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December 14, 2020

Derek Donald
Technical Advisor
Nunavut Water Board
P.O. Box 119
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Sent via Email: licensing@nwb-oen.ca; derek.donald@nwb-oen.ca

Re: Water License 2AM-DOH1335 – Notice of Modification – Installation of 'Madrid North Portal Pad Contact Water Pond'

Dear Mr. Donald,

This letter represents TMAC Resources Inc (TMAC) written notification to the Nunavut Water Board (NWB) regarding the planned installation of a Contact Water Pond and surface water diversion berms, in proximity to the existing Madrid North Portal Pad. This notification is being provided to the NWB prior to commencement of work, as required under the Type A Water License (2AM-DOH1335). TMAC can confirm the following conditions, under Water Licence 2AM-DOH1335 Part G Item 1, are met:

a) The Licensee has notified the Board in writing of such proposed modifications at least sixty (60) days prior to beginning the Modifications;
b) Such Modifications do not place the Licensee in contravention of the License or the Act; and
c) Such Modifications are consistent with the applicable terms and conditions of the NIRB Project Certificate No. 009.

Background

As part of the verification, monitoring and management plans for the Hope Bay Project, seepage is monitored downstream of mine infrastructure, pads, roads, and waste rock. The scope of the seepage survey includes Madrid North infrastructure constructed since the previous seepage survey. The June 2020 seepage survey indicated elevated levels of chloride and ammonia at the downstream toe of the Madrid Portal Pad (Figure 1). At this time, the contributing sources of chloride and ammonia are expected to have originated from waste rock stored on the lined area and geotechnical inspection suggest that the lined area within the portal pad may have been compromised. Since this lined area is in front of the portal, and is well utilized for operations, repair of the liner cannot be completed to the certainty required, TMAC has decided to install a Contact Water Pond (CWP), directly adjacent to the north end of the Madrid North Portal Pad.

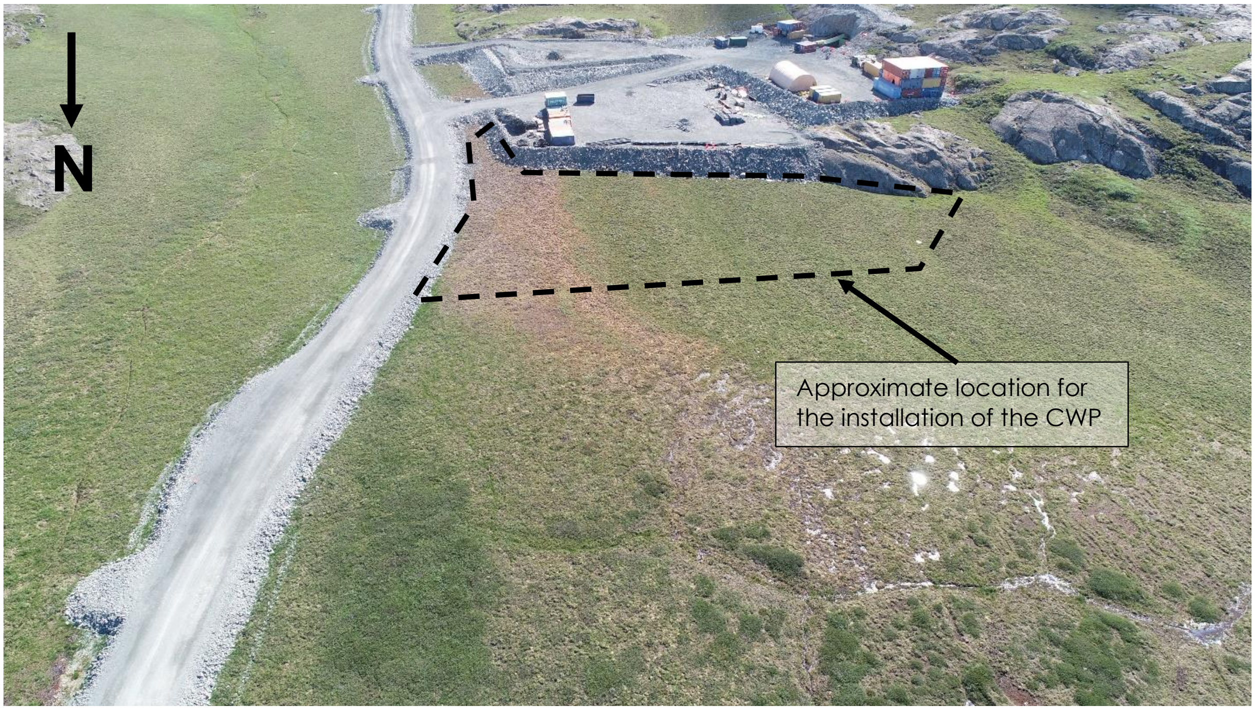

Figure 1. Madrid North Portal Pad

Design

The overall design concept for the Madrid North Portal CWP is to achieve an impermeable barrier using a geomembrane liner installed on the upstream berm face. The CWP will consist of a rock fill berm with an upstream liner system keyed into frozen permafrost in February 2021. The full final CWP system (once fully built, starting first with the pond berm) will also contain two surface water diversion located upgradient of the Portal Pad. These will be constructed to reduce contact water reporting to the Portal Pad CWP. The berm and surface water diversions will be constructed of geochemically suitable run-of-quarry (ROQ) fill and crush material (typically a ¾" minus size crush material).

The pond has been designed with the capacity to contain at a minimum the contact water from the 1:10 year, 24-hour storm event, and the maximum daily snowmelt. When the surface water diversion berms are constructed the design event is increased to the 1:100 year, 24-hour storm event. The Detailed Design Memorandum along with IFC drawings are provided in Attachment 1.

Monitoring

Routine visual inspections of the CWP berm will be carried out by operational staff and by the engineer-of- record during annual inspections to ensure the facility is functioning as intended. If areas are identified requiring maintenance, it will be carried out using similar materials used for initial construction. An updated Hope Bay Project Doris-Madrid Water Management will be provided to the NWB prior to operation of the CWP. The management plan will require a tundra discharge location under Water Licence 2AM-DOH1335 Part F, Item 18. a., which includes the same discharge criteria granted for the existing CWP located adjacent to the Madrid North waste rock pile.

TMAC appreciates the attention of the NWB on this notification considering that the Portal Pad CWP requires construction to be initiated in February 2021 and completed well before spring freshet in order to protect permafrost conditions during winter construction. Once constructed, the Portal Pad CWP will be included in the annual geotechnical inspection reports, which are submitted to the NWB as part of annual reporting.

Further discussion on 2020 seepage program will be provided in the 2020 NWB Annual Report.

Should you have any further questions please feel free to contact me at oliver.curran@tmacresources.com.

Sincerely,

Oliver Curran

Vice President, Environmental Affairs, TMAC

Cc:
Licensing (NWB)
Kyle Conway / Sarah Warnock (TMAC)
Ashley Mathai (TMAC)

Attachments:

1. Detailed Design of the Madrid North Portal Pad Contact Water Pond Berm

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Technical Memo

December 11, 2020

To	Oliver Curran, VP Environmental Affairs
From	Christopher Stevens, PhD
Reviewed By	John Kurylo, MSc, PEng
Subject	Hope Bay Project – Detailed Design of the Madrid North Portal Pad Contact Water Pond Berm
Revision	0
Client	TMAC Resources Inc.
Project	1CT022.055

1 Introduction

The Hope Bay Project is a gold mining and milling undertaking of TMAC Resources Inc. The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet. The Project comprises of three distinct areas of known mineralization plus extensive exploration potential and targets. The three areas that host mineral resources are Doris, Madrid, and Boston.

The Project consists of two phases: Phase 1 (Doris project), which is currently being carried out under an existing Type A Water Licence, and Phase 2 (Madrid-Boston project) which has been granted a new Type A Water Licence. Phase 1 includes mining and infrastructure at Doris, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively.

A contact water pond (CWP) berm will be constructed at the Madrid North site to intercept contact water runoff from the portal pad. This Madrid North Portal CWP will normally be kept in a dry state with a maximum one-week (i.e., seven-day) residence time for water in the pond (modified from SRK 2017a).

The design of the CWP berm incorporates a high-density polyethylene (HDPE) liner on the upstream face of the berm to contain the contact water. This HDPE liner is sandwiched between two layers of non-woven geotextile with a protective crush layer placed over the liner system. The liner will be tied-in to frozen permafrost within an excavated key trench to provide a seal and connection to the underlying permafrost foundation. The remaining pond footprint will not be lined and instead the design relies upon the low permeability of the frozen overburden soil and/ or bedrock tie-ins to achieve containment.

