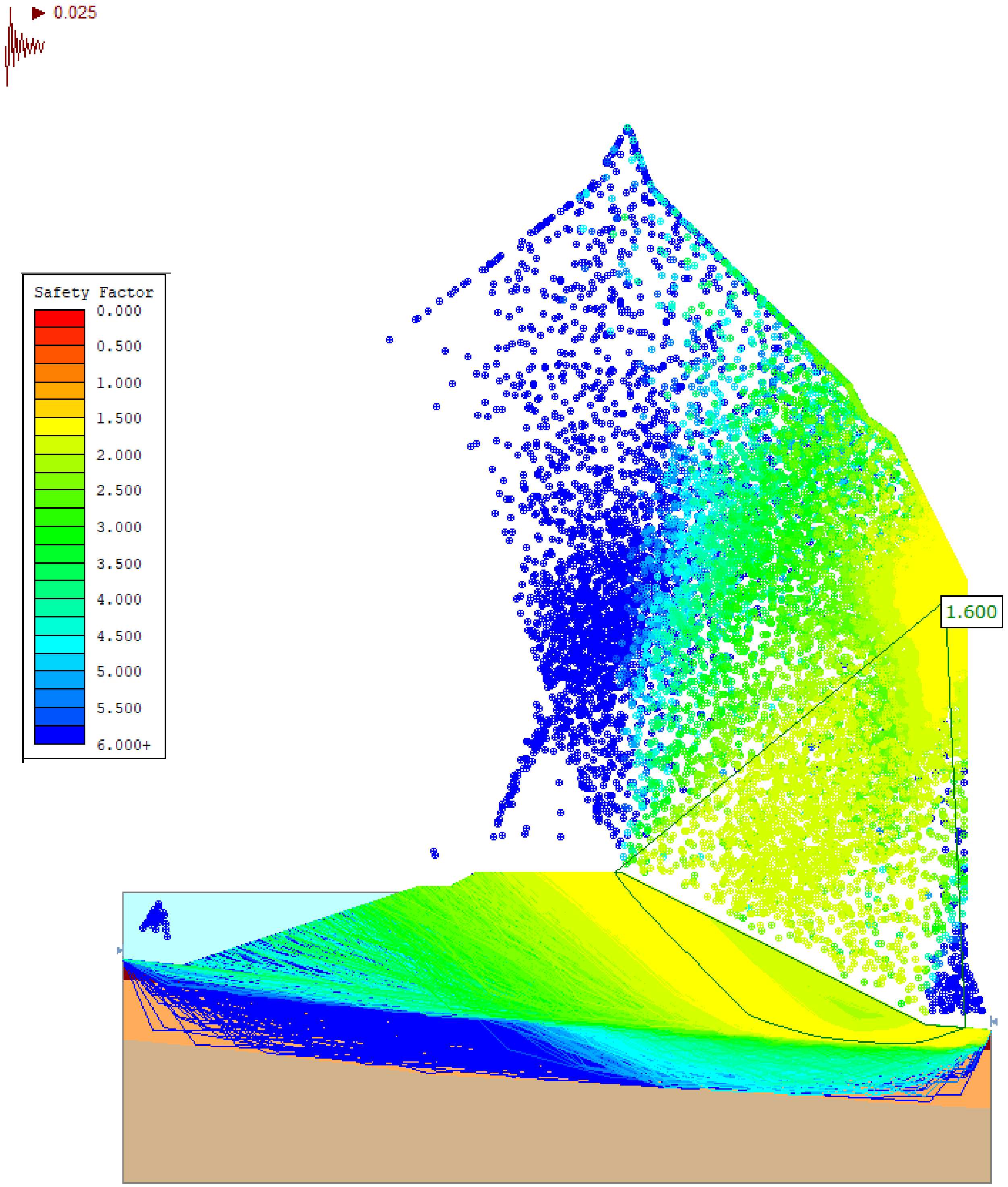
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) – Frozen OB
Pseudo-static Analysis

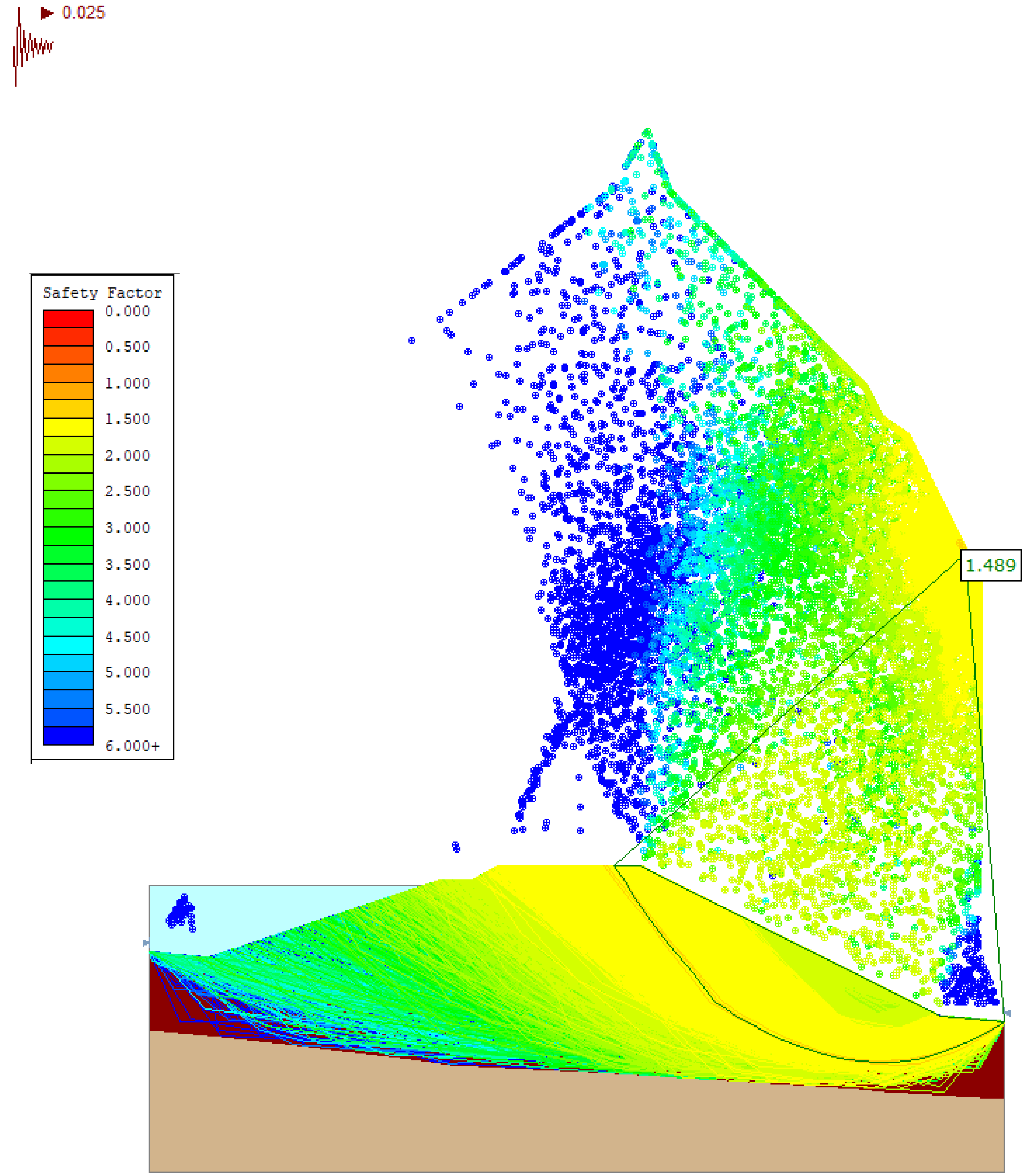
Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	2



srk consulting	MAC RESOURCES	Madrid CWP – As Built Slope Stability
		2.0:1.0 (H:V) – Thawed Active Layer Pseudo-static Analysis
Job No: 1CT022.43 Filename: Pseudo-Static_Stability_Figures.pptx	Hope Bay Project	Date: November 2019 Approved: RW Figure: 3



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TMAC RESOURCES

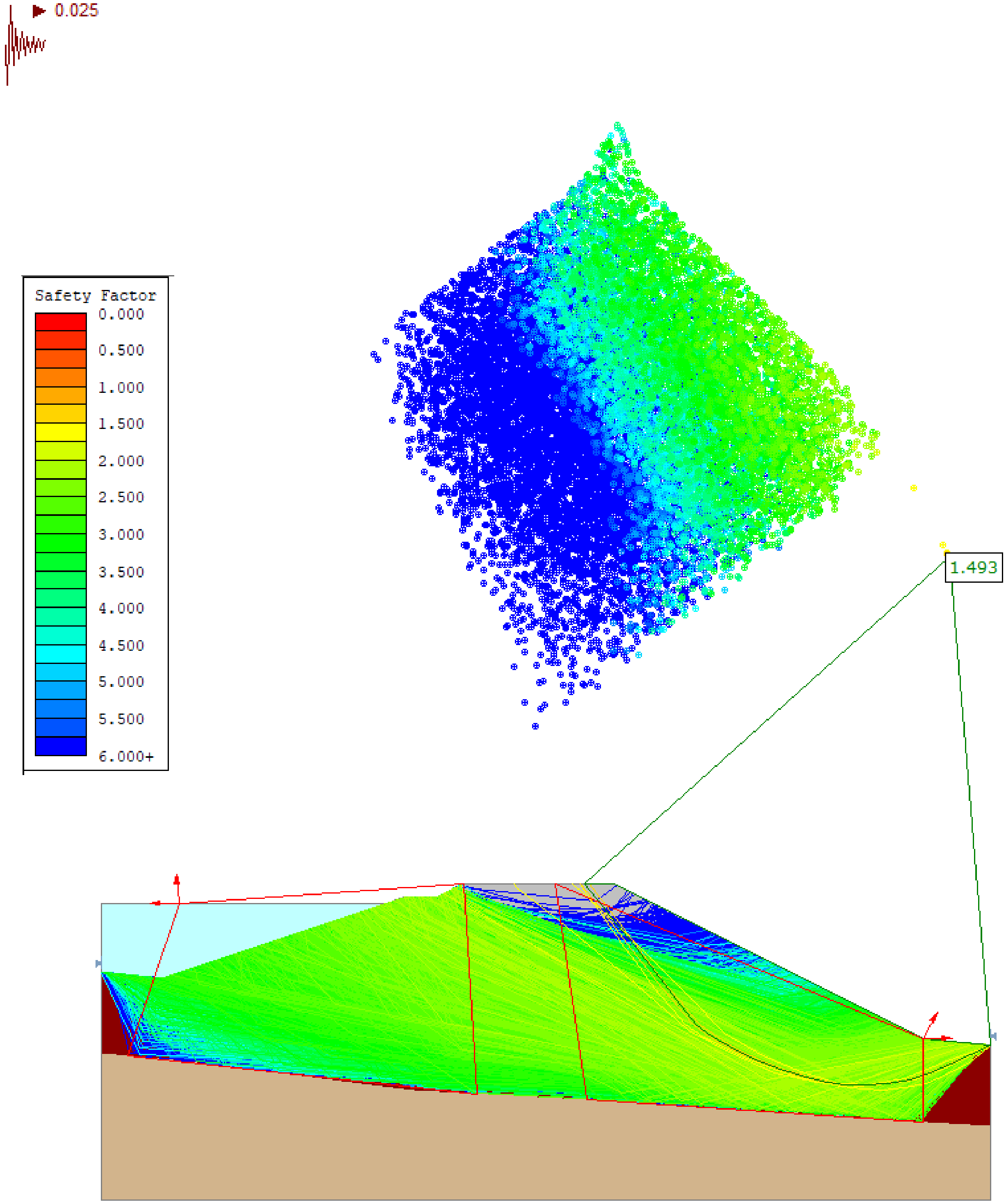
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) – Thawed OB
Pseudo-static Analysis

Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	4



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TMAC RESOURCES

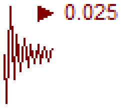
Madrid CWP – As Built Slope Stability

2.0:1.0 (H:V) – Thawed OB (Block Search)
Pseudo-static Analysis

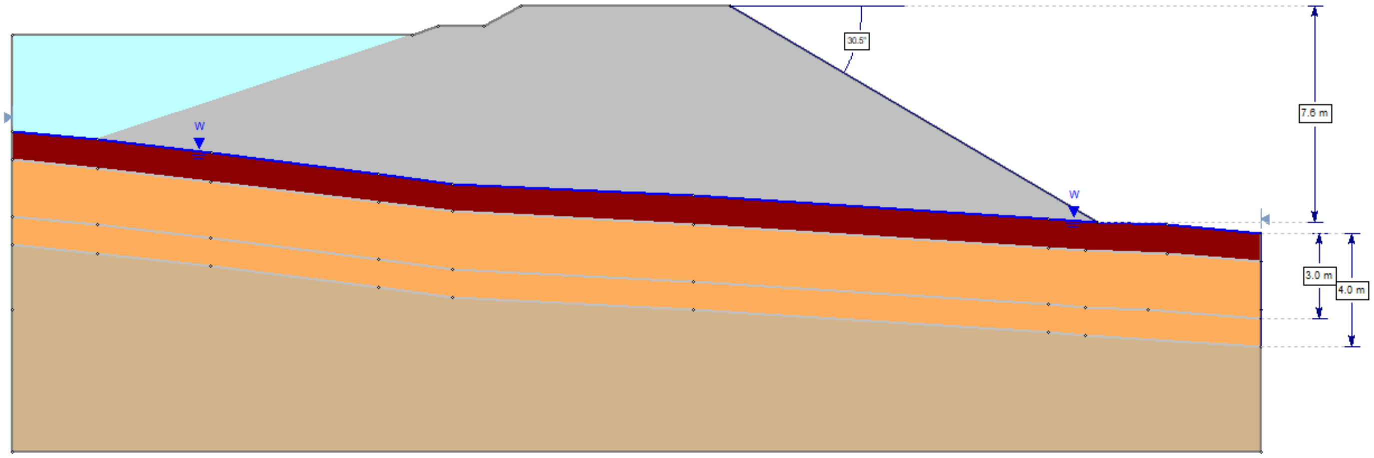
Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	5



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26	Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function			Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength			Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26	Water Surface	Custom	0
Pond	🟦	10	No strength			Water Surface	Custom	0