This memo presents the geotechnical, thermal and hydrotechnical design overview of the Madrid North Portal CWP berm for Phase 2 of the Hope Bay Project. The methods and assumptions inherent for the berm design, and stability and thermal analysis are provided.

2 Design

2.1 Approach

The overall design concept for the CWP berm is to achieve an impermeable barrier using the HDPE liner installed on the upstream berm face. The design uses the frozen permafrost and naturally low permeability of the foundation soils and bedrock to contain the contact water on the bottom of the pond. Containment will require establishing a reliable seal between the liner and frozen permafrost soils within an excavated key-trench. Permafrost present within the berm footprint will be maintained due to the thermal protection of the berm fill, as discussed in Section 3.4.2.

The CWP berm has been sized for the catchment area immediately upgradient of the Madrid North Portal Pad (see section 3.5). During the initial phases of construction and commission, the larger upstream catchment will report to this pond location. The sizing of this pond during this interim phase will be the 1:10 year 24hr event. As outlined on the attached Issued For Construction (IFC) revision 0 drawings (Attachment 1), two small diversion berms will be placed around the existing as-built Madrid North portal pad to further reduce the size of the catchment. With the additional diversion measures in place the pond will then reach its full design capacity in excess of the 1:100 year 24hr event. The size of the pond is constrained by the topography and more unfavourable ice-rich overburden soils that are expect if the alignment was moved further south. Based on this, active water management will be required to be carried out by TMAC site personnel to ensure adequate water capacity and to limit thermal impacts on the berm foundation.

2.2 Components

The Madrid North Portal CWP will consist of a rock fill berm with an upstream liner system keyed into frozen permafrost. The full final CWP system will contain two surface water diversion located upgradient of the Portal Pad. These will be constructed to reduce contact water (see drawings in Attachment 1). The CWP berm and surface water diversions will be constructed of geochemically suitable run-of-quarry (ROQ) fill and crush material (typically a ¾” minus size crush material).

2.3 Foundation Conditions

The Doris, Madrid and Boston areas have been well-studied (SRK 2017c), and it is expected that foundation conditions and geology from these areas will be similar to those encountered along the berm alignment. Permafrost in these areas extends to depths of about 570 m and are absent beneath some large lakes. The ground temperature near the depth of zero annual amplitude ranges from −9.8 to −5.6°C, with an average of −7.6°C. Active layer depth based on ground temperatures measured in overburden soil averages 0.9 m with a range from 0.5 to 1.4 m.

Permafrost soils are comprised mainly of marine clays, silty clay and clayey silt, with pockets of moraine till underlying these deposits. The most prevalent rock type on site with surface exposure is mafic volcanics, predominantly basalt. The marine silts and clays contain ground ice which is expected to be on average in the range of 10 to 30% by volume, but occasionally as high as 50%, and in some areas with the occurrence of pockets of massive ground ice. The typically coarse (sandier) glacier till typically contains low to moderate ice contents ranging from 5 to 25%.

Overburden soil pore water is typically saline due to past inundation of the land by seawater following deglaciation of the Project area. The salinity typically ranges from 37 to 47 parts per thousand which depresses the freezing point and contributes to higher unfrozen water content at below freezing temperatures. The average freezing point depression of the soil porewater has been estimated to be – 2.1°C (SRK 2017c).

Detailed site investigations have not been performed along the length of the current Madrid North CWP berm alignment. However, SRK has reviewed drill holes previously completed in the area and available aerial photographs. More recent investigation included seven sonic drill holes completed in winter of 2018 (SRK 2018). The recovered cores generally consisted of clay with silt often underlain by sand and gravel overlying bedrock. Ground temperatures recorded within one of the drill holes was consistent with local permafrost conditions. Based on our review of aerial photos, it is inferred that the berm footprint extends across overburden soil with exception of notable outcropping bedrock at the western most abutment of the CWP berm.

The design will be adapted as necessary based on drilling completed prior to construction to optimize the key trench arrangement designs and to reduce the overall construction execution risk.

3 Contact Water Pond Berm Design

3.1 Berm Design Criteria

The primary containment berm specific design criteria are listed below:

- The pond will be normally operated empty (i.e., the pond will be kept in a dry state);
- Maximum residence time for ponded water is one week based on 1 in 10 year 24 hr storm; the storm event would increase towards the 1 in 100 year 24hr storm once the surface water diversion berms are installed
- Pond has a 20-year design life;
- Effects of climate change during the 2021 to 2040 timeframe are considered;
- Geochemically suitable run-of-quarry (ROQ) rock to be used for berm construction;
- A small swale (through the crest of the dam and with 10% side slopes) will be put into the dam after the initial construction is complete to act as an emergency spillway for the system; and
- Disturbance of surface vegetation and soil resulting in permafrost degradation within the pond footprint should / will be minimized.

3.2 Liner System Design Criteria

Liner system specific design criteria are listed below:

- Containment liner to be a welded HDPE liner;
- HDPE to be protected by heavy duty (12 oz) non-woven geotextile;
- Minimum 0.3 m thick layer of bedding material (crushed and screened geochemically suitable quarry or waste rock material) on the outsides of the non-woven geotextile (covering the HDPE) and Transition material (transition material more of a 6" minus jaw run material or a carefully sorted ROQ material); and
- Maximum internal (within berm structure) geomembrane slope of 1.5H:1V (33.7°) if anchored or short spans, or with general slopes of 2.5H:1V (21.8°).

3.3 Design Overview

The key features of the Madrid North Portal CWP berm design are listed below and shown in the attached design drawings (Attachment 1):

- 6 m wide crest and maximum crest elevation (top of liner) at 44.0 m;
- Upstream and downstream side slopes of 2.5H:1V (21.8°);
- Textured HDPE liner underlain and overlain by heavy duty non-woven geotextile;
- Upstream geomembrane slope of 2.5 H:1V (21.8°);
- Minimum of 1 m overlap of the HDPE liner overtop of the ROQ bulk fill at the top of the berm slope which transitions into a linter anchor trench (to prevent liner pull out);
- A 0.3 m thick layer of bedding material (crushed and screened geochemically suitable quarry or waste rock material) around the HDPE liner system;
- One 0.5 m thick layer of transition material (crushed and screened or blasted and sorted geochemically suitable quarry rock) between the bedding layer and bulk ROQ fill, and as a final layer on top of the berm;
- Two ground temperature cables with dataloggers to monitor thermal performance; and
- Ten surficial survey monitoring points to monitor for berm settlement.

3.4 Geotechnical Analysis

3.4.1 Stability Analysis

The Madrid North Portal CWP berms has been designed to be thermal stable with an overall stability that meets minimum factor of safety (FOS) criteria as per CDA (2014) under both long-term static and pseudo-static loading conditions (SRK 2017b, Attachment 3). Two-dimensional limit equilibrium stability checks were completed with the RocScience Slide software package. Additional checks were then done looking at overall global stability as well as stability of any potential material that would be placed over the upstream liner system. The stability checks only considered overburden (thawed and unthawed) for the foundation conditions. Available overburden information from past drilling campaigns was used and sensitivity checks were done on the unfrozen rock and unfrozen overburden foundation properties. Attachment 3 gives an overview of these stability checks. Overall, the modeling determined that both the upstream and downstream slopes would be set to a minimum of 2.5H:1V to achieve overall FOS of 1.5 or greater. If overburden conditions are different than anticipated, a design change may be required, and new stability analysis may be warranted. The need for additional stability checks will be assessed by the engineer following the additional planned geotechnical drilling (to be completed in quarter one 2021).

3.4.2 Thermal Analysis

The CWP berm relies upon maintaining the liner keyed into permafrost to create an impermeable layer within the berm. Permafrost will also be maintained beneath the berm to limit instability of the foundation soil. Thermal performance of the CWP was evaluated using thermal modeling.

Modeling was completed in a two-dimensional domain by solving for conductive heat movement using SoilVision's SVHeat (SoilVision 2011) software package in combination with FlexPDE (FlexPDE 2014). SVHeat was utilized for the problem setup, while FlexPDE 6.35 solver was used to complete the calculation. The model domain and results for representative maximum and minimum fill sections are shown in Attachment 2.

The model assumed a 20-year design life with consideration of climate change, and surface boundary conditions and materials properties previously developed for the project site. A constant heat source of +6°C was applied for the entire design life along the upstream face of the berm and bottom of the pond. This boundary is conservative in the model since the pond will normally be kept dry. The ROQ bulk fill assumed an initial material temperature of -1°C.

The CWP thermal models predict the ground temperature at the liner tie-in will remain frozen for the maximum and minimum fill sections (Attachment 2, Figures 2 and 6). The maximum estimated key-trench temperature is -2.7C and -2.6°C for the maximum and minimum fill sections, respectively. Thaw is predicted for the upstream toe and bottom of the pond due to the conservative, constant water temperature boundary applied to the model (Attachment 2, Figures 3 to 5 and Figures 7 to 9). The pond will be maintained dry through active water management, resulting in significantly less thermal forcing and ground warming over the design life.