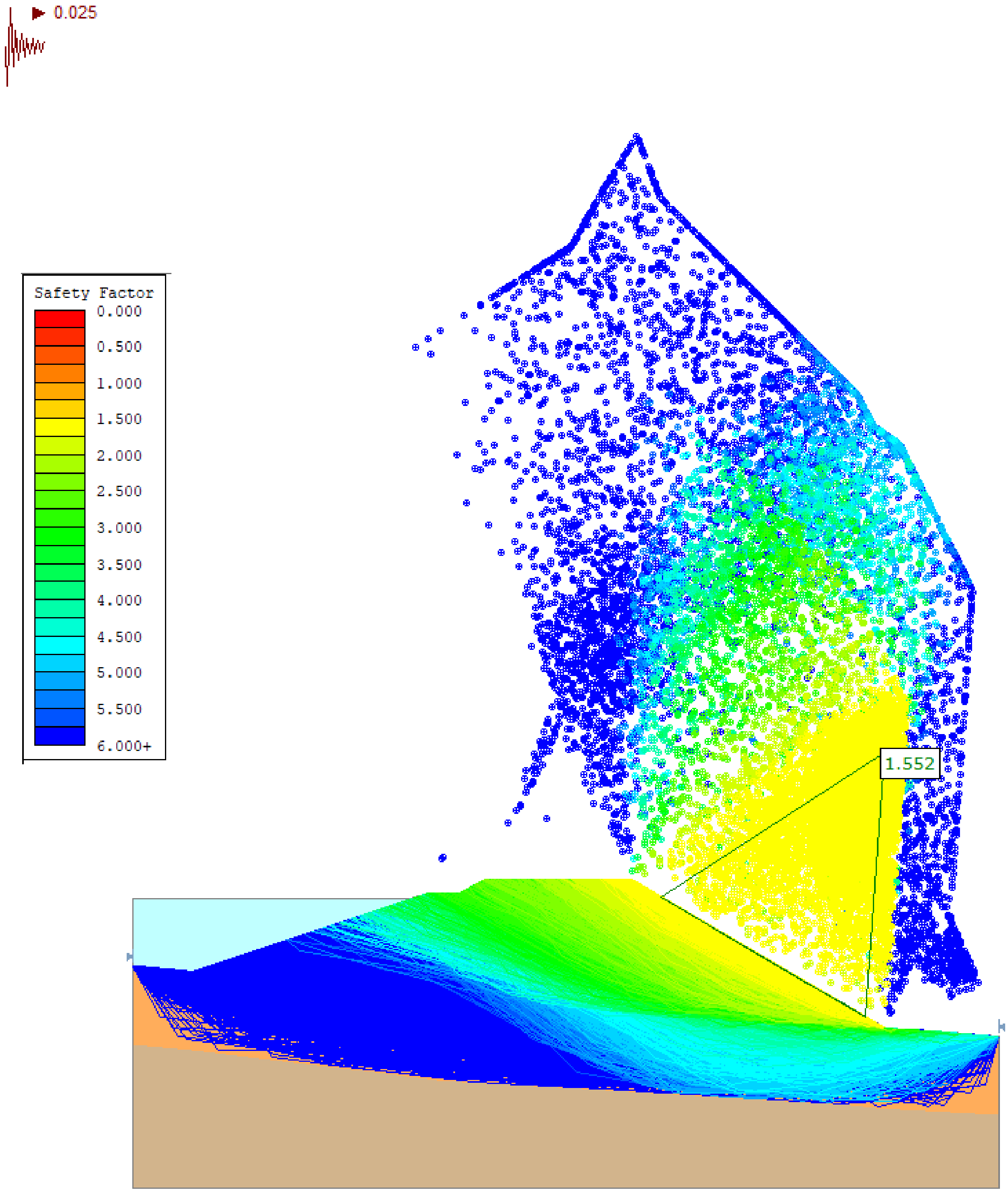
Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) - Geometry

Job No:	1CT022.43
Filename:	Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	6



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TMAC RESOURCES

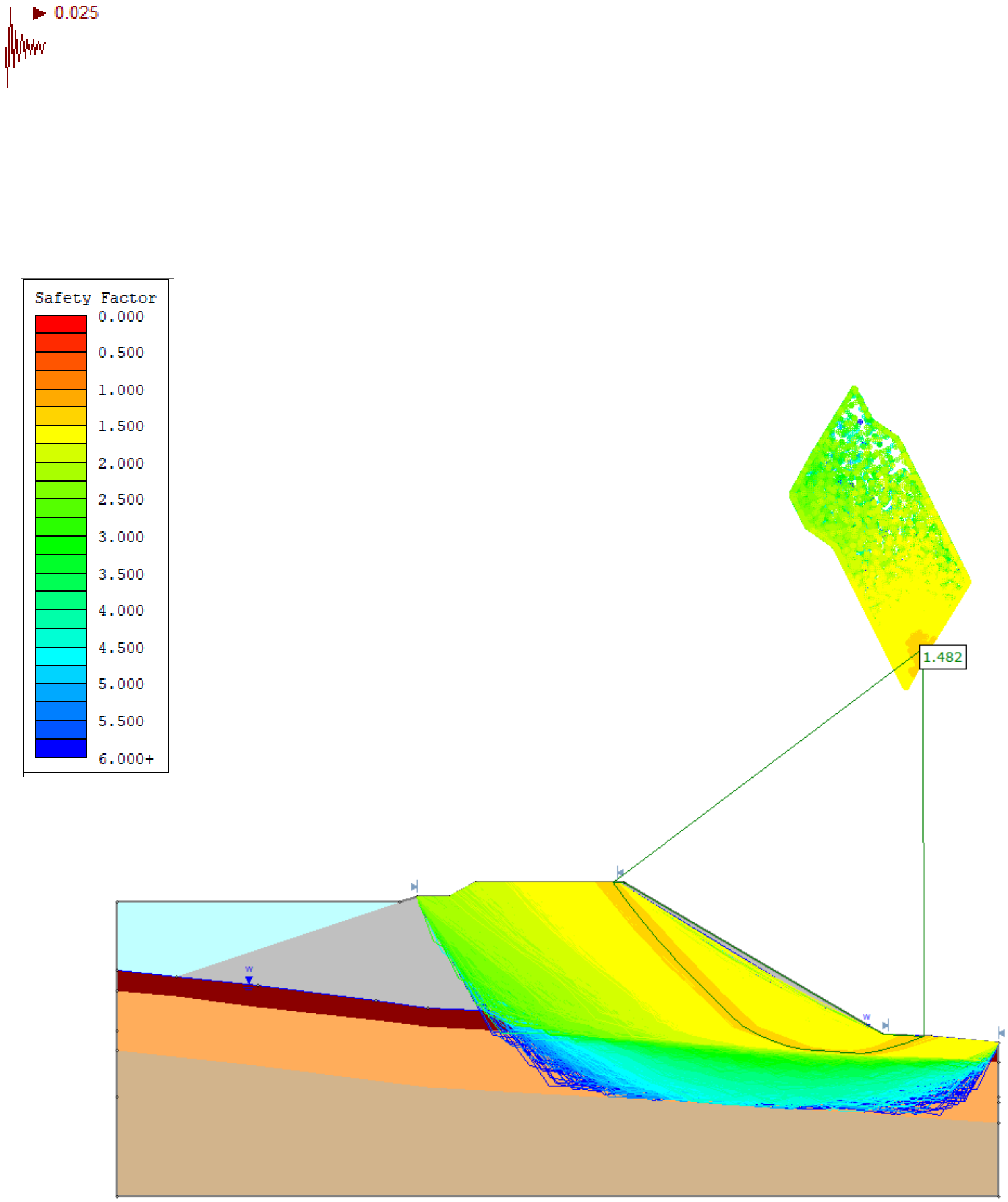
Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) – Frozen OB
Pseudo-static Analysis

Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019
Approved: RW
Figure: 7



Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) – Thawed Active Layer Pseudo-static Analysis

Job No: 1CT022.43

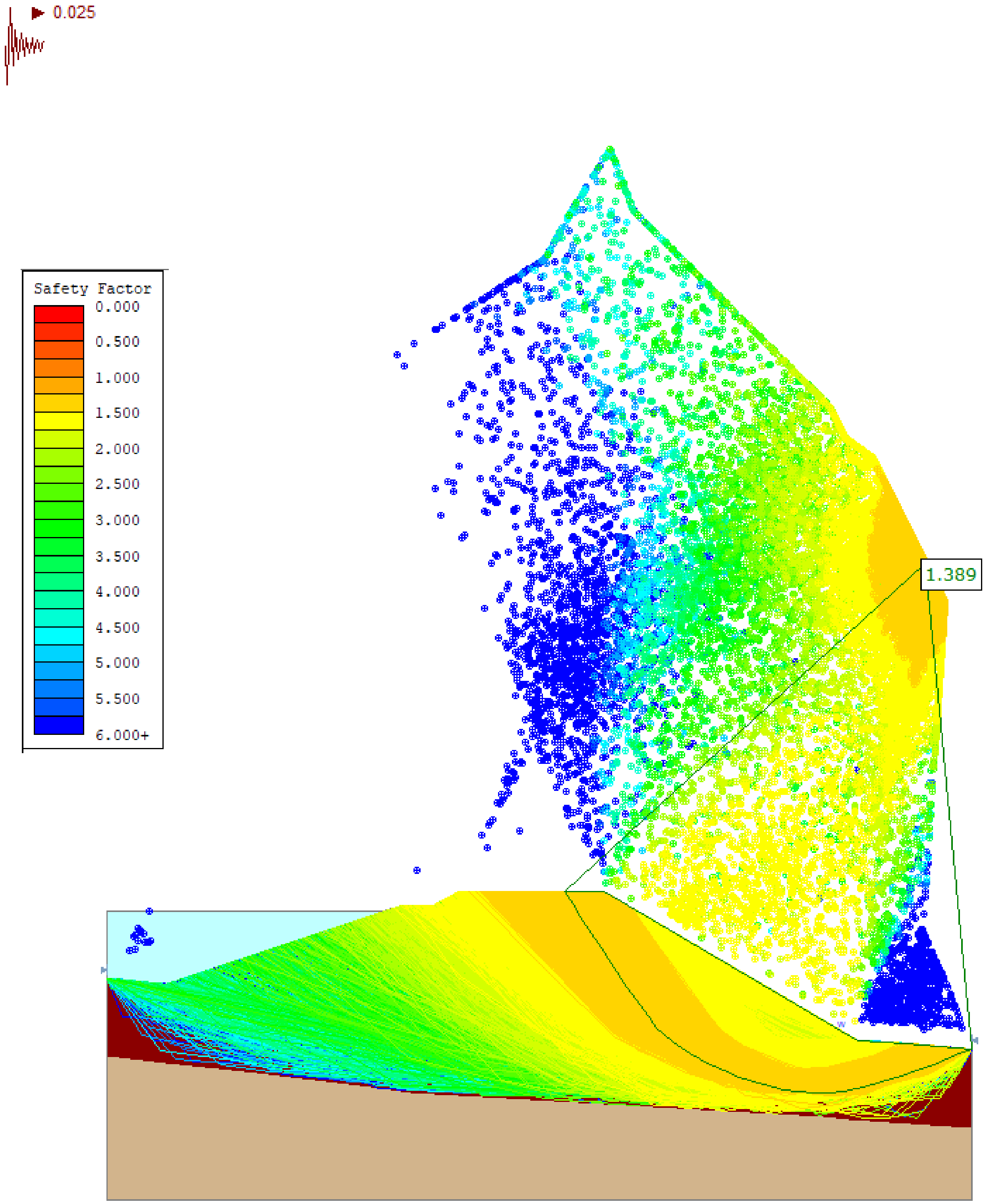
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 8



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TMAC RESOURCES

Madrid CWP – As Built Slope Stability

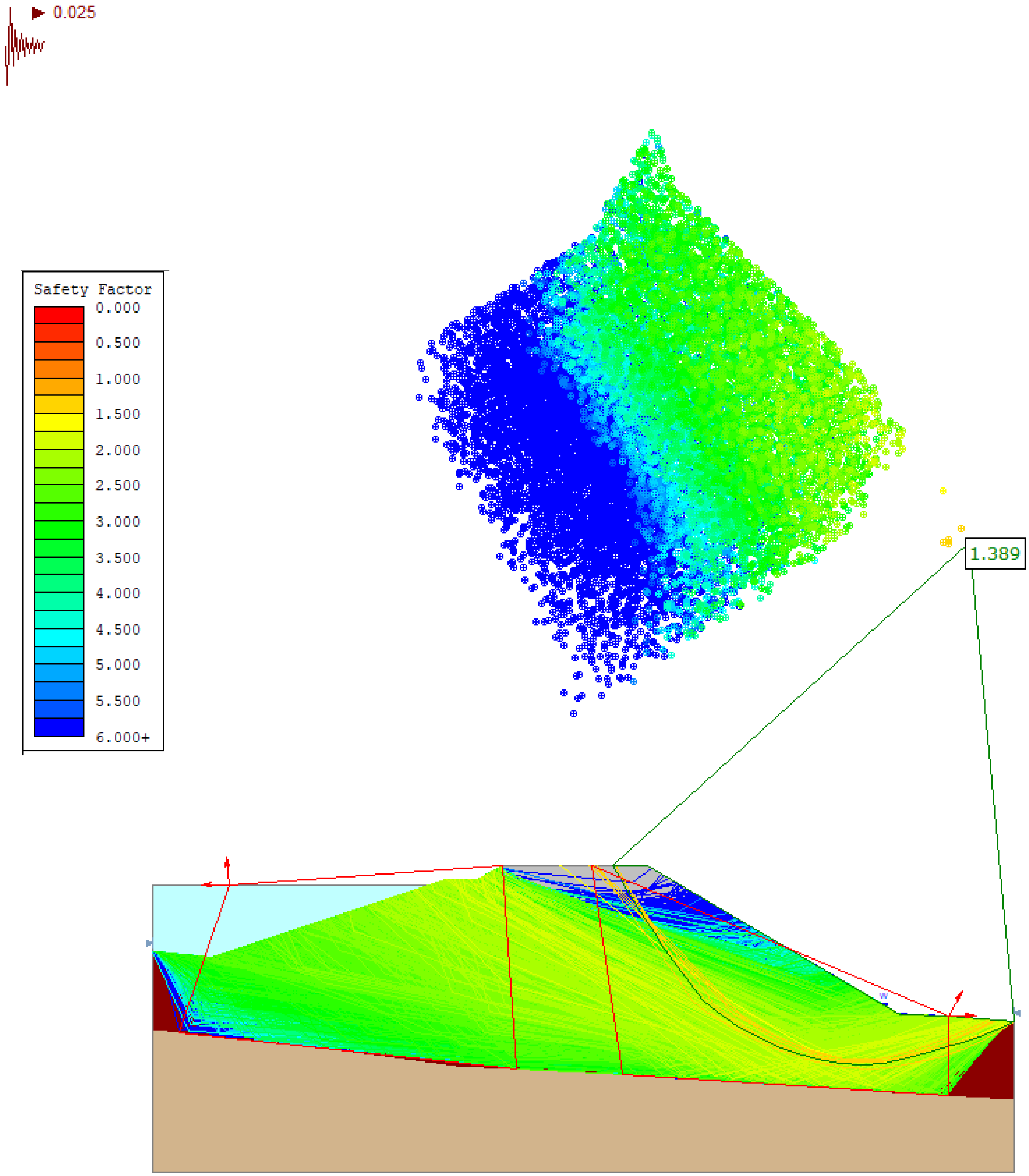
1.7:1.0 (H:V) – Thawed OB
Pseudo-static Analysis