3.5 Hydrotechnical Design

Hydrotechnical design and an alternatives assessment of the CWP is presented in the site-specific Water Management Design Report (SRK 2017a). The pond has been designed with the capacity to contain at a minimum the contact water from the 1:10 year, 24-hour storm event, and the maximum daily snowmelt without the construction of surface water diversions to further limit the amount of contact water. Additional details on the climate date, Intensity Duration Frequency (IDF) and evaporation distribution adopted are found in SRK (2017e).

When the surface water diversion berms are constructed then the primary catchment area reduced to the footprint immediately over and surrounding the Madrid North Portal pad and the design event can then be increased to 1:100 year, 24-hour storm event. The full supply level has been designed at an elevation of 42.0 m (2.0 m below top of liner). With an allowance for settlement the operational freeboard is set at 1.5 m.

The Madrid North Portal CWP is designed to be operated dry (less than one-week residence time) so that the pond containment volume is available for a large storm event. To ensure that this condition is met, TMAC will need to ensure that appropriate equipment, and / or pumps are on site to operate this pond in this manner. It is suggested that equipment and or pumps should be sourced to ensure that up to 850 m^3 (or around 2,500 m^3 removed over a three-day period) could be removed from the Madrid North Portal CWP. This will increase operational flexibility and add some robustness to the operational performance should any unforeseen issues and / or large storm events larger than the 1:10 year 24-hr event arise.

3.6 Key Trench Design

The key trench will be excavated into frozen overburden soil to a minimum depth of 2.0 m below natural grade. The minimum excavation depth is expected to be greater than the naturally occurring active layer to allow for line tie-in to perennially frozen permafrost beneath the berm.

The key trench will terminate at the specified minimum depth within frozen overburden soil or on competent bedrock. Should any massive ice be encountered, the key trench may be deepened until all the massive ice has been removed, as directed by the supervising engineer. At the locations where bedrock is encountered in the key trench, the bedrock surface will be required to be ripped down to competent bedrock and scrapped smooth and then a bituminous seal will be placed over the bedrock contact and the HDPE liner, or a small concrete plinth would be made with a polylock strip where the liner could be welded to it.

Excavation of the key trench must be completed in the winter when the ground is completely frozen. This is necessary to ensure that the ground is as cold as possible before backfilling starts to avoid any thaw of the excavated slopes. Over excavation of the key trench beyond the design lines should be avoided. The excavated material will have to be relocated to the designated overburden dump.

3.7 Liner Design

The lining system will consist of a single HDPE geomembrane underlain and overlain by a heavy duty non-woven geotextile (12 oz.). The liner will be anchored to the top of the slope with a 0.5 m thick cover of transition or bedding material at a minimum length of 1 m, to prevent pull-out. Where the liner overlaps with the ROQ bulk fill, there is an additional requirement that the liner overlap a minimum of 1 m with the ROQ crest. At the toe of the slope, the upstream liner slope may be required to be welded to the key trench liner to form a complete seal. A bituminous seal may also be applied if necessary.

The majority of the liner to foundation key is expected to be in overburden. This noted, on the west side abutment some bedrock may be intercepted.

Where the key trench intercepts bedrock, 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. In this case, the liner will be affixed to the top of the concrete plinth by welding to a GSE Polylock Concrete Embedment Strip or approved alternative. The bedrock conditions and contact point for the liner will be inspected in the field by the engineer. The engineer will then make a final decision for the required adhesion method.

3.8 Surface Water Diversion Design

Two surface water diversion are planned to be constructed to reduce contact water (Attachment 1.). The diversions will consist of geochemically suitable quarry rock placed with an excavator and compacted. No excavation along the alignment nor ground disturbance to areas outside of the diversion footprint will be permitted. The diversion alignments have been selected so that the upstream toe of the diversions will direction water around the Madrid North Portal area, in the case of the longer most southern diversion, or will direct surface water into the portal CWP area, in the case of the shorter most northern diversion.

3.9 Construction Materials

Geochemically suitable quarry rock from selected areas of the mine will be used for the bedding, transition and bulk fill materials. Geochemical analysis of proposed quarry rock materials determined that rock from Quarries 1 to 4 (SRK 2007) and Quarries A to E (SRK 2008) are suitable for use as construction material. However, all construction materials will be subject to operational monitoring to validate their geochemical suitability for use as construction material (TMAC 2017a, 2017b). Waste rock from the deposit area, e.g. Madrid Crown Pillar Recovery Trenches, are not recommended for construction due to risk of neutral pH metal leaching (SRK 2017d).

4 Foundation Geotechnical Investigation

An additional, complimentary to the existing information, geotechnical investigation will be completed prior to construction. The recovered material will be described in the field and sampled by a qualified engineer. A planned 20 drill holes will be completed through overburden soils and into the top of bedrock using an air rotary drill (Attachment 1).

At a minimum, the recovered materials will be described in general accordance with standard ASTM soil description and identification methods (ASTM D2488-17) and with standard ASTM method for describing of frozen soils (ASTM D4083-89). The lack of intact core will limit the ability to log ice structures.

Air rotary cuttings would be sampled every 0.5 m for the upper (top) 4 m below ground surface (bgs), and every 1 m thereafter to a depth of 10 m bgs. Material returned from a depth greater than 10 m bgs should be sampled every 2 m. Drill holes should be advanced a minimum of 2 m into bedrock. Photographs should be taken of the collected samples in the field.

Collected samples should be double bagged, tied, and labeled at the time of field collection. All samples should be maintained in a frozen state until processed by the receiving laboratory to preserve moisture contents. The basic soil index testing will then give indication of the soil type and properties and the salinity testing and moisture content testing will help to give an indication of the soil salinity and ice contents respectively.

Laboratory analysis will be required on representative samples:

- Particle size distribution
  - ASTM C117, ASTM C136, ASTM D422, ASTM D7928
- Gravimetric water content
  - ASTM D2216
- Atterberg limit
  - ASTM D4318
- Porewater salinity
  - ASTM 4542
- Porewater chemistry and pH
  - To be specified by SRK geochemist

5 Construction

All construction should be performed in accordance with the technical specifications (SRK 2018). Construction fill materials will be obtained from geochemically suitable permitted quarries and include bedding (19 mm minus), transition (150 mm minus), and bulk fill material (typically 1000 mm minus with no since particle being larger than 1500mm). Management and monitoring of these quarries will be according to the quarry management and monitoring plan (TMAC 2017a). The Madrid North CWP Portal CWP layouts and 'neat-line' volume estimates are shown in Attachment 1.

Based on previous surface infrastructure construction on the Project, it is assumed that the construction fleet will consist of CAT 40-ton haul trucks, CAT D8 dozers, CAT C330 excavator(s), CAT CS563 compactor or similar sized equipment.

Prior to construction, the berm alignment should be cleared of snow and ice. Near-surface massive ground ice intercepted by overburden excavation at the liner tie-in to bedrock may be removed if detailed analysis confirms the need for it. At no time will disturbance of the tundra vegetation or soils be allowed outside of the infrastructure footprint. Initial construction of the bulk ROQ fill will be placed by end-dumping from a newly constructed CWP access road and pushing the dumped material with a bulldozer. Excavation of any overburden materials at the upstream toe will be achieved by an excavator with access provided by the upstream ROQ slope.

Placement of transition and bedding material will occur from the constructed crest of the bulk ROQ fill. The liner system will only be installed once the design surface of the bedding material and any overburden excavation at the upstream toe have been surveyed and approved by the supervising engineer. Placement of the last 0.5 m lift of transition fill above the ROQ and final road surfacing material will not proceed until both the HDPE liner and ROQ material layer is at design level.

Any excavated overburden materials will be placed in a designated overburden pile within the Madrid North WRP footprint (depending on the site investigation testing results), or at any other existing overburden dumps on the Hope Bay Belt.

Wherever possible, the entire berm will be constructed in the winter to ensure the foundation materials remain frozen. Some summer construction may be required to meet development schedules. Construction fill placement techniques in winter and summer will be identical; however, summer construction will result in the use of more construction material as greater imbedding of material into the active layer will occur. Summer construction will also require screening of the site for nesting birds, and modifications to the construction schedule may be required to avoid disturbing nesting birds.

Routine visual inspections of berm will be carried out by operational staff and by the engineer-of-record during annual inspections and if areas are identified requiring maintenance that will be carried out using similar materials used for initial construction.

Attachments:

Attachment 1	Engineering Drawings for the Madrid North Contact Water Pond Berm
Attachment 2	Thermal Modeling Results
Attachment 3	Slope Stability Checks

References

ASTM C117. Standard Test Method for Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing. ASTM International. West Conshohocken, PA. 2017.