Job No: 1CT022.43

Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	9



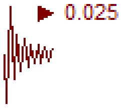
Madrid CWP – As Built Slope Stability

1.7:1.0 (H:V) – Thawed OB (Block Search)
Pseudo-static Analysis

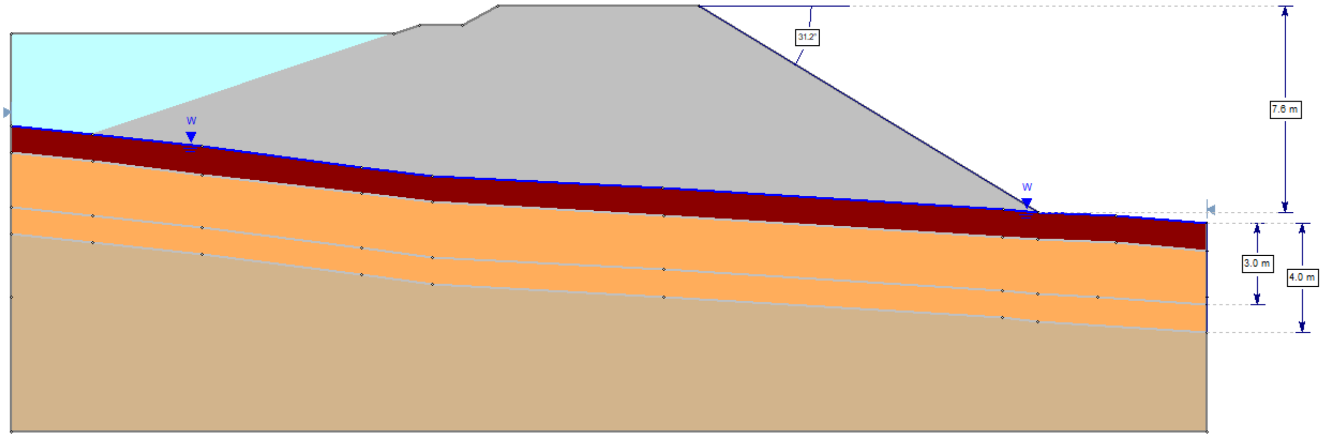
Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019
Approved: RW
Figure: 10



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26	Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function			Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength			Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26	Water Surface	Custom	0
Pond	🟦	10	No strength			Water Surface	Custom	0



Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) - Geometry

Job No: 1CT022.43

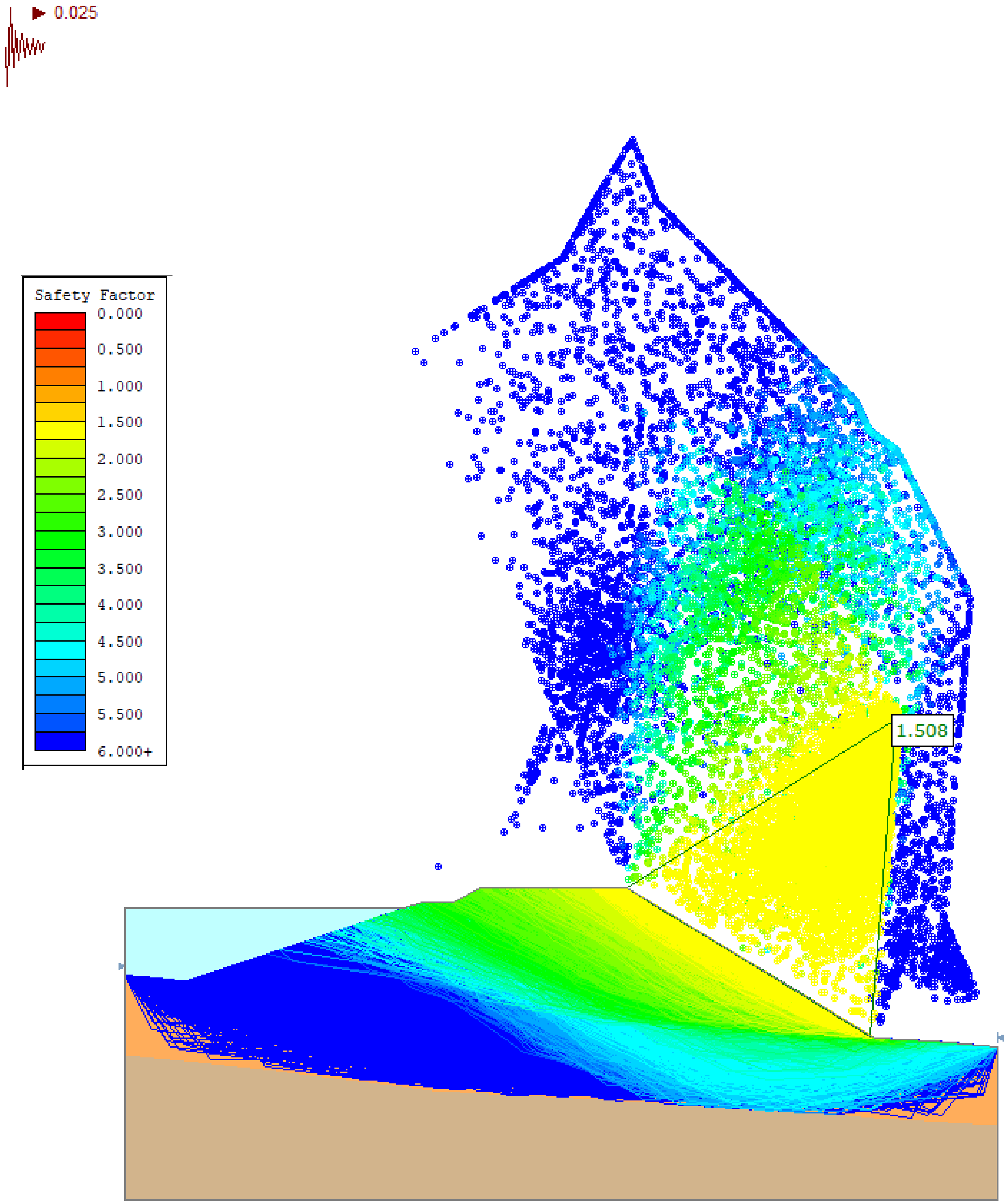
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 11



srk consulting

TMAC RESOURCES

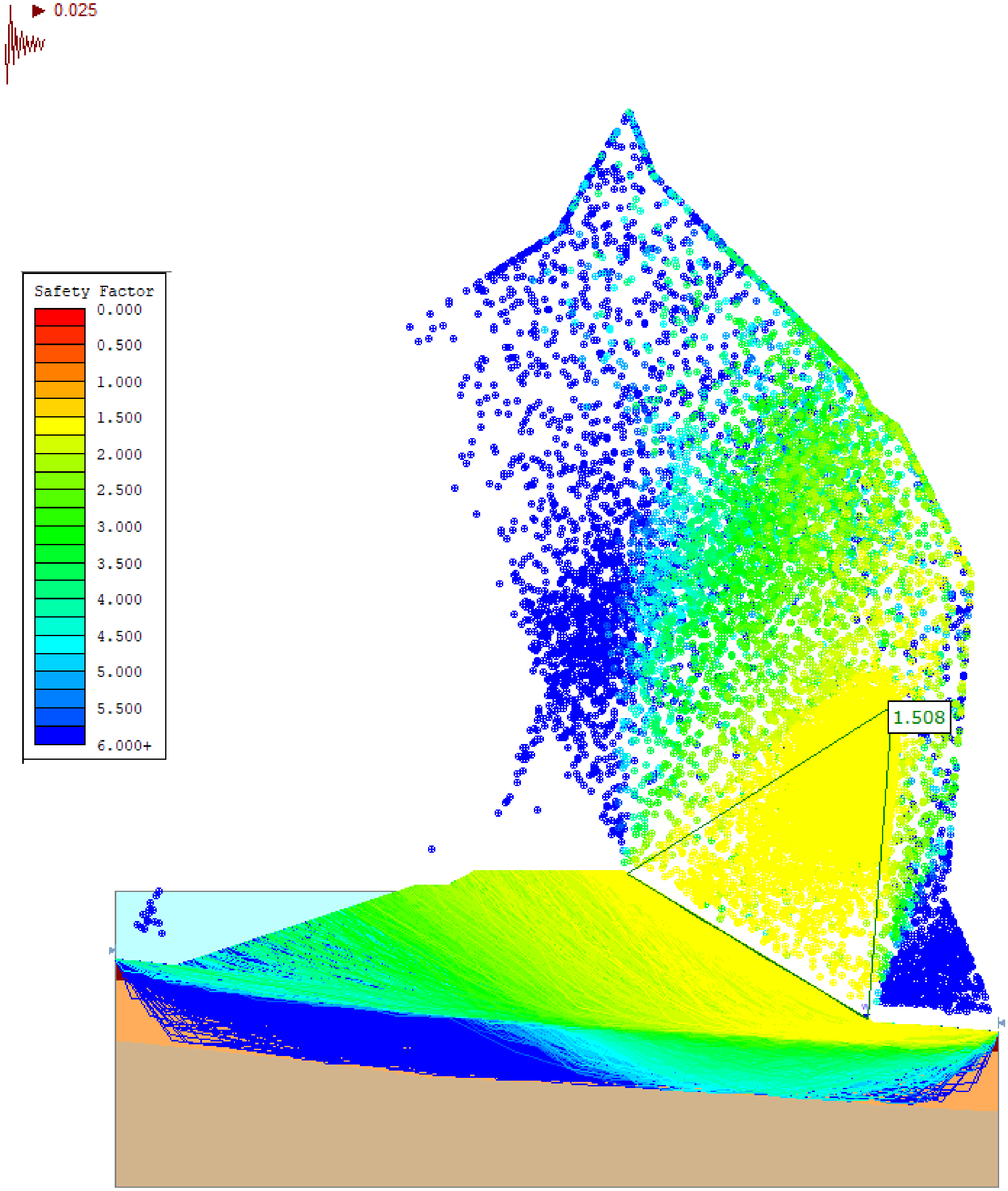
Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Frozen OB
Pseudo-static Analysis

Job No:	1CT022.43
Filename:	Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	12



srk consulting

TMAC RESOURCES

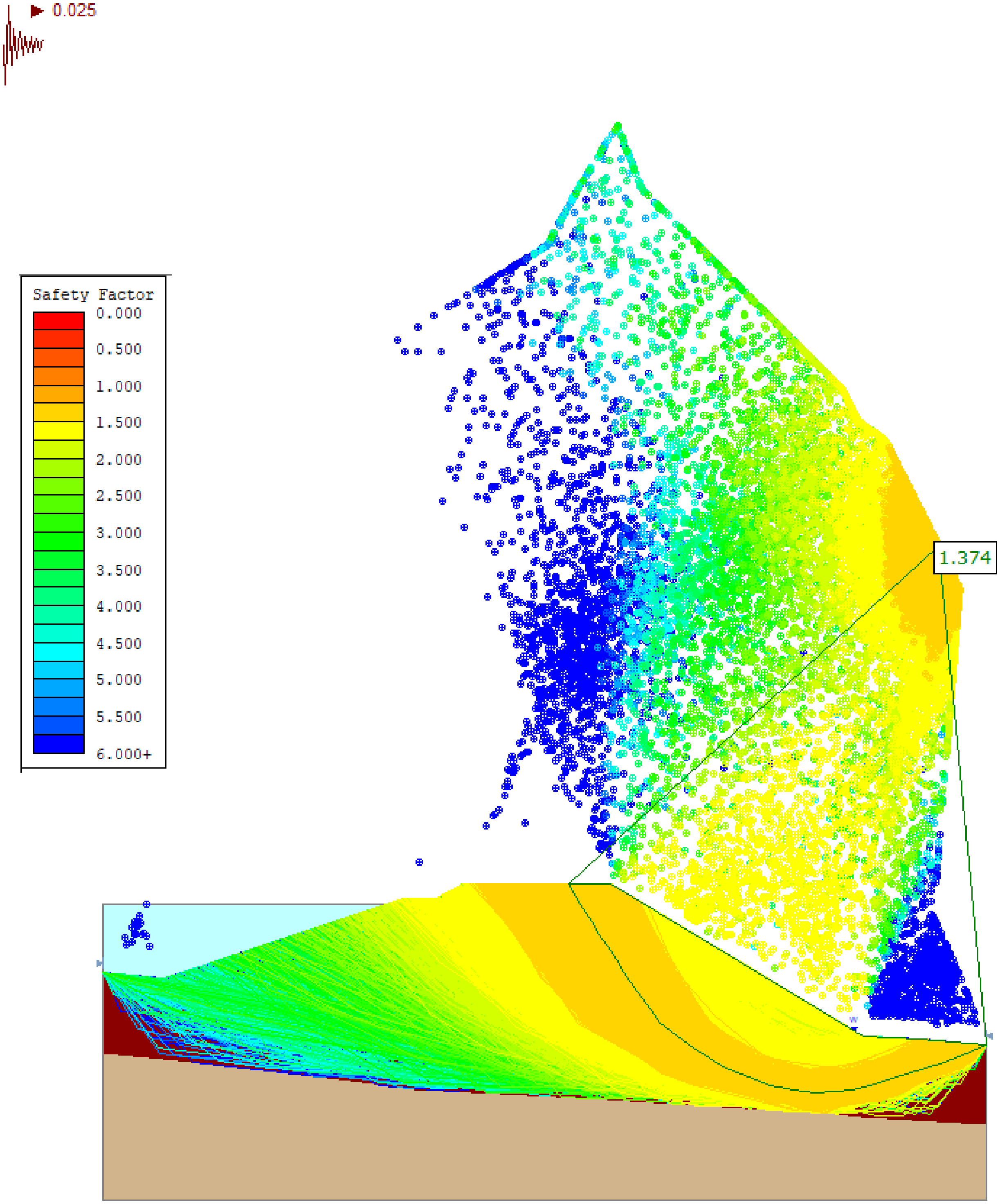
Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Thawed Active Layer Pseudo-static Analysis

Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	13



srk consulting

TMAC RESOURCES

Madrid CWP – As Built Slope Stability

1.65:1.0 (H:V) – Thawed OB
Pseudo-static Analysis

Job No: 1CT022.43

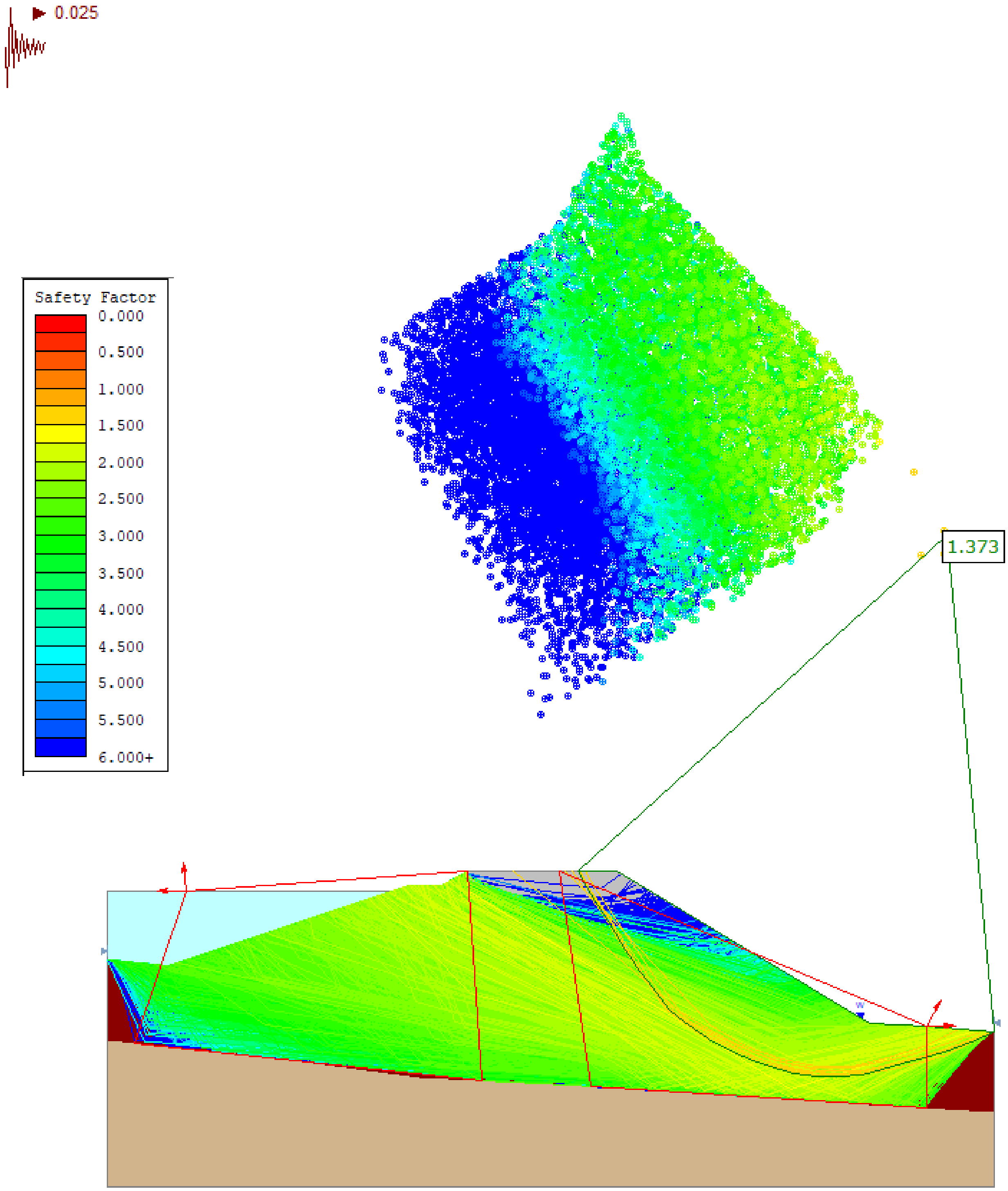
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 14



srk consulting	MAC RESOURCES	Madrid CWP – As Built Slope Stability
		1.65:1.0 (H:V) – Thawed OB (Block Search) Pseudo-static Analysis

Job No: 1CT022.43

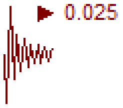
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

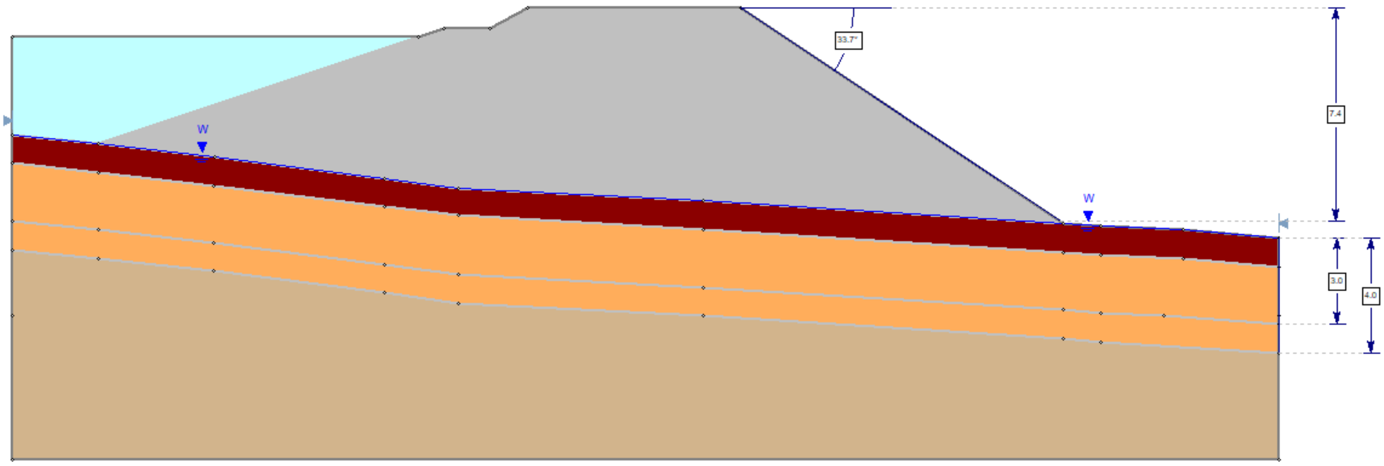
Date: November 2019

Approved: RW

Figure: 15



Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Allow Sliding	Water Surface	Hu Type	Hu
Overburden - Thawed	🟥	17	Mohr-Coulomb	6	26		Water Surface	Custom	1
Construction Fill	⬜	20	Shear Normal function				Water Surface	Custom	1
Bedrock	🟫	24	Infinite strength			No	Water Surface	Custom	0
Overburden - Frozen	🟧	17	Mohr-Coulomb	100	26		Water Surface	Custom	0
Pond	🟦	10	No strength				Water Surface	Custom	0



srk consulting

TMAC RESOURCES

Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) - Geometry

Job No: 1CT022.43

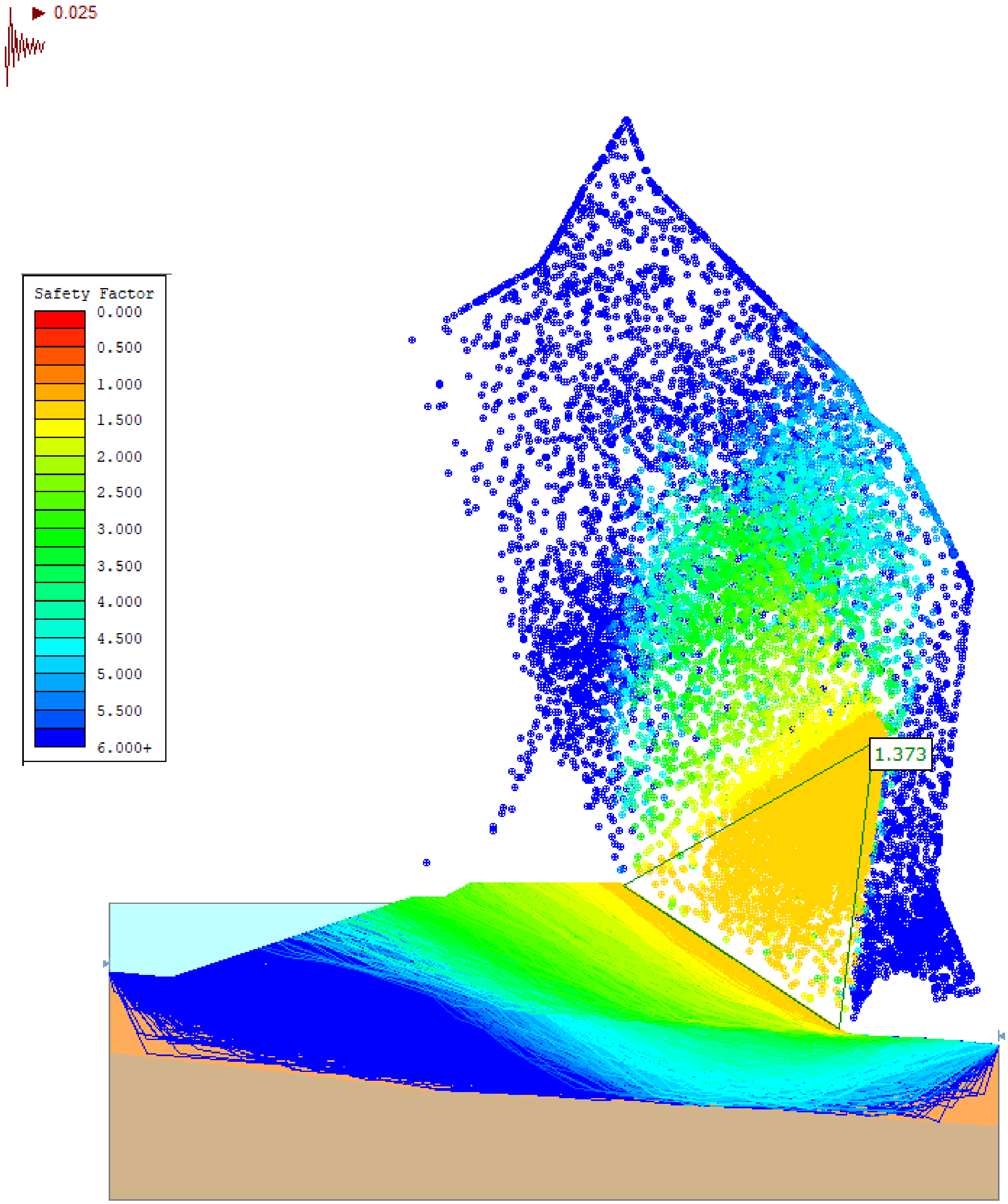
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019

Approved: RW

Figure: 16



srk consulting

TMAC RESOURCES

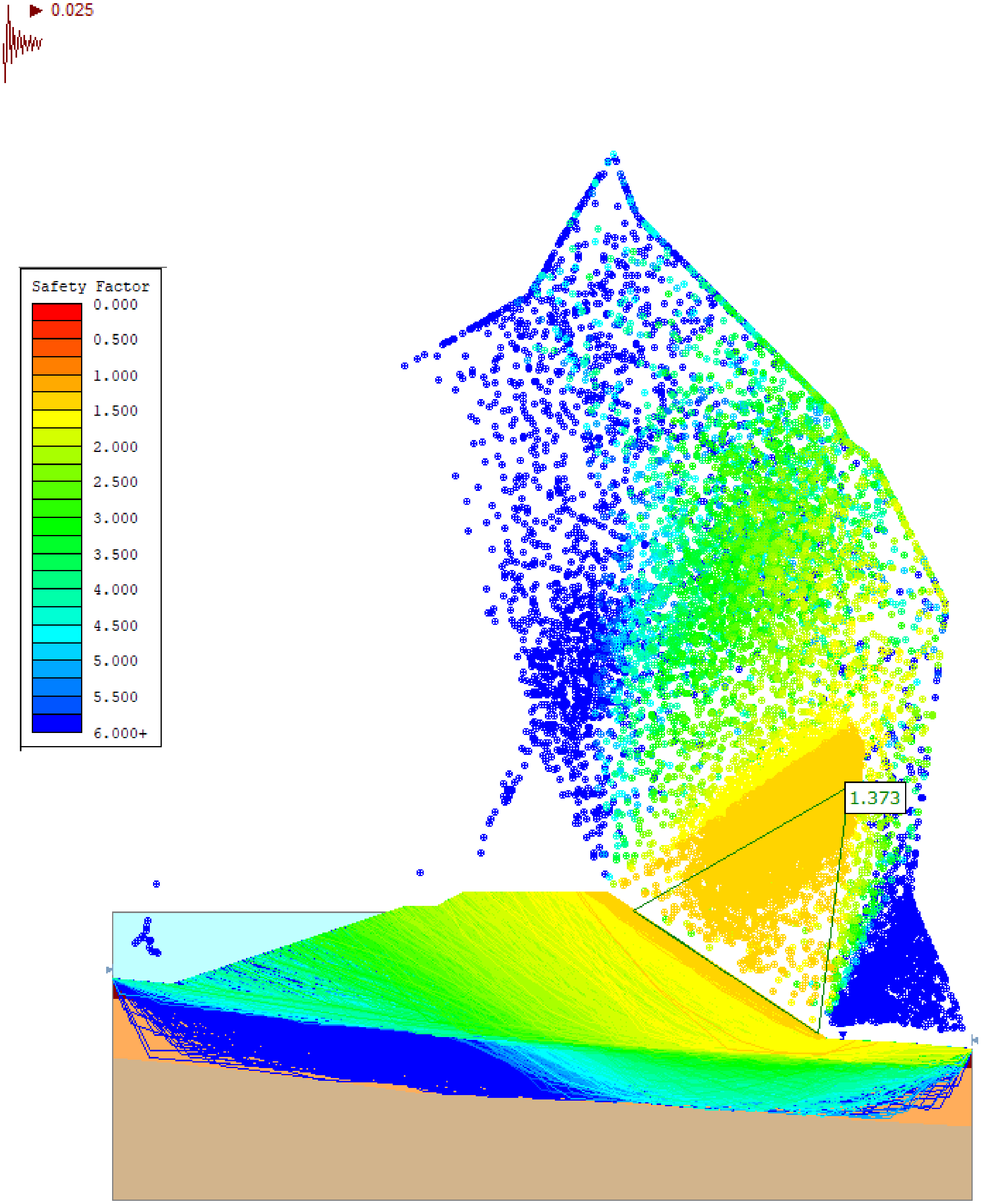
Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) – Frozen OB
Pseudo-static Analysis

Job No:	1CT022.43
Filename:	Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	17