ASTM C136. Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates. ASTM International. West Conshohocken, PA. 2006.

ASTM D422. Standard Test Method for Particle-Size Analysis of Soils. ASTM International. West Conshohocken, PA. 2007.

ASTM D2216. Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass. ASTM International. West Conshohocken, PA. 2005.

ASTM D4318. Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. ASTM International. West Conshohocken, PA. 2005.

ASTM D4542. Standard Test Method for Pore Water Extraction and Determination of the Soluble Salt Content of Soils by Refractometer. ASTM International. West Conshohocken, PA. 2007.

ASTM D7928. Standard Test Method for Particle – Size Distribution (Gradation) of Fine – Grained Soils Using the Sedimentation (Hydrometer) Analysis. ASTM International. West Conshohocken, PA. 2017.

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

SRK Consulting (Canada) Inc., 2017b. Hope Bay Project – Contact Water Pond Design. Memo 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., 2017d. Geochemical Characterization of Waste Rock and Ore, Madrid North Deposit, Hope Bay Project. Report Prepared for TMAC Resources Inc., 1CT022.013. November 2017.

SRK Consulting (Canada) Inc., 2017e. 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, Nunavut Canada. Revision H – Issued for Construction, 1CT022.031. April 2018.

TMAC Resources Inc., 2017a. Hope Bay Project Quarry Management Plan. December 2017.

TMAC Resources Inc., 2017b. Hope Bay Project Waste Rock, Ore and Mine Backfill Management Plan. December 2017.

Attachment 1 Engineering Drawings for the Madrid North Portal Contact Water Pond

TMAC Resources Inc.

Madrid North Project

Madrid North Portal Contact Water Pond

Drawing Number	Drawing Title	Issue	Date	Revision
MNP-CWP-01	Site Location	Issued for Regulators	2020-12-11	A
MNP-CWP-02	General Arrangement and Geotechnical Investigation Locations (with Orthophoto)	Issued for Regulators	2020-12-11	A
MNP-CWP-03	General Arrangement (with Orthophoto)	Issued for Regulators	2020-12-11	A
MNP-CWP-04	Key Trench Excavation Plan and Profile	Issued for Regulators	2020-12-11	A
MNP-CWP-05	Key Trench Bedding and Liner Placement	Issued for Regulators	2020-12-11	A
MNP-CWP-06	Key Trench Transition Placement	Issued for Regulators	2020-12-11	A
MNP-CWP-07	Downstream ROQ Placement	Issued for Regulators	2020-12-11	A
MNP-CWP-08	Slope Transition Placement	Issued for Regulators	2020-12-11	A
MNP-CWP-09	Slope Bedding and Liner Placement	Issued for Regulators	2020-12-11	A
MNP-CWP-10	Final Arrangements	Issued for Regulators	2020-12-11	A

srk consulting

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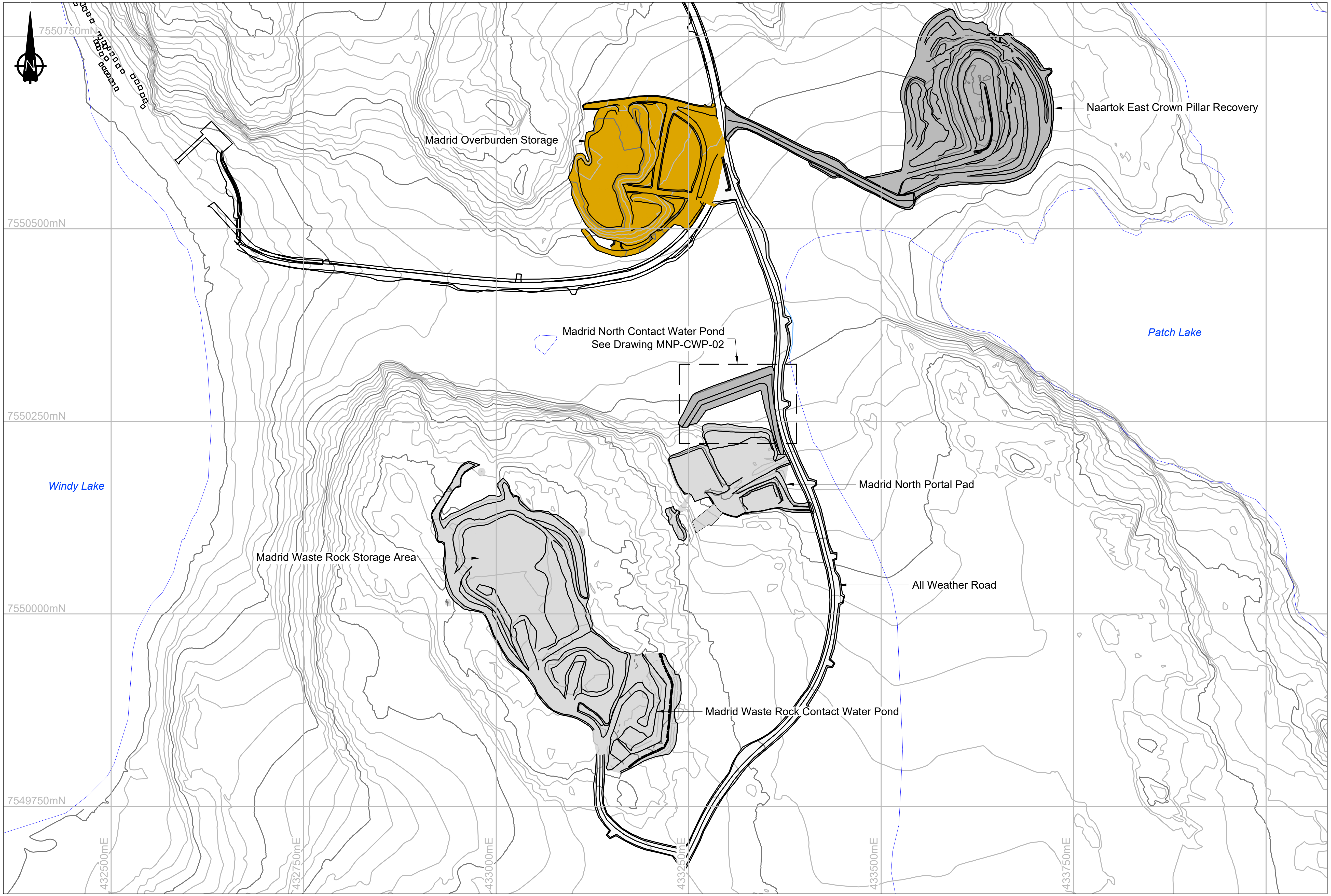

LEGEND

- Existing Site Elements and Infrastructure
- Overburden Dump
- Proposed Infrastructure (to be constructed)

NOTES

1. Contours shown at 2.0m intervals.
2. All units 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. 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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REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
- -	- -

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	- -	- -	- -
A	Issued for Regulatory Review	TMAC	JBK	20/12/11

PROFESSIONAL ENGINEERS STAMP

REGISTERED PROFESSIONAL ENGINEER
B. KURYLO
LICENSEE
2020/12/11
NT/NU

srk consulting

DESIGN: JBK	DRAWN: TAH	REVIEWED: CWS
CHECKED: TMAC	APPROVED: JBK	DATE: 2020/12/11

FILE NAME: 1CT022.055 - MNP - SL.dwg

TMAC RESOURCES

Hope Bay Project

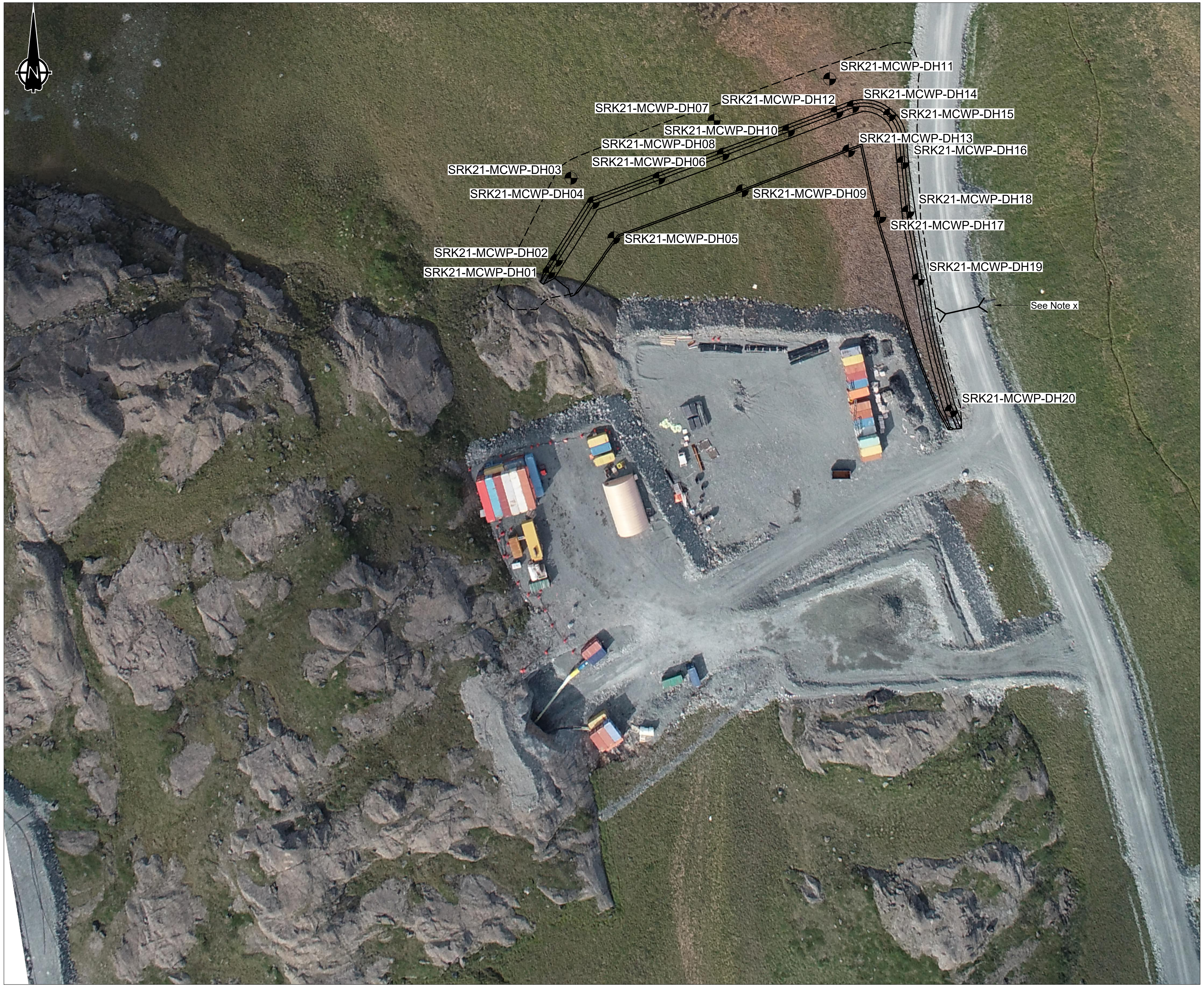
SRK JOB NO.: 1CC022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE:

Site Location

DRAWING NO.: MNP-CWP-01 | SHEET: 1 OF 13 | REVISION NO.: A



LEGEND

- Proposed Borehole Location
- Proposed CWP Footprint
- Proposed Key Trench Excavation

NOTES

1. All dimensions in meters unless otherwise specified
2. Air rotary cuttings should be sampled every 0.5m for the upper (top) 4.0m below ground surface (bgs), and every 1m thereafter to a depth of 10.0mbgs. Material returned from a depth greater than 10mbgs should be sampled every 2.0m. Photographs should be taken of the collected samples in the field.
3. Observations of massive ground ice and crushed ice cuttings should be logged and sampled based on occurrence.
4. Collected samples should be double bagged, tied, and labeled at the time of field collection. All samples should be maintained in a frozen state until processed by the receiving laboratory to preserve moisture content.
5. Drillholes to be advanced a minimum 2.0m into bedrock.
6. All existing access road culverts along alignment of CWP berm to be properly removed in advance of construction.

REFERENCES

1. NAD83 UTM Zone 13.
2. Drone imagery provided by TMAC Resources Inc., file name: "DJI_0045.jpg", September 2020.

PROPOSED INVESTIGATION LOCATIONS

ID	Northing	Easting
SRK21-MCWP-DH01	7550253.34	433251.97
SRK21-MCWP-DH02	7550256.96	433254.17
SRK21-MCWP-DH03	7550281.20	433258.47
SRK21-MCWP-DH04	7550272.28	433265.70
SRK21-MCWP-DH05	7550263.58	433271.13
SRK21-MCWP-DH06	7550281.20	733284.46
SRK21-MCWP-DH07	7550298.16	433300.64
SRK21-MCWP-DH08	7550288.28	433303.35
SRK21-MCWP-DH09	7550277.49	433308.95
SRK21-MCWP-DH10	7550295.23	433322.62
SRK21-MCWP-DH11	7550310.48	433334.73
SRK21-MCWP-DH12	7550300.60	733336.82
SRK21-MCWP-DH13	7550289.25	433340.32
SRK21-MCWP-DH14	7550302.29	433341.62
SRK21-MCWP-DH15	7550299.87	433352.41
SRK21-MCWP-DH16	7550285.78	433356.32
SRK21-MCWP-DH17	7550269.76	433349.52
SRK21-MCWP-DH18	7550271.29	433357.79
SRK21-MCWP-DH19	7550251.34	433360.85
SRK21-MCWP-DH20	7550212.60	433370.56

0m 10 20 30 40

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	- -	- -	- -	- -	- -	A	Issued for Regulatory Review	TMAC	JBK	20/12/11

REFERENCE DRAWINGS | REVISIONS

PROFESSIONAL ENGINEERS STAMP

REGISTERED PROFESSIONAL ENGINEER
B. KURYLO
LICENSEE
2020/12/11
NT/NU

srk consulting

DESIGN: JBK	DRAWN: TAH	REVIEWED: CWS
CHECKED: TMAC	APPROVED: JBK	DATE: 2020/12/11

FILE NAME: 1CT022.055 - MNP - GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: General Arrangement and Geotechnical Investigation Locations (with Orthophoto)

DRAWING NO. MNP-CWP-02 | SHEET 2 OF 13 | REVISION NO. A

P:\Projects\01_SITES\Hope Bay\ACAD\IFR\Madrid Portal Pad CWP\1CT022.055 - MNP - GA.dwg

LEGEND

- Proposed CWP Footprint
- Proposed Key Trench Excavation

NOTES

1. Contours shown at 2.0m intervals.
2. All dimensions shown in meters unless otherwise stated.
3. The CWP will normally be kept in a dry state with a maximum one-week (i.e. seven-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. Existing culvert at this location to be removed and backfilled with Transition Material before construction.

REFERENCES

1. NAD83 UTM Zone 13.
2. 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.
3. Drone imagery provided by TMAC Resources Inc., file name: "DJI_0045.jpg", September 2020.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	- -	- -	- -	- -	- -	A	Issued for Regulatory Review	TMAC	JBK	20/12/11

REFERENCE DRAWINGS | REVISIONS

REGISTERED PROFESSIONAL ENGINEER — J.B. KURYLO — LICENSEE — 2020/12/11 — NT/NU

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JBK | DRAWN: TAH | REVIEWED: CWS
CHECKED: TMAC | APPROVED: JBK | DATE: 2020/12/11
FILE NAME: 1CT022.055 - MNP - GA.dwg

TMAC RESOURCES

Hope Bay Project

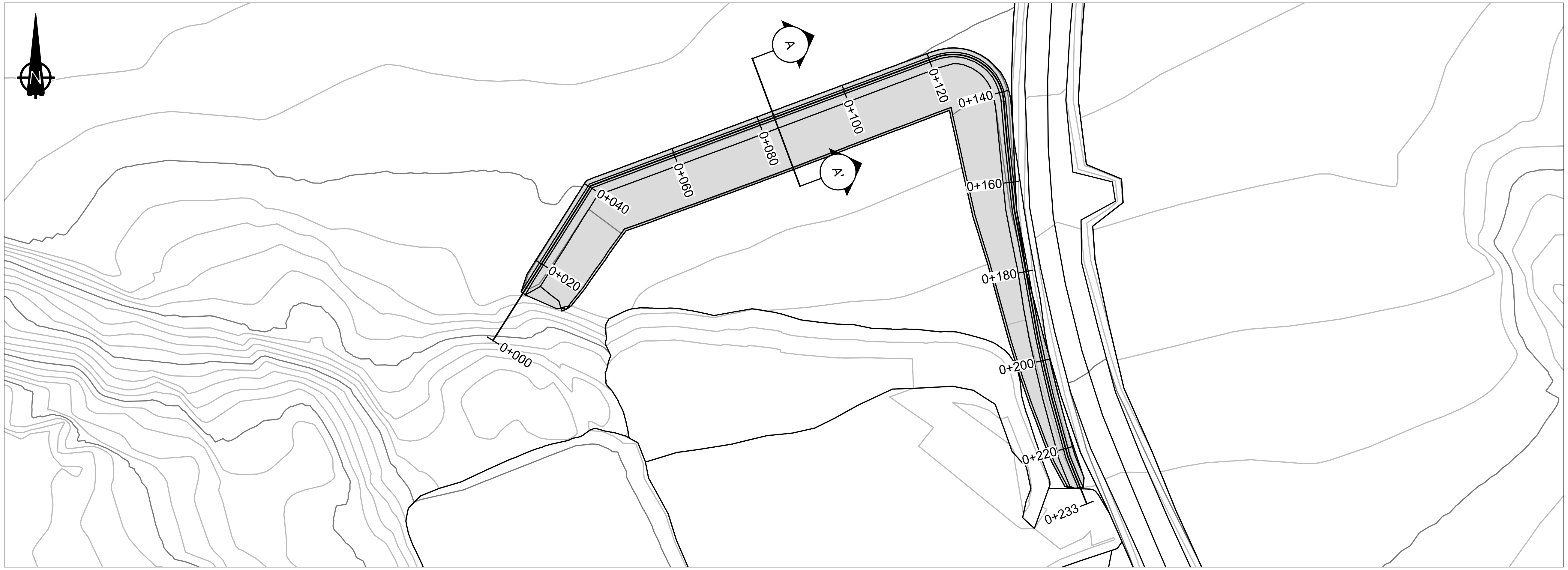
SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: General Arrangement (with Orthophoto)