Madrid CWP – As Built Slope Stability

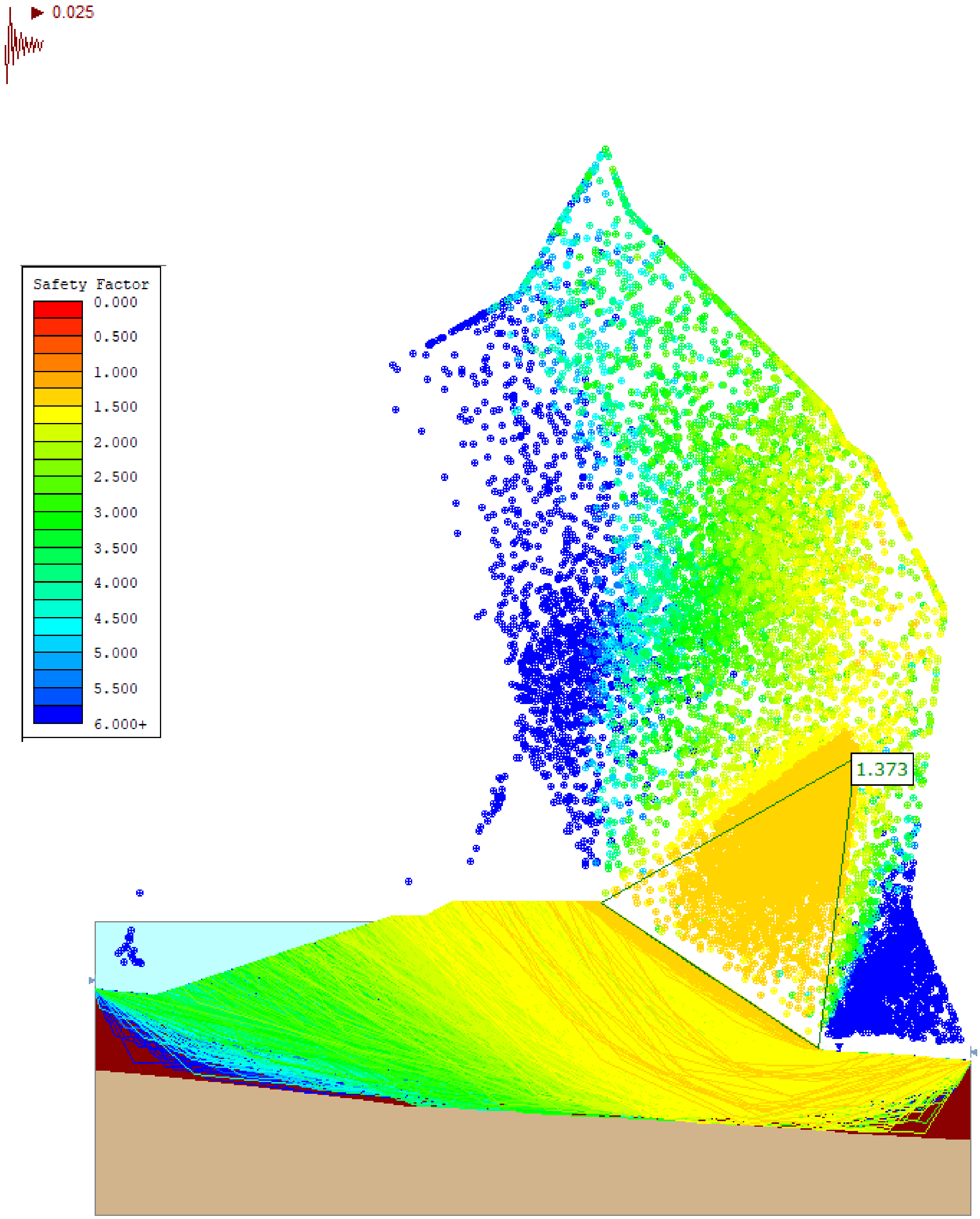
1.5:1.0 (H:V) – Thawed Active Layer Pseudo-static Analysis

Job No: 1CT022.43

Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date:	Approved:	Figure:
November 2019	RW	18



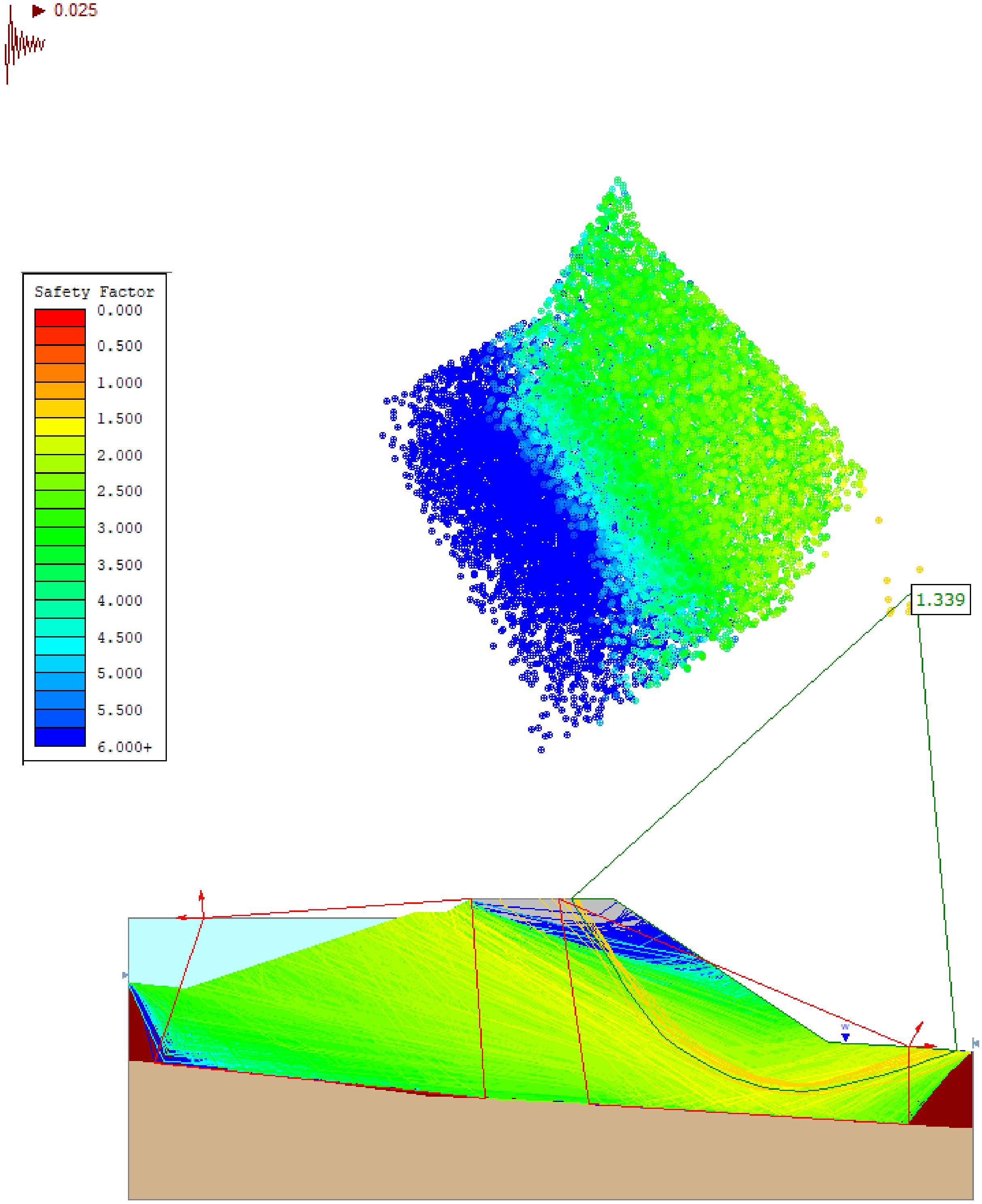
Job No:	1CT022.43
Filename:	Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) – Thawed OB
Pseudo-static Analysis

Date:	Approved:	Figure:
November 2019	RW	19



Madrid CWP – As Built Slope Stability

1.5:1.0 (H:V) – Thawed OB (Block Search)
Pseudo-static Analysis

Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019
Approved: RW
Figure: 20

Slope H:V	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Frozen OB	Thawed Act. Layer	Thawed OB	Thawed OB*
2.00:1.0	1.8	1.6	1.5	1.5
1.70:1.0	1.6	1.5	1.4	1.4
1.65:1.0	1.5	1.5	1.4	1.4
1.50:1.0	1.4	1.4	1.4	1.3

Target Factor of Safety (FoS) for pseudo-static analysis is 1.0.
(*) Block Search method to verify if different failure mechanism with lower FoS exists.

srk consulting

TMAC RESOURCES

Madrid CWP – As Built Slope Stability

Slope Stability Results Summary

Job No: 1CT022.43
Filename: Pseudo-Static_Stability_Figures.pptx

Hope Bay Project

Date: November 2019
Approved: RW
Figure: **21**

Appendix E – Grout and Mortar Product Datasheets

www.multicretesystems.com

MULTICRETE SUB ZERO™ GROUT

TECHNICAL DATA SHEET

Specially Formulated Grout

DESCRIPTION

Multicrete Sub Zero ™Grout is hydraulic cement based, non-ferrous, unsanded grout. This specially formulated grout features reliability and high performance for a variety of general grouting purposes.

USES

- Low temperature grouting
- Grouting anchors or cable bolts requiring rapid tensioning.
- Providing high early strength for anchors to allow quick "cycle" time.
- Patching high traffic areas that require minimal disruption.
- Grouting earth tieback anchors into porous soil where is flowing into drill holes.

ADVANTAGES

- This product can be used in applications where the substrate temperature can range from -10^{0}C to +5^{0}C (14^0 F to 41^0 F)
- Non-bleeding
- Non-segregation
- Precision Non-shrink

- Multicrete Sub Zero™Grout achieves strength of 15 MPa (over 2000 psi) in two to three hours.

- This makes it ideal for grouting in water-laden areas that require rapid strength gain.

- 29 MPa at 24 hours in -10^0 C conditions
- 31 MPa at 3 days in -10^0 C conditions

PACKAGING

Multicrete Sub Zero™Grout is packaged in 20 kg, heavy- duty, polyethylene-lined bags. Each bag yields approximately 0.46 cubic feet of grout. All Multicrete Sub Zero™ Grout packaged materials can be custom packaged to meet specific project requirements.

SAFETY PRECAUTIONS

Multicrete Sub Zero™ Grout contains Portland cement and carefully selected additives. Freshly mixed materials may cause skin irritation. Avoid direct contact and wash exposed skin area promptly with water. If any cementitious material gets into eyes, rinse immediately and repeatedly with water and seek prompt medical attention. Normal safety wear such as dust mask and rubber gloves used to handle conventional cement based products should be worn. See SDS for more information.

MIXING

- Recommended use with mechanical mixer with paddles. 40-60 rpm mixer is required to achieve max pot life.

- Product must remain dry prior to mixing.

- Use 7-8L of potable water per 20 kg bag.

- Ideally the dry product and water will be 17-22^{0}C prior to mixing. The wet mix temperature must initially be 17-22^{0}C. Ideal mix temperature is 20^{0}C.

- Note:
  Mixed grout will remain fluid/pumpable for 15 min after adding water. If more time is required, the grout must remain agitated as much as possible. If continuously mixed it will remain fluid for up to 30 min. After grout is 15 minutes old it MUST remain continuously agitated until ready to pump. It will begin to set up after 5 min in a static state after 15 min life.
  Due to limited pot life, only mix grout that can be placed within the time limit.
  Wash out equipment IMMEDIATELY after placing grout. Once grout has hardened it can only be removed manually or by mechanical device.

LIMITATIONS

- The area in which the grout will be placed must not be below -10^{0}C, be free of water, and cleared of all debris.

QC Dept 6/18

PRODUCT DATA SHEET

Edition 12.2018/v1
CSC Master Format™ 03 01 00
MAINTENANCE OF CONCRETE

Sikaset® Plug

FAST-SETTING COMPOUND FOR LEAK SEALING AND CONCRETE REPAIRS

Description

Use Sikaset® Plug to seal leaks and make permanent high strength repairs. Grey, non-hygroscopic, chloride-free powder, contains Sika's exclusive organic accelerator.

Where to Use

- Seal leaks or makes quick masonry or concrete repairs.
- Floors, walls, sidewalks.
- For fast repair of pipe and other precast concrete products.
- Excellent for sewage and water treatment plant maintenance and repair.

Advantages

- Ready to use powder requires only addition of water.
- Sets rapidly even when mix water temperature is at 4 °C (39 °F) and ambient temperature is at 2 °C (35 °F).
- Low-shrinkage Sikaset® Plug is highly resistant to sewage and sulfate attack.

Technical Data

Packaging	1 kg (2.2 lb) bag, 6/carton, 5 kg (11 lb) bag, 4/carton, 22.7 kg (50 lb) pail
Colour	Concrete Grey
Yield	Mixed as below, 1 kg (2.2 lb) will yield approx 0.6 L (0.02 ft³) of mortar or 5 plugs; 5 kg (11 lb) will yield approx. 2.9 L (0.1 ft³) of mortar or 25 plugs; 22.7 kg (50 lb) will yield approx 13 L (0.45 ft³) of mortar or 113 plugs.
Shelf Life	1 year in original, unopened packaging. Store dry at 5 to 32 °C (41 to 89 °F), ensuring that product is not exposed to rain, condensation or high humidity.
Mix Ratio (by volume)	Water: Sikaset® Plug 1:3

Properties at 23 °C (73 °F) and 50 % R.H.

Setting Time ASTM C266	90 - 130 sec
Compressive Strength ASTM C109	
28 days	30 MPa (4350 psi)

Product properties are typically averages, obtained under laboratory conditions. Reasonable variations can be expected on-site due to local factors, including environment, preparation, application, curing and test methods.

HOW TO USE

Surface Preparation / Application

Leak Sealing - Prepare leaking areas by chipping away unsound concrete and forming a V-shaped hole or slot. Use Sikaset® Plug to seal all adjacent seepage and slight leaks before plugging the larger leaks. For large leaks, form carrot-shaped plugs and wait until nearly hard before pushing into leak.

Patching - Trowel Sikaset® Plug on damaged precast members; knead into honeycombs with rubber gloved hand. Seal container tightly after use.

Mixing

Add 1 part by volume of potable water to 3 parts of Sikaset® Plug and mix to consistency of stiff putty. Use mixing water with temperature of 21 °C (70 °F). Set is slowed slightly at lower temperatures.

Clean Up

Remove Sikaset® Plug from tools and mixing equipment with water. Cured product can only be removed mechanically.

Limitations

- Important: protect stored material from exposure to rain, condensation and high humidity as moisture may penetrate packaging, causing lumps.
- For best results, condition product to 18 to 29 °C (65 to 84 °F) prior to mixing and installation. Lower temperatures may result in slower strength development and longer cure times.

Health and Safety Information

For information and advice on the safe handling, storage and disposal of chemical products, users should refer to the most recent SAFETY DATA SHEET containing physical, ecological, toxicological and other safety-related data.

KEEP OUT OF REACH OF CHILDREN

SIKA CANADA INC.
Head Office
601, avenue Delmar
Pointe-Claire, Quebec
H9R 4A9

Other locations
Toronto
Edmonton
Vancouver

1-800-933-SIKA
www.sika.ca

Certified ISO 9001 (CERT-0102780)
Certified ISO 14001 (CERT-0102791)

Appendix F – Geotextile and Liner Product Datasheets

TE-12

12oz CIVIL NONWOVEN GEOTEXTILE

Titan has provided the containment and erosions control industries with the highest quality geotextiles available. Our nonwoven needle punched geotextiles are manufactured using polypropylene fibers, which are formed into a dimensionally stable network which allows the fibers to maintain their relative position. These products resist ultraviolet deterioration, rotting, biological degradation, and are inert to commonly encountered soil chemicals.