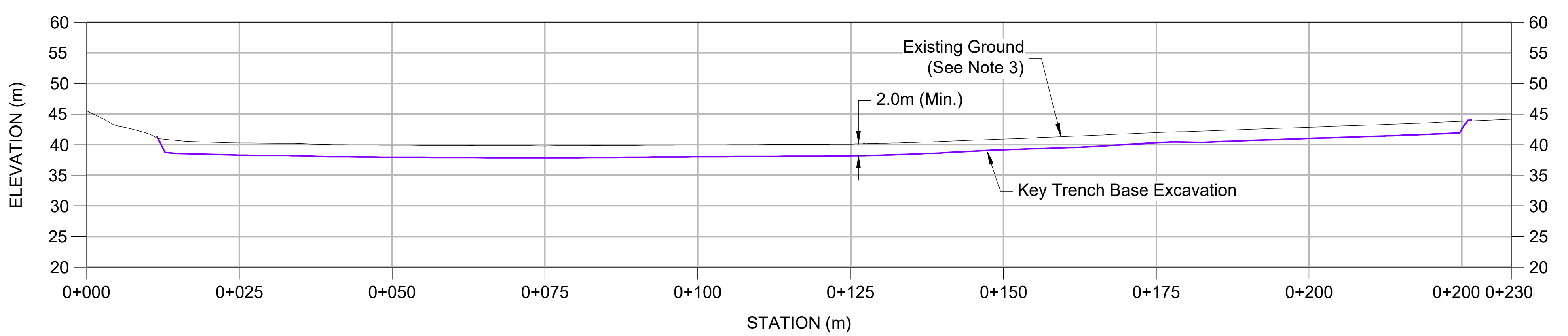
DRAWING NO.: MNP-CWP-03 | SHEET: 3 OF 13 | REVISION NO.: A

P:\Projects\01_SITES\Hope Bay\ACAD\FR\Madrid Portal Pad CWP\1CT022.055 - MNP - GA.dwg



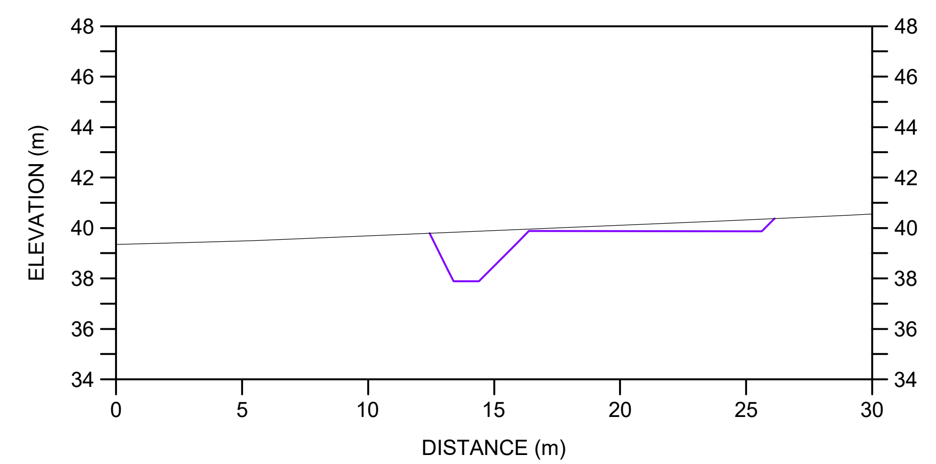
Key Trench Plan View

0m 10 20 30 40



Key Trench Profile View

0m 10 20 30 40



A -- **Cross Section A-A'**

0m 3 6 9 12

LEGEND

Proposed Key Trench

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
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).

REFERENCES

1. NAD83 UTM Zone 13.
2. 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.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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REFERENCE DRAWINGS | REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JBK | DRAWN: TAH | REVIEWED: CWS

CHECKED: TMAC | APPROVED: JBK | DATE: 2020/12/11

FILE NAME: 1CT022.055 - MNP - KT.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO.: MNP-CWP-04 | SHEET 4 OF 13 | REVISION NO. A

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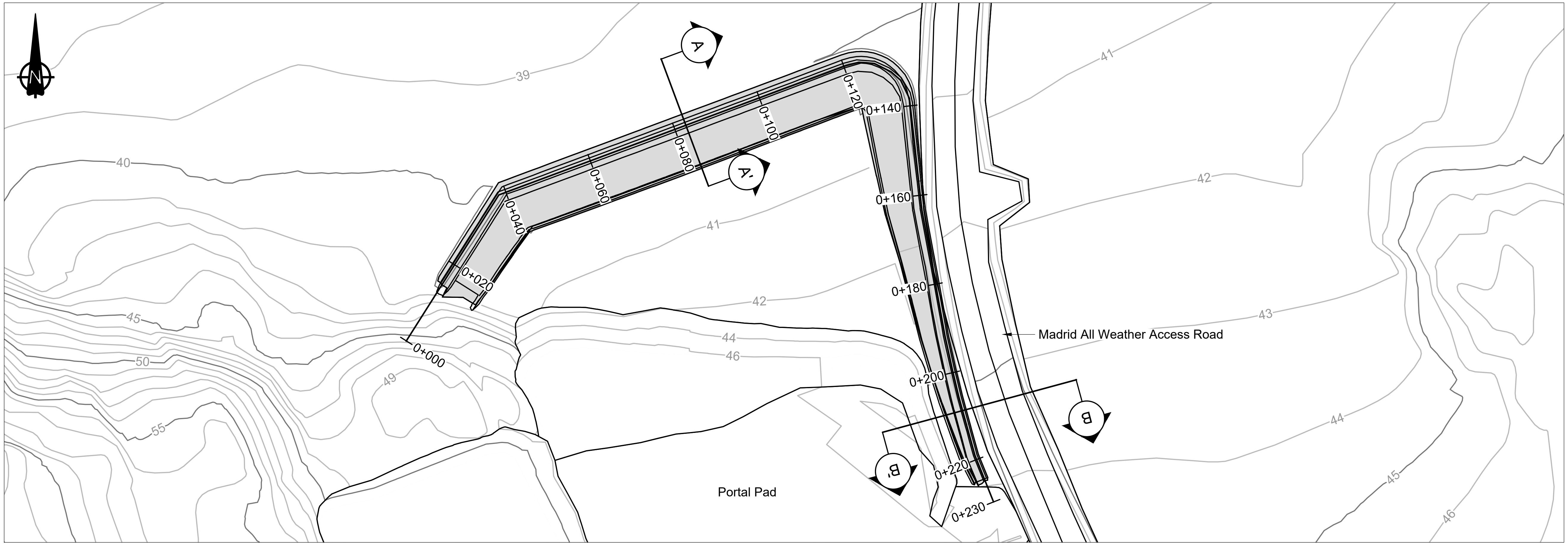
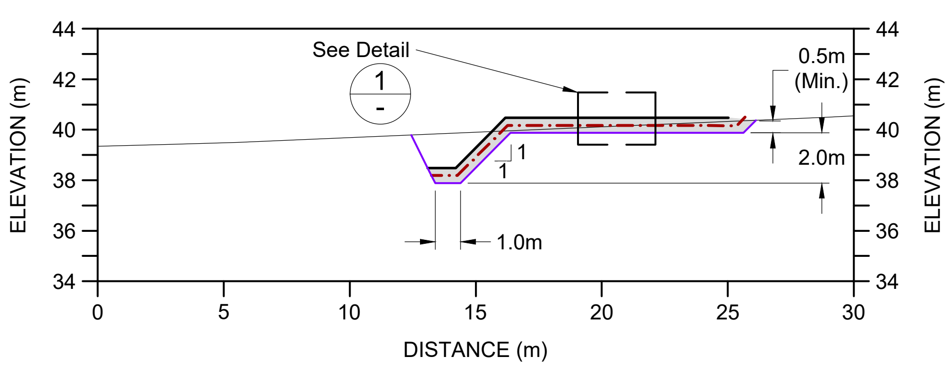