TESTED PROPERTY	**TEST METHOD**	**UNIT ENGLISH (METRIC)**	**VALUE ENGLISH (METRIC)**
Tensile Strength (Grab)	ASTM D 4632	lbs (N)	300 (1335)
Elongation	ASTM D 4632	%	50
CBR Puncture	ASTM D 6241	lbs (N)	825 (3671)
Trapezoid Tear	ASTM D 4533	lbs (N)	115 (511)
U.V. Resistance	ASTM D 4355	%/hrs	70/500
Apparent Opening Size (AOS)*	ASTM D 4751	U.S. Sieve (mm)	100 (0.150)
Permittivity	ASTM D 4491	sec^{-1}	1.0
Water Flow	ASTM D 4491	gpm/ft^2 ($l/min/m^2$)	75 (3055)
TYPICAL ROLL DIMENSIONS			
Roll Dimensions		ft	12.5 x 360 15 x 300
Roll Area		yd^2	500
Estimated Roll Weight		lbs	375

NOTES:

*Maximum average roll value.

Mullen Burst ASTM D 3768 has been removed. It is not recognized by ASTM D 35 on Geosynthetics.

Puncture ASTM D 4833 has been removed. It is not recognized by AASHTO M288 and has been replaced with CBR Puncture ASTM D 6241.

TECHNICAL DATA SHEET

HDPE Series, 1.50 mm

Black, Top Side Single Textured

2801 Marie-Victorin Blvd. Varennes, Quebec Canada J3X 1P7
Tel: (450) 929-1234 Sales: (450) 929-2544 Toll free in North America:1-800-571-3904 www.Solmax.com www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Metric	1022403
SPECIFICATIONS				
Nominal Thickness		-	mm	1.50
Thickness (min. avg.)	ASTM D5994	Every roll	mm	1.43
Lowest ind. for 8 out of 10 values			mm	1.35
Lowest ind. for 10 out of 10 values			mm	1.28
Asperity Height (min. avg.) (3)	ASTM D7466	Every roll	mm	0.40
Textured side		-		Top
Melt Index - 190/2.16 (max.)	ASTM D1238	1/Batch	g/10 min	1.0
Sheet Density (8)	ASTM D792	Every 10 rolls	g/cc	≥ 0.940
Carbon Black Content (9)	ASTM D4218	Every 2 rolls	%	2.0 - 3.0
Carbon Black Dispersion	ASTM D5596	Every 10 rolls	Category	Cat. 1 / Cat. 2
OIT - standard (avg.)	ASTM D3895	1/Batch	min	100
Tensile Properties (min. avg) (2)	ASTM D6693	Every 2 rolls		
Strength at Yield			kN/m	23
Elongation at Yield			%	13
Strength at Break			kN/m	23
Elongation at Break			%	150
Tear Resistance (min. avg.)	ASTM D1004	Every 5 rolls	N	200
Puncture Resistance (min. avg.)	ASTM D4833	Every 5 rolls	N	535
Dimensional Stability	ASTM D1204	Certified	%	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D5397	1/Batch	hr	500
Oven Aging - % retained after 90 days	ASTM D5721	Per formulation		
HP OIT (min. avg.)	ASTM D5885		%	80
UV Res. - % retained after 1600 hr	ASTM D7238	Per formulation		
HP-OIT (min. avg.)	ASTM D5885		%	50
Low Temperature Brittleness	ASTM D746	Certified	°C	- 77
SUPPLY SPECIFICATIONS (Roll dimensions may vary ±1%)				
Roll Dimension - Width			m	8.00
Roll Dimension - Length			m	135.0
Area (Surface/Roll)			m²	1080.0

(Rev. 03 / 2018-05-31)

NOTES

1. Testing frequency based on standard roll dimension and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

* All values are nominal test results, except when specified as minimum or maximum.
* The information contained herein is provided for reference purposes only and is not intended as a warranty of guarantee. Final determination of suitability for use contemplated is the sole responsability of the user. SOLMAX assumes no liability in connection with the use of this information.

Solmax is not a design professional and has not performed any design services to determine if Solmax's goods comply with any project plans or specifications, or with the application or use of Solmax's goods to any particular system, project, purpose, installation or specification.

Appendix G – QC Report for Liner Installation

A&A Technical Services
Yellowknife NT

TMAC Resources
Hope Bay
Madrid CWP HDPE Liner installation
June 25 - July 24, 2019

A&A Technical Services
Yellowknife NT

TMAC Resources
Hope Bay
Madrid CWP HDPE Liner installation
June 25 - July 24, 2019

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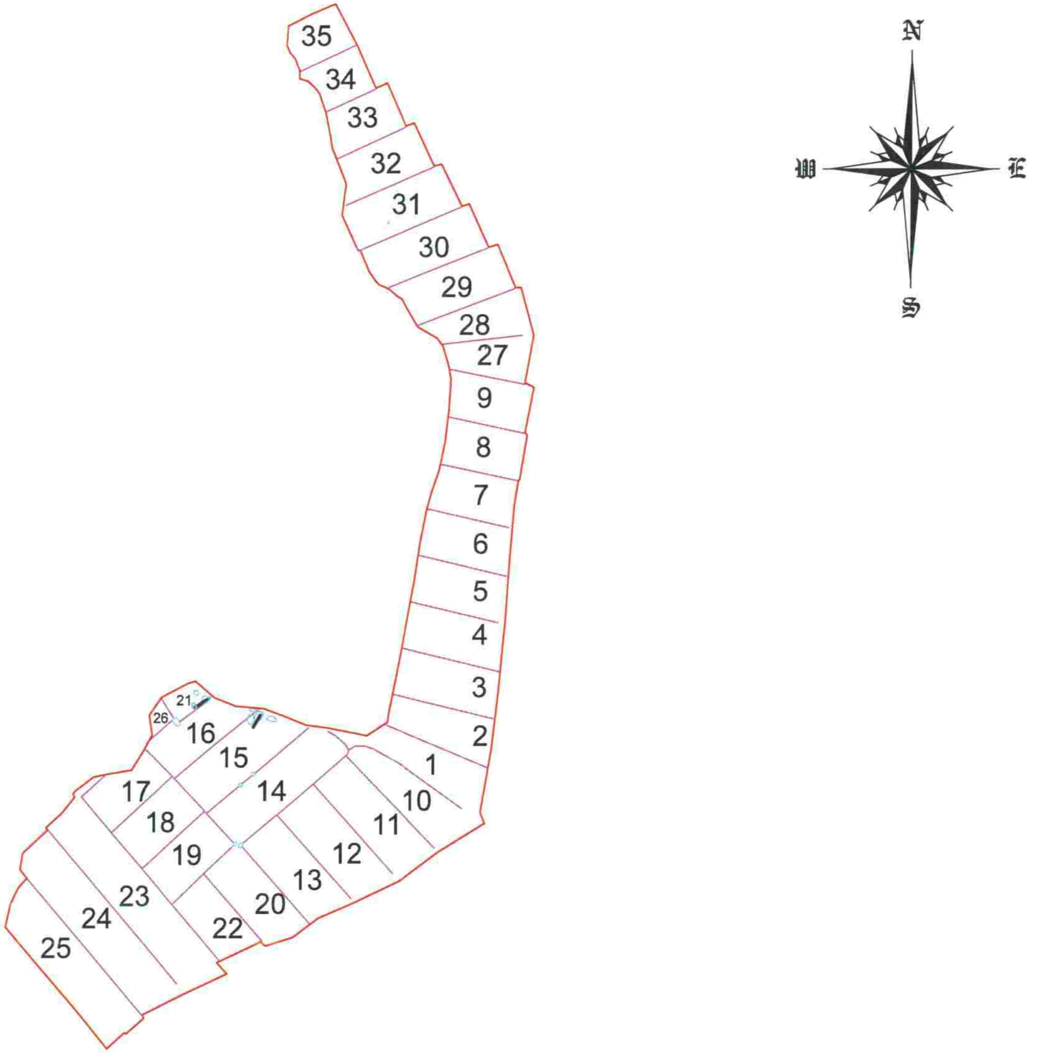
A&A TECHNICAL SERVICES



NOTES:
ALL UNITS IN METRES U.N.O.

PERIMETER : 409 m

AREA : 3202 m2

DATA FILE(S):		REV	DESCRIPTION

DRAWN BY: Jean-Simon Hurtubise
CHECKED BY: Jean-Simon Hurtubise
SURVEYED BY: Jean-Simon Hurtubise
DATE DRAWN: JULY 23 , 2019
DATE SURVEYED: JULY 19-23, 2019
FILE NAME: CWP LINER ASB
SUB-ARCTIC GEOMATICS JOB NO.: 80003

Sub-Arctic Geomatics Ltd.
a CHALLENGER GEOMATICS LTD. company

BOX 2441 YELLOWKNIFE
NORTHWEST TERRITORIES
X1A 2P8
PHONE: 867-873-2047 FAX: 867-873-9079
WEB: WWW.SUB-ARCTIC.CA
EMAIL: SAG@SUB-ARCTIC.CA

TMAC RESOURCES
HOPE BAY PROJECT

HOPE BAY

CWP LINER AS BUILT

DRAWING NO.: CWP LINER ASB
SHEET: 1 OF 1
REVISION NO.: 0

A&A Technical Services
Yellowknife NT

TMAC Resources
Hope Bay - Madrid CWP HDPE Liner
Panel log

Panel #	Solmax roll number	Length m	width	m2
P-1	138390	22.5	6.7	150.8
P-2	138390	14.5	6.7	99.3
P-3	138390	14.3	6.7	97.2
P-4	138390	14.5	6.7	95.8
P-5	138390	13.5	6.7	97.2
P-6	138390	11.8	6.7	90.5
P-7	138390	11.4	6.7	79.1
P-8	138390	11.0	6.7	76.4
P-9	138390	12.0	6.7	73.7
P-10	138390	11.0	6.7	80.4
P-11	138390	16.0	6.7	73.7
P-12	138390	15.0	6.7	107.2
P-13	138390	15.0	6.7	100.5
P-14	138390	19.5	6.7	100.5
P-15	138390	18.4	6.7	130.7
P-16	138390	17.6	6.7	123.3
P-17	138390	6.0	6.7	117.9
P-18	138390	12.0	6.7	40.2
P-19	138390	12.0	6.7	80.4
P-20	138401	12.0	6.7	80.4
P-21	138401	7.0	6.7	80.4
P-22	138401	11.3	2.3	46.9
P-23	138401	28.5	6.7	26.0
P-24	138401	27.1	6.7	191.0
P-25	138401	28.1	6.7	181.6
P-26	138401	3.7	1.1	188.3
P-27	138401	4.0	5.5	4.1
P-28	138401	11.2	5.5	22.0
P-29	138401	14.5	6.8	61.6
P-30	135267	14.7	6.6	98.6
P-31	135267	16.1	6.7	97.0
P-32	135267	15.1	6.7	107.9
P-33	135267	11.5	6.7	101.2
P-34	135267	9.1	6.7	77.1
P-35	135267	7.9	6.7	61.0
P-36	135267	8.9	6.7	52.9
			Total m2	**3292.26**

A&A Technical Services
Yellowknife NT
June/July 2019

TMAC Resources
Hope Bay - Madrid CWP HDPE Liner

Daily welder qualifiction tests

Peel strength Temp. 400 C Speed 2.3m/minute

28-Jun-19	Inside weld	Outside weld	Minimum ppi (lbs/inch)
1	136	141	91
2	140	140	91
3	142	136	91
4	145	142	91
28-Jun-19	**Shear Strength**		Minimum ppi (lbs/inch)
1	161		120
2	155		120

Peel strength Temp. 400 C Speed 2.3m/minute

05-Jul-19	Inside weld	Outside weld	Minimum ppi (lbs/inch)
1	144	135	91
2	146	150	91
3	148	151	91
4	146	149	91
05-Jul-19	**Shear Strength**		Minimum ppi (lbs/inch)
1	161		120
2	160		120

Peel strength Temp. 400 C Speed 2.3m/minute

08-Jul-19	Inside weld	Outside weld	Minimum ppi (lbs/inch)
1	140	142	91
2	146	138	91
3	139	144	91
4	142	145	91
08-Jul-19	**Shear Strength**		Minimum ppi (lbs/inch)
1	158		120
2	155		120

A&A Technical Services
Yellowknife NT
June/July 2019

TMAC Resources
Hope Bay - Madrid CWP HDPE Liner

Daily welder qualifiction tests

Peel strength Temp. 400 C Speed 2.3m/minute

16-Jul-19	Inside weld	Outside weld	Minimum ppi (lbs/inch)
1	144	142	91
2	140	137	91
3	148	142	91
4	139	139	91
16-Jul-19	**Shear Strength**		Minimum ppi (lbs/inch)
1	158		120
2	161		120

Peel strength Temp. 400 C Speed 2.3m/minute

22-Jul-19	Inside weld	Outside weld	Minimum ppi (lbs/inch)
1	144	145	91
2	135	139	91
3	140	143	91
4	145	140	91
22-Jul-19	**Shear Strength**		Minimum ppi (lbs/inch)
1	153		120
2	159		120

Extrusion welder qualification Preheat 250 C Extrudite 250 C

08-Jul-19	**Peel strength**		Minimum ppi (lbs/inch)
1	138		78
2	144		78
	Shear Strength		
1	158		120
2	152		120

Extrusion welder qualification Preheat 250 C Extrudite 250 C

22-Jul-19	**Peel strength**		Minimum ppi (lbs/inch)
1	141		78
2	139		78
	Shear Strength		
1	162		120
2	158		120

A&A Technical Services
Yellowknife NT
June/July 2019

TMAC Resources
Hope Bay - Madrid CWP HDPE Liner

Non destructive air pressure testing of wedge weld seams. (5minutes)

Date	Technician	Seam location	Start psi	Finish psi	Pass/Fail	Comments
28-Jun-19	AH	P1-P2	35	35	Pass	
28-Jun-19	AH	P2-P3	30	30	Pass	
28-Jun-19	AH	P-3-P4	32	32	Pass	
28-Jun-19	AH	P-4-P5	32	32	Pass	
28-Jun-19	AH	P-5-P-6	35	35	Pass	
28-Jun-19	AH	P6-P7	30	30	Pass	
03-Jul-19	AH	P7-P8	30	30	Pass	Witnessed by SRK
03-Jul-19	AH	P8-P9	35	35	Pass	
05-Jul-19	AH	P1-P10	30	30	Pass	
05-Jul-19	AH	P10-P11	35	35	Pass	
05-Jul-19	AH	P11-P12	35	35	Pass	
05-Jul-19	AH	P12-P13	35	35	Pass	
08-Jul-19	AH	P14-P15a	35	35	Pass	
08-Jul-19	AH	P14-P15b	32	32	Pass	
08-Jul-19	AH	P15-P16	35	35	Pass	
16-Jul-19	GH	P17-P18	30	30	Pass	
16-Jul-19	GH	P18-P19	30	30	Pass	
16-Jul-19	GH	P13-P20	30	30	Pass	
16-Jul-19	GH	P20-P22	30	30	Pass	
16-Jul-19	GH	Toe P11	30	30	Pass	
16-Jul-19	GH	Toe P12	30	30	Pass	
16-Jul-19	GH	Toe P13	30	30	Pass	
16-Jul-19	GH	Toe P20	30	30	Pass	
16-Jul-19	GH	Toe P22	30	30	Pass	
16-Jul-19	GH	P22-P23	30	30	Pass	
17-Jul-19	GH	P19-P23	30	30	Pass	
17-Jul-19	GH	P18-P23	30	30	Pass	
17-Jul-19	GH	P17-P23	30	30	Pass	
17-Jul-19	GH	P23-P24	30	30	Pass	
17-Jul-19	GH	P21-P26	32	32	Pass	
17-Jul-19	GH	P26-P16	30	30	Pass	
22-Jul-19	GH	P9-P27	30	30	Pass	
22-Jul-19	GH	P27-P28	30	30	Pass	
22-Jul-19	GH	P28-P29	30	30	Pass	