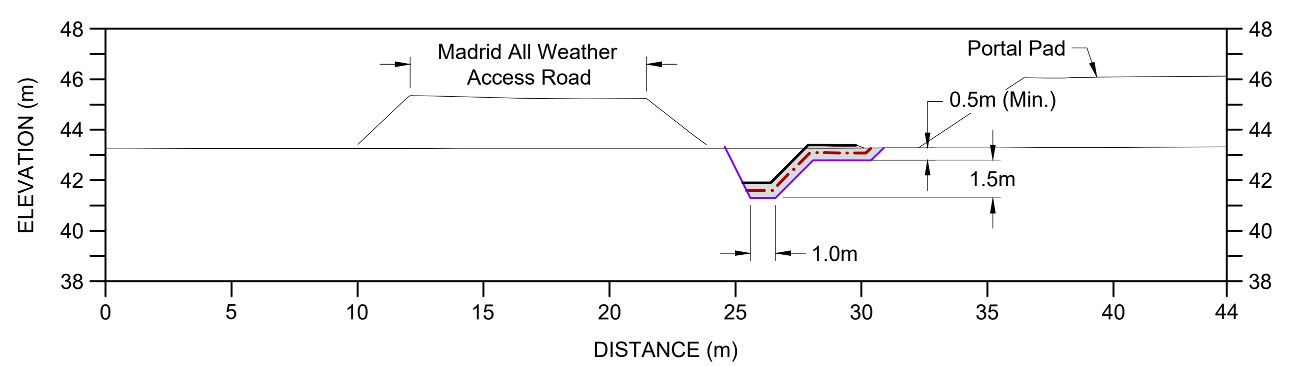
Key Trench Bedding Plan View

0m 10 20 30 40



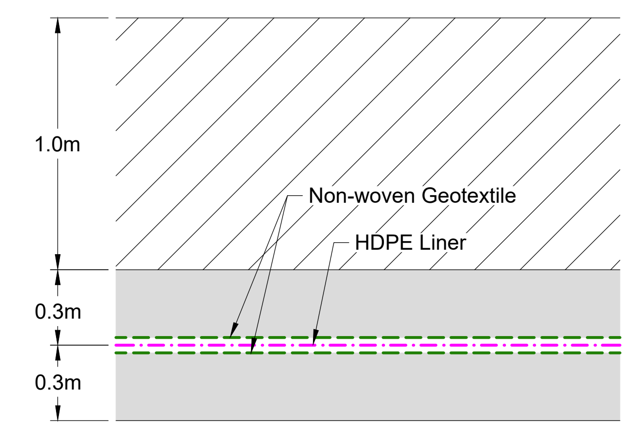
A Cross Section A-A'

0m 3 6 9 12



B Cross Section B-B'

0m 3 6 9 12



1 Detail 1: Liner System Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- HDPE Liner
- Non-woven Geotextile
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
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).

REFERENCES

1. NAD83 UTM Zone 13.
2. 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.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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REFERENCE DRAWINGS | REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JBK	DRAWN: TAH	REVIEWED: CWS
CHECKED: TMAC	APPROVED: JBK	DATE: 2020/12/11

FILE NAME: 1CT022.055 - MNP - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: Key Trench Bedding and Liner Placement

DRAWING NO.: MNP-CWP-05 | SHEET: 5 OF 13 | REVISION NO.: A

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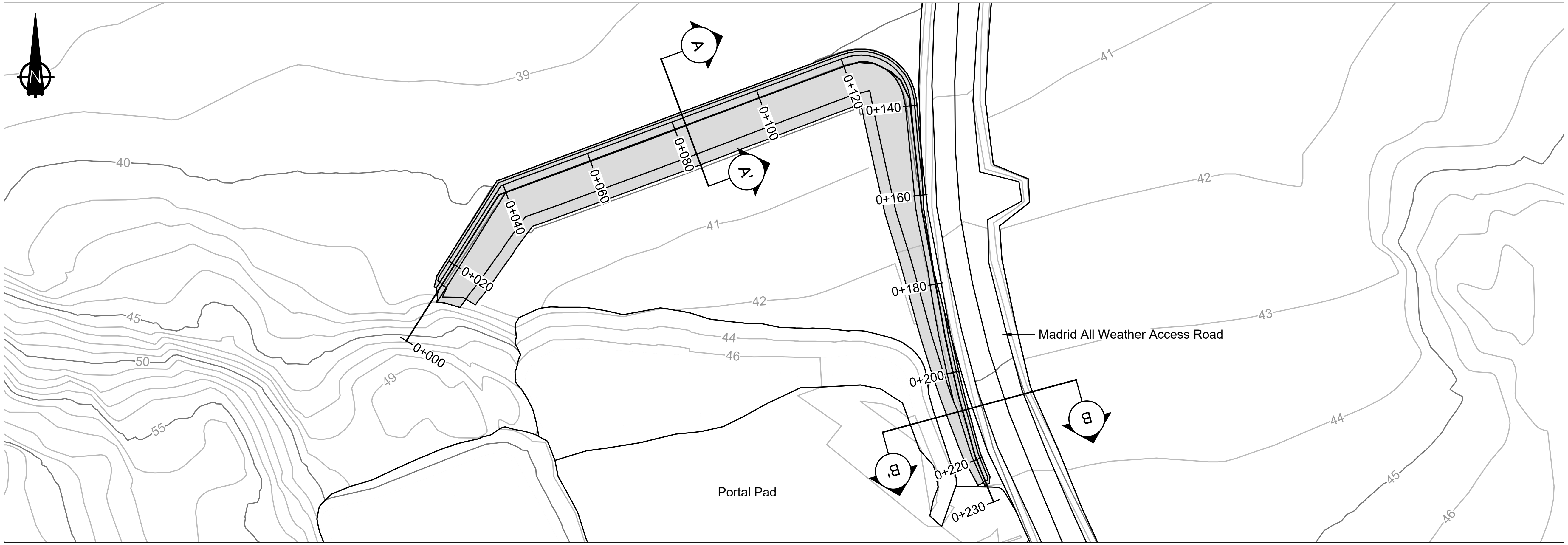


LEGEND

- HDPE Liner
- Non-woven Geotextile
- Bedding Material
- Transition Material

NOTES

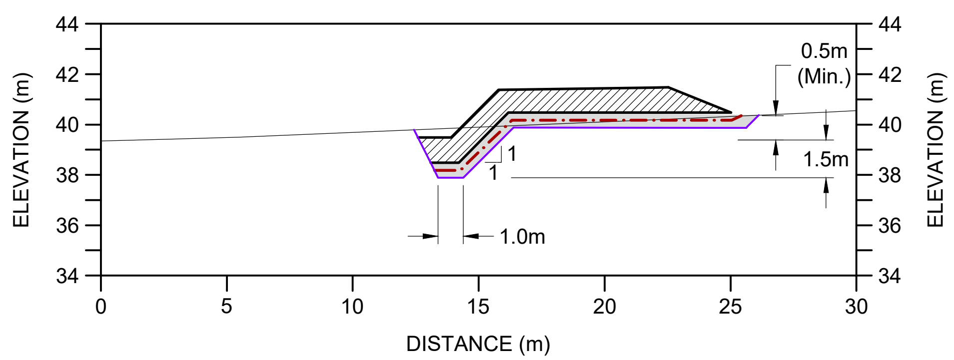
1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
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).