P1 = Liner panel number in relation to drawing

A&A Technical Services
Yellowknife NT
June/July 2019

TMAC Resources
Hope Bay - Madrid CWP HDPE Liner

Non destructive air pressure testing of wedge weld seams. (5minutes)

Date	Technician	Seam location	Start psi	Finish psi	Pass/Fail	Comments
22-Jul-19	GH	P29-P30	30	30		
22-Jul-19	GH	P30-P31	30	30		
22-Jul-19	GH	P31-P32	30	30		
22-Jul-19	GH	P32-P33	30	30		
22-Jul-19	GH	P34-P35	30	30		
	Vaccum box testing of extrusion patches					
Date	Technician	Location			Pass/Fail	
18-Jul-19	patches on seam				Pass	
		P14-P15				
18-Jul-19	Patches at toe of				Pass	
		P20 and P13				
22-Jul-19	Patches on P15-P16-P26				Pass	

P1 = Liner panel number in relation to drawing

CERTIFIED WELDING TECHNICIAN

The International Association of Geosynthetic Installers
Certifies:

ALAN HARMAN

As a **Certified Welding Technician**, in polyethylene wedge and extrusion welding, having demonstrated superior hands-on skills, knowledge and experience in the welding and installation of polyethylene (PE) geomembranes, and having basic mechanical aptitude for working with welders and equipment on the job site.
Registration number: **CWT162010**

Valid 07 June 2016 — 07 June 2021

President, IAGI
Todd Harman

Managing Director, IAGI

CERTIFIED WELDING TECHNICIAN

The International Association of Geosynthetic Installers
Certifies:

GUY HORESAY

As a **Certified Welding Technician**, in polyethylene wedge and extrusion welding, having demonstrated superior hands-on skills, knowledge and experience in the welding and installation of polyethylene (PE) geomembranes, and having basic mechanical aptitude for working with welders and equipment on the job site.
Registration number: **CWT170010**

Valid 07 June 2016 — 07 June 2021

President, IAGI

Todd Harman

Managing Director, IAGI

A&A Technical Services
Subgrade acceptance and warranty

Client –TMAC Resources
Hope Bay
Madrid CWP HDPE Liner installation
June 25 - July 24, 2019

Upon arrival to site the fuel tank pad area to be lined was thoroughly inspected by A&A Technical Services installation supervisor and deemed to be a suitable surface on which to place the HDPE lining system. The SOLMAX 60mil textured HDPE liner was under laid with a layer of 540g/m2 non-woven geotextile supplied by the client.

Warranties issued by A&A Technical Services shall cover only the cost of replacement and/or repair of defective installations, determined or agreed to be the responsibility of A&A Technical Services, provide that the warranty work will be performed to the same standards and scope of work set out in the contract documents. A&A's installation warranty shall commence upon acceptance of the individual geosynthetic components by the owner or its representative as such components are completed. The installation warranty period shall not exceed beyond 1 years. Our installation warranty is rendered null and void if the installed geosynthetics are subject to abuse by machinery, equipment or personnel not under the control of A&A, harmful chemicals or unusual weather conditions or catastrophic earthworks failures.

A&A Technical Services shall not be held liable for defects, damage and/or deficient materials and installations, either in whole or in part should the defects, damage or deficient materials and installations arise as the result from the use of poor quality and inappropriate or unsuitable earthworks material or site preparation. This limitation of liability extends to improper and/or construction techniques, and methods and equipment used to create the earthworks covering all or any portion of the completed geosynthetic installation.

Signed: Alan Harman Dated: July 25, 2019

Al Harman
President
A&A Technical Services
Yellowknife NT

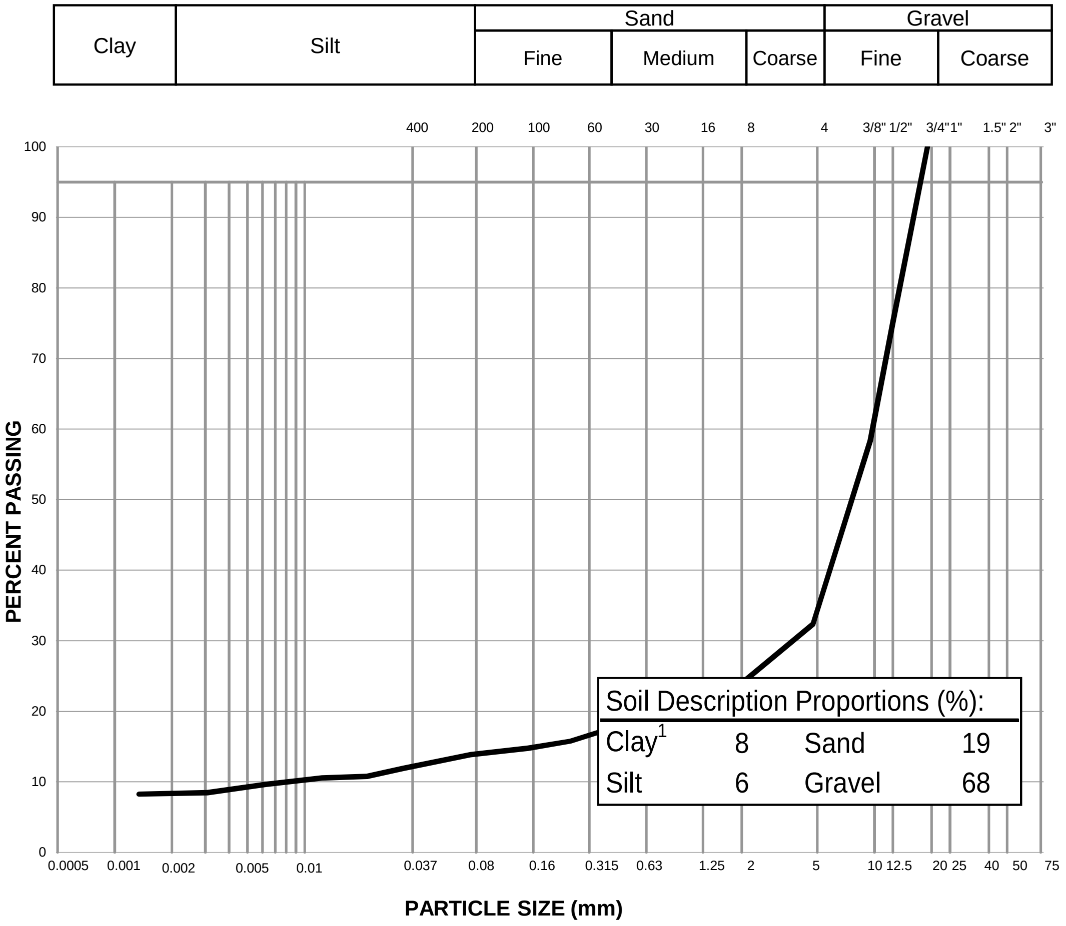
Appendix H – QA/QC Testing Laboratory Results

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Laboratory Testing Services, South Dam	Sample No.:	7031-A		
Project No.:	704-Y14103336-02.003	Material Type:	Gravel Bentonite Mix		
Site:	HB -Madrid Contact Water Pond Project	Sample Loc.:	N/R		
Client:	TMAC Resources Inc.	Sample Depth:	N/R		
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab		
Date Tested:	August 5, 2019 By: WM/TO	Date sampled:	N/R		
Soil Description[2]:	GRAVEL, some sand, trace silt and clay	Sampled By:	Client		
		USC Classification:	GC	Cu:	1185.2
Moisture Content:	1.5%			Cc:	196.1

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	75
9.5	58
4.75	32
2	24
0.83	20
0.425	18
0.25	16
0.15	15
0.075	13.9
0.0330	11.9
0.0213	10.8
0.0123	10.6
0.0088	10.1
0.0063	9.6
0.0031	8.5
0.0013	8.3



Soil Description Proportions (%):

Clay[1]	8	Sand	19
Silt	6	Gravel	68

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks: Load B-1

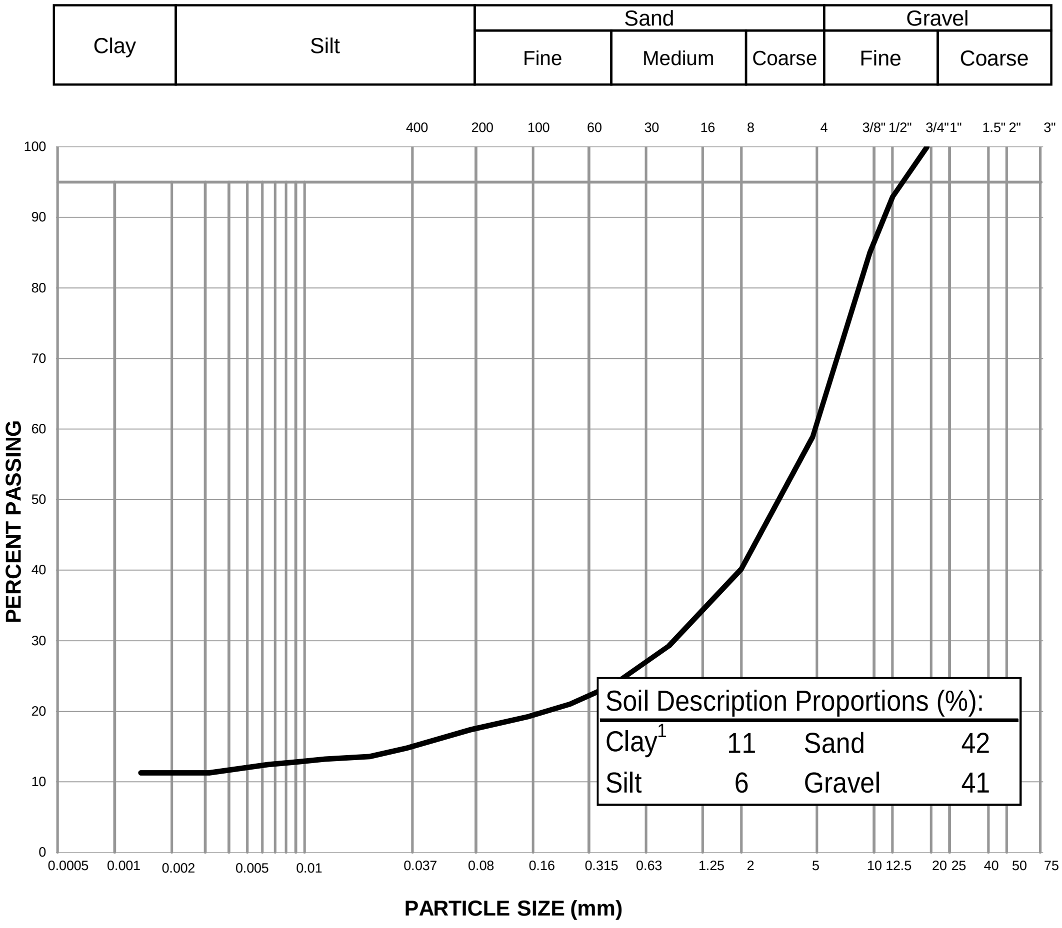
Reviewed By: P.Eng.

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Laboratory Testing Services, South Dam	Sample No.:	7031-B
Project No.:	704-Y14103336-02.003	Material Type:	Gravel Bentonite Mix
Site:	HB -Madrid Contact Water Pond Project	Sample Loc.:	N/R
Client:	TMAC Resources Inc.	Sample Depth:	N/R
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2019 By: WM/TO	Date sampled:	N/R
Soil Description[2]:	SAND and GRAVEL, some clay, trace silt	Sampled By:	Client
		USC Classification:	SC Cu: #N/A
Moisture Content:	2.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	93
9.5	85
4.75	59
2	40
0.83	29
0.425	24
0.25	21
0.15	19
0.075	17.4
0.0346	14.8
0.0221	13.6
0.0128	13.2
0.0091	12.8
0.0064	12.4
0.0031	11.3
0.0014	11.3



Soil Description Proportions (%):

Clay[1]	11	Sand	42
Silt	6	Gravel	41

Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks: Load B-2

Reviewed By: P.Eng.

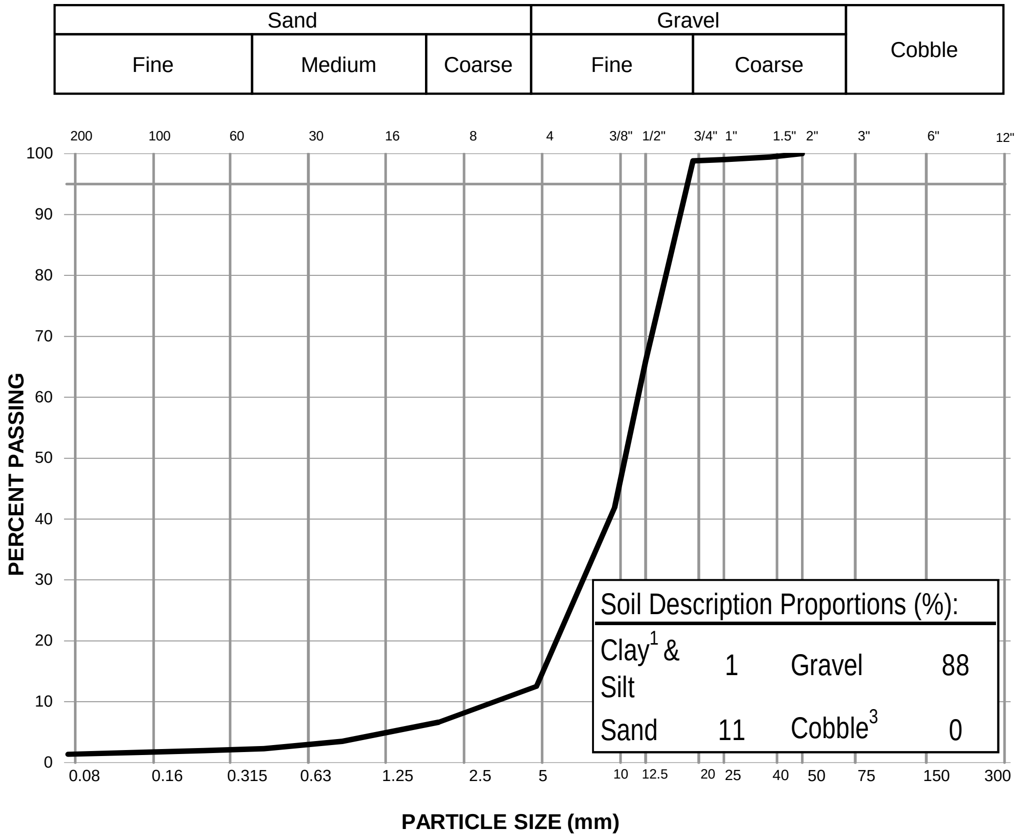
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Laboratory Testing Services, South Dan	Sample No.:	7012
Project No.:	Y14103336-02.003	Material Type:	Crushed Gravel
Site:	CWP	Sample Loc.:	Not Reported
Client:	TMAC Resources Inc.	Sample Depth:	Not Reported
Client Rep.:	Ryan Williams	Sampling Method:	Not Reported
Date Tested:	July 20, 2019 By: WM/TO	Date sampled:	Not Reported
Soil Description[2]:	GRAVEL, some sand, trace silt/clay	Sampled By:	Client
		USC Classification:	GP Cu: 3.3
Moisture Content:	2.4%		Cc: 1.4

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	
50	100
37.5	99
25	99
19	99
12.5	66
9.5	42
4.75	13
2	7
0.85	4
0.425	2
0.25	2
0.15	2
0.075	1.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to Tt WM4400 description protocols

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: __________

Remarks: Bucket had hole melted through bottom, approximately 20 mm diameter.

Reviewed By: __________ P.Eng.

TETRA TECH

CONCRETE STRENGTH TEST RESULTS

CSA Standard A283
Concrete Testing

CSA A23.2

Project No.: Y14103336-02.001
Project: **Hope Bay Concrete Testing**

Client: TMAC Resources Inc.

Email: mike.monk@tmacresources.com

Att'n: Mike Monk

Element Cast & Location Tested:
Plinth 6 and 7, dental towards northern tie in

Test No.: 3336-817-820
Placing Method: Not Reported

Information From Delivery Ticket

Supplier: Nahanni Construction Ltd.
Truck No: 1 Batch Time:
Ticket No: Mix No:
Load Amount: m³ Total: m³
Strength: MPa Max Agg. Size: mm
Cement Type: Slump/Flow: mm
Admixture: Air ☐ SP ☐ Acc. ☐ Air Content: %
Other: Winter Heat: ☐

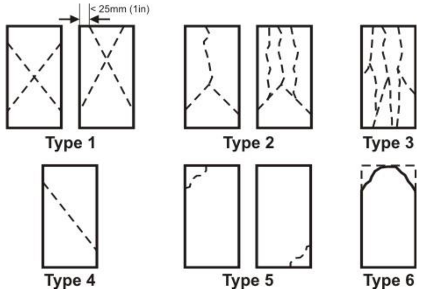
Contract Specifications as Provided

Same as Delivery Ticket: ☐ Not Available: ☐
Strength: MPa Test Age: days
Slump/Flow: mm Air Content: %
Class of Concrete: Cement Type:

Concrete Samples Delivered by Client, Field Testing by Others

Test Time: Unit Weight: kg/m³ Mould Type: Plastic
Temperature: Air: °C Concrete: °C Diameter: 101.6 mm
Cast Slump/Flow: mm Cast Air Content: %
Initial Slump: mm Initial Air content: %
Concrete Setting Temp. Within CSA Limits (15-25 °C): y/n (see remarks if No)
Date Cast: June 30, 2019 By: Client
Date Received: July 9, 2019 By: WM

Sample Fracture Type



Laboratory Test Data

Cylinder Number	Age Days	Test Date (Y/M/D)	Test By	Load kN	Strength MPa	Type of Fracture	Comments
3336-817	10	19 07 10	WM	227.1	28.0	1	Cylinder mass = 3831 g
3336-818	28	19 07 28					Cylinder mass = 3779 g
3336-819	28	19 07 28					Cylinder mass = 3842 g
3336-820	56	19 08 25					Cylinder mass = 3781 g

Remarks: No test data reported. Cylinder tops unusable, cylinders trimmed. No length/diameter correction necessary.

Apparent density of cylinder 817 = 2392 kg/m³

Distribution:
mike.monk@tmacresources.com
JeanPhilippe.Houle@tmacresources.com
murray.weddell@tmacresources.com>

Reviewed By: ______ P.Geol.

Yellowknife, NT

TETRA TECH

CONCRETE STRENGTH TEST RESULTS

CSA Standard A283
Concrete Testing

CSA A23.2

Project No.: Y14103336-02.001

Project: **Hope Bay Concrete Testing**

Client: TMAC Resources Inc.

Email: mike.monk@tmacresources.com

Att'n: Mike Monk

Element Cast & Location Tested:
Plinth 6 and 7, dental towards northern tie in.

Test No.: 3336-821-822

Placing Method: Not Reported

Information From Delivery Ticket

Supplier: Nahanni Construction Ltd.

Truck No: 2

Batch Time:

Ticket No:

Mix No:

Load Amount: m³

Total: m³

Strength: MPa

Max Agg. Size: mm

Cement Type:

Slump/Flow: mm

Admixture: Air ☐ SP ☐ Acc. ☐

Air Content: %

Other:

Winter Heat: ☐

Contract Specifications as Provided

Same as Delivery Ticket: ☐

Not Available: ☐

Strength: MPa

Test Age: days

Slump/Flow: mm

Air Content: %

Class of Concrete:

Cement Type:

Concrete Samples Delivered by Client, Field Testing by Others

Test Time:

Unit Weight: kg/m³

Mould Type: Plastic

Temperature: Air: °C

Concrete: °C

Diameter: 101.6 mm

Cast Slump/Flow: mm

Cast Air Content: %

Initial Slump: mm

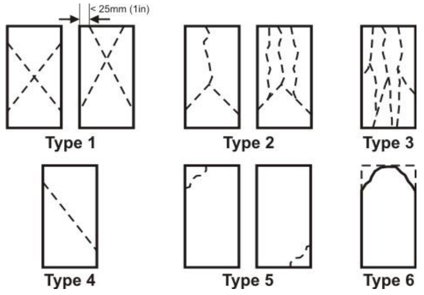
Initial Air content: %

Concrete Setting Temp. Within CSA Limits (15-25 °C): y/n (see remarks if No)

Date Cast: June 30, 2019 By: Client

Date Received: July 9, 2019 By: WM

Sample Fracture Type



Laboratory Test Data

Cylinder Number	Age Days	Test Date (Y/M/D)	Test By	Load kN	Strength MPa	Type of Fracture	Comments
3336-821	10	19 07 10	WM	240.8	29.7	1	Cylinder mass = 3773 g
3336-822	28	19 07 28					Cylinder mass = 3777 g

Remarks: No test data reported. Cylinder tops unusable, cylinders trimmed. No length/diameter correction necessary.

Apparent density of cylinder 821 = 2383 kg/m³

Distribution:

mike.monk@tmacresources.com
JeanPhilippe.Houle@tmacresources.com
murray.weddell@tmacresources.com>

Reviewed By: BF. P.Geol.

Yellowknife, NT

TETRA TECH

CONCRETE STRENGTH TEST RESULTS

CSA Standard A283
Concrete Testing

CSA A23.2

Project No.: Y14103336-02.001
Project: **Hope Bay Concrete Testing**

Client: TMAC Resources Inc.

Email: mike.monk@tmacresources.com

Att'n: Mike Monk

Element Cast & Location Tested:
Plinth 8 (at northern tie in), dental either side of plinth 7, plinths.
Test No.: 3336-823-824
Placing Method: Not Reported

Information From Delivery Ticket

Supplier: Nahanni Construction Ltd.
Truck No: 1
Batch Time:
Ticket No:
Mix No:
Load Amount: m³
Total: m³
Strength: MPa
Max Agg. Size: mm
Cement Type:
Slump/Flow: mm
Admixture: Air ☐ SP ☐ Acc. ☐
Air Content: %
Other:
Winter Heat: ☐

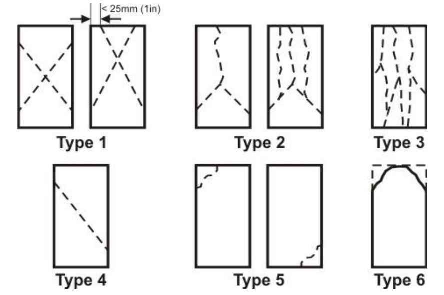
Contract Specifications as Provided

Same as Delivery Ticket: ☐
Not Available: ☐
Strength: MPa
Test Age: days
Slump/Flow: mm
Air Content: %
Class of Concrete:
Cement Type:

Concrete Samples Delivered by Client, Field Testing by Others

Test Time:
Unit Weight: kg/m³
Mould Type: Plastic
Temperature: Air: °C
Concrete: °C
Diameter: 101.6 mm
Cast Slump/Flow: mm
Cast Air Content: %
Initial Slump: mm
Initial Air content: %
Concrete Setting Temp. Within CSA Limits (15-25 °C): y/n (see remarks if No)
Date Cast: July 2, 2019 By: Client
Date Received: July 9, 2019 By: WM

Sample Fracture Type



Laboratory Test Data

Cylinder Number	Age Days	Test Date (Y/M/D)	Test By	Load kN	Strength MPa	Type of Fracture	Comments
3336-823	8	19 07 10	WM	332.0	41.0	1	Cylinder mass = 3829 g
3336-824	28	19 07 30					Cylinder mass = 3830 g

Remarks: No test data reported.
Apparent density of cylinder 823 = 2350 kg/m³

Distribution:
mike.monk@tmacresources.com
JeanPhilippe.Houle@tmacresources.com
murray.weddell@tmacresources.com>

Reviewed By: ____________ P.Geol.

Yellowknife, NT

TETRA TECH

CONCRETE STRENGTH TEST RESULTS

CSA Standard A283
Concrete Testing

CSA A23.2

Project No.: Y14103336-02.001
Project: **Hope Bay Concrete Testing**

Client: TMAC Resources Inc.

Email: mike.monk@tmacresources.com

Att'n: Mike Monk

Element Cast & Location Tested:
Most of plinth 4, some dental between plinth 2 and 3.

Test No.: 3336-825-826
Placing Method: Not Reported

Information From Delivery Ticket

Supplier: Nahanni Construction Ltd.
Truck No: 2
Batch Time:
Ticket No:
Mix No:
Load Amount: m³
Total: m³
Strength: MPa
Max Agg. Size: mm
Cement Type:
Slump/Flow: mm
Admixture: Air ☐ SP ☐ Acc. ☐
Air Content: %
Other:
Winter Heat: ☐

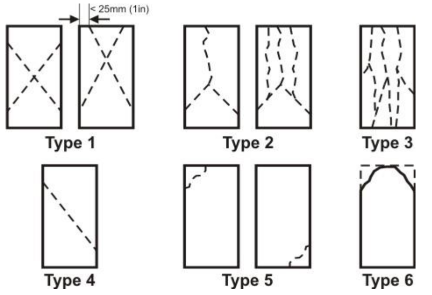
Contract Specifications as Provided

Same as Delivery Ticket: ☐
Not Available: ☐
Strength: MPa
Test Age: days
Slump/Flow: mm
Air Content: %
Class of Concrete:
Cement Type:

Concrete Samples Delivered by Client, Field Testing by Others

Test Time:
Unit Weight: kg/m³
Mould Type: Plastic
Temperature: Air: °C
Concrete: °C
Diameter: 101.6 mm
Cast Slump/Flow: mm
Cast Air Content: %
Initial Slump: mm
Initial Air content: %
Concrete Setting Temp. Within CSA Limits (15-25 °C): y/n (see remarks if No)
Date Cast: July 2, 2019 By: Client
Date Received: July 9, 2019 By: WM

Sample Fracture Type



Laboratory Test Data

Cylinder Number	Age Days	Test Date (Y/M/D)	Test By	Load kN	Strength MPa	Type of Fracture	Comments
3336-825	8	19 07 10	WM	290.4	35.8	1	Cylinder mass = 3854 g
3336-826	28	19 07 30					Cylinder mass = 3875 g

Remarks: No test data reported.
Apparent density of cylinder 825 = 2361 kg/m³

Distribution:
mike.monk@tmacresources.com
JeanPhilippe.Houle@tmacresources.com
murray.weddell@tmacresources.com>

Reviewed By: ____________ P.Geol.

Yellowknife, NT

CONCRETE STRENGTH TEST RESULTS

CSA Standard A283
Concrete Testing

CSA A23.2

Project No.: Y14103336-02.001
Project: **Hope Bay Concrete Testing**

Client: TMAC Resources Inc.

Email: mike.monk@tmacresources.com

Att'n: Mike Monk

Element Cast & Location Tested:
All of southern section plinths 9 and 10, plus dental remainder of plinth 4.
Test No.: 3336-827-828
Placing Method: Not Reported

Information From Delivery Ticket

Supplier: Nahanni Construction Ltd.
Truck No: 3
Batch Time:
Ticket No:
Mix No:
Load Amount: m³
Total: m³
Strength: MPa
Max Agg. Size: mm
Cement Type:
Slump/Flow: mm
Admixture: Air ☐ SP ☐ Acc. ☐
Air Content: %
Other:
Winter Heat: ☐

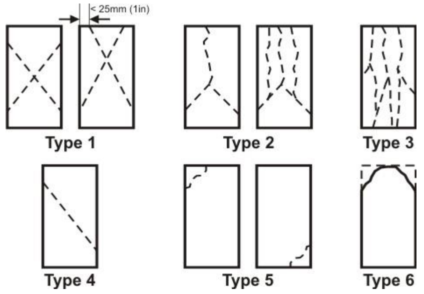
Contract Specifications as Provided

Same as Delivery Ticket: ☐
Not Available: ☐
Strength: MPa
Test Age: days
Slump/Flow: mm
Air Content: %
Class of Concrete:
Cement Type:

Concrete Samples Delivered by Client, Field Testing by Others

Test Time:
Unit Weight: kg/m³
Mould Type: Plastic
Temperature: Air: °C
Concrete: °C
Diameter: 101.6 mm
Cast Slump/Flow: mm
Cast Air Content: %
Initial Slump: mm
Initial Air content: %
Concrete Setting Temp. Within CSA Limits (15-25 °C): y/n (see remarks if No)
Date Cast: July 2, 2019 By: Client
Date Received: July 9, 2019 By: WM

Sample Fracture Type



Laboratory Test Data

Cylinder Number	Age Days	Test Date (Y/M/D)	Test By	Load kN	Strength MPa	Type of Fracture	Comments
3336-827	8	19 07 10	WM	335.6	41.4	1	Cylinder mass = 3872 g
3336-828	28	19 07 30					Cylinder mass = 3880 g

Remarks: No test data reported.
Apparent density of cylinder 827 = 2362 kg/m³

Distribution:
mike.monk@tmacresources.com
JeanPhilippe.Houle@tmacresources.com
murray.weddell@tmacresources.com>

Reviewed By: P.Geol.

Yellowknife, NT

TETRA TECH