REFERENCES

1. NAD83 UTM Zone 13.
2. 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.

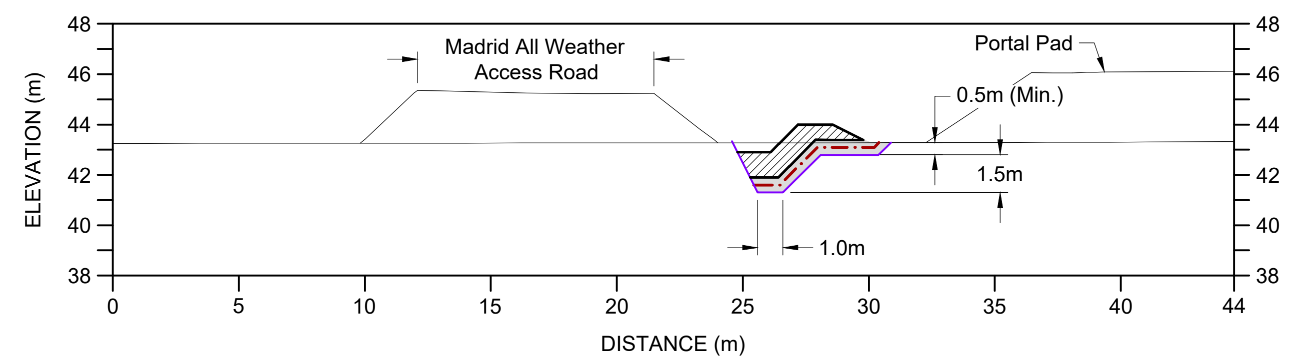
Key Trench Bedding Plan View

0m 10 20 30 40



A / -- Cross Section A-A'

0m 3 6 9 12



B / -- Cross Section B-B'

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	- -	- -	- -	- -	- -	A	Issued for Regulatory Review	TMAC	JBK	20/12/11

REFERENCE DRAWINGS — REVISIONS

PROFESSIONAL ENGINEERS STAMP

J.B. KURYLO — LICENSEE — 2020/12/11 — NT/NU

srk consulting

DESIGN: JBK — DRAWN: TAH — REVIEWED: CWS
CHECKED: TMAC — APPROVED: JBK — DATE: 2020/12/11
FILE NAME: 1CT022.055 - MNP - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: Key Trench Transition Placement

DRAWING NO.: MNP-CWP-06 — SHEET: 6 OF 13 — REVISION NO.: A

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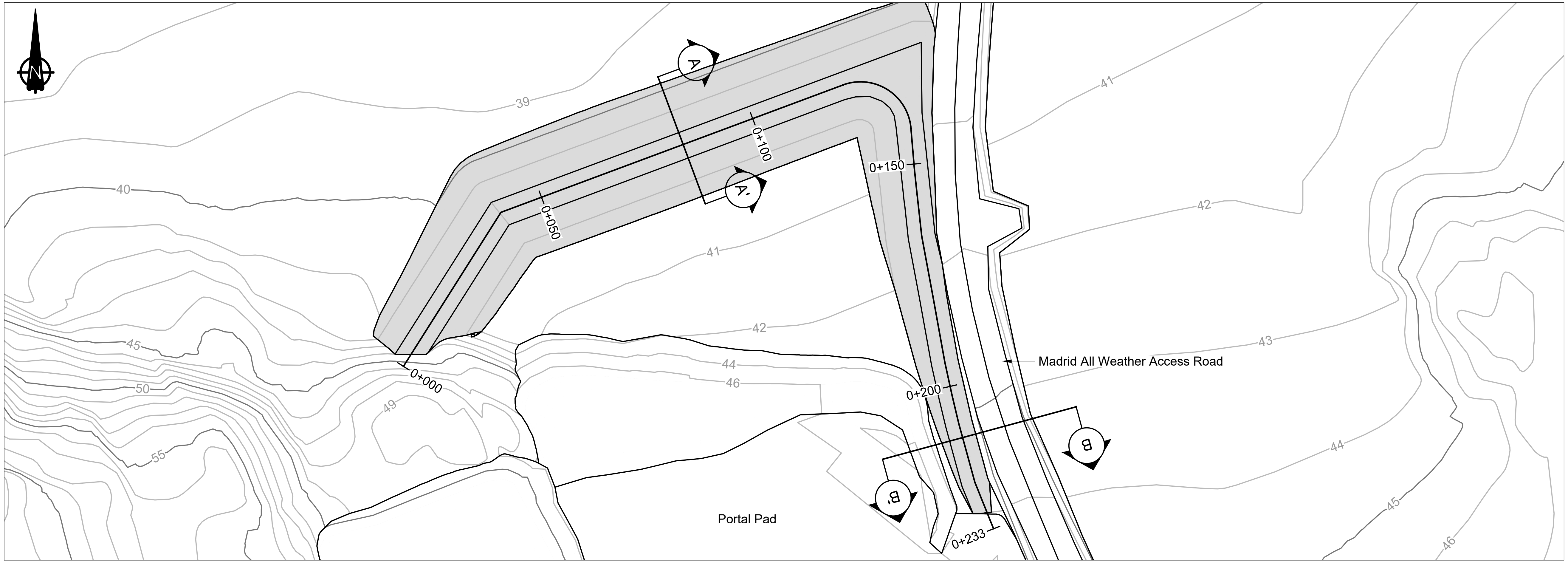
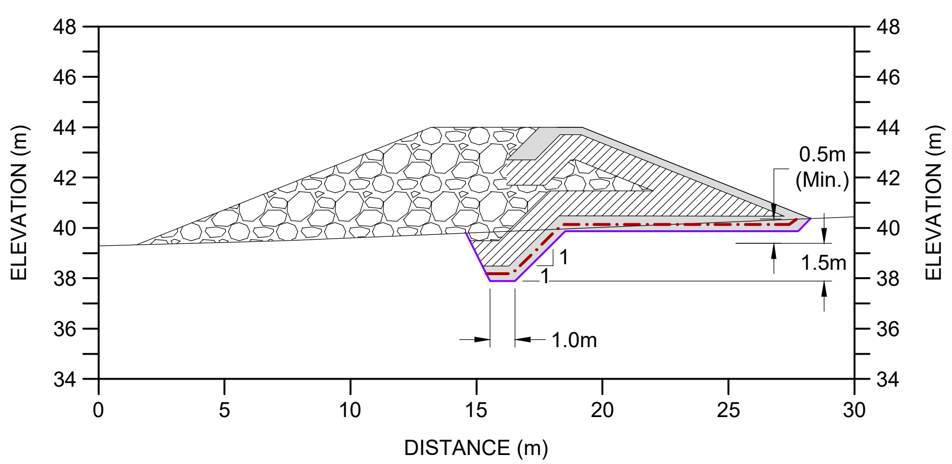
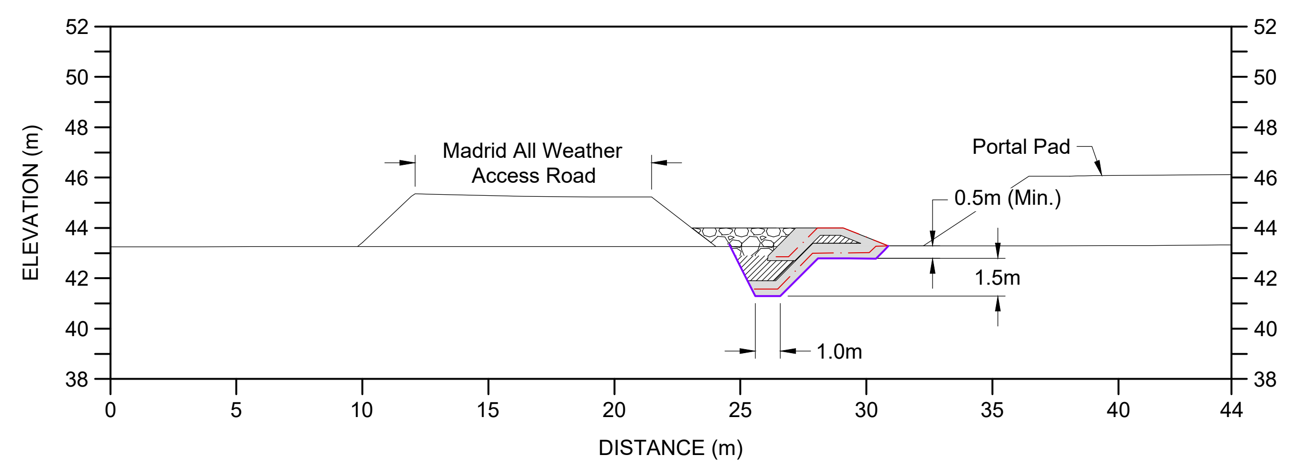


Key Trench Bedding Plan View



A -- **Cross Section A-A'**



B -- **Cross Section B-B'**

LEGEND

- Liner System
- Bedding Material
- Transition Material
- ROQ Material

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
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).

REFERENCES

1. NAD83 UTM Zone 13.
2. 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.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
--	--	--	--	--	--	--	A	Issued for Regulatory Review	TMAC	JBK	Nov2020

REFERENCE DRAWINGS | REVISIONS | PROFESSIONAL ENGINEERS STAMP

J.B. KURYLO LICENSEE NT/NU 12/11/2020

srk consulting

DESIGN: JBK | DRAWN: TAH | REVIEWED: CWS
CHECKED: TMAC | APPROVED: JBK | DATE: November 2020
FILE NAME: 1CT022.055 - MNP - ROQ.dwg

TMAC RESOURCES

Hope Bay Project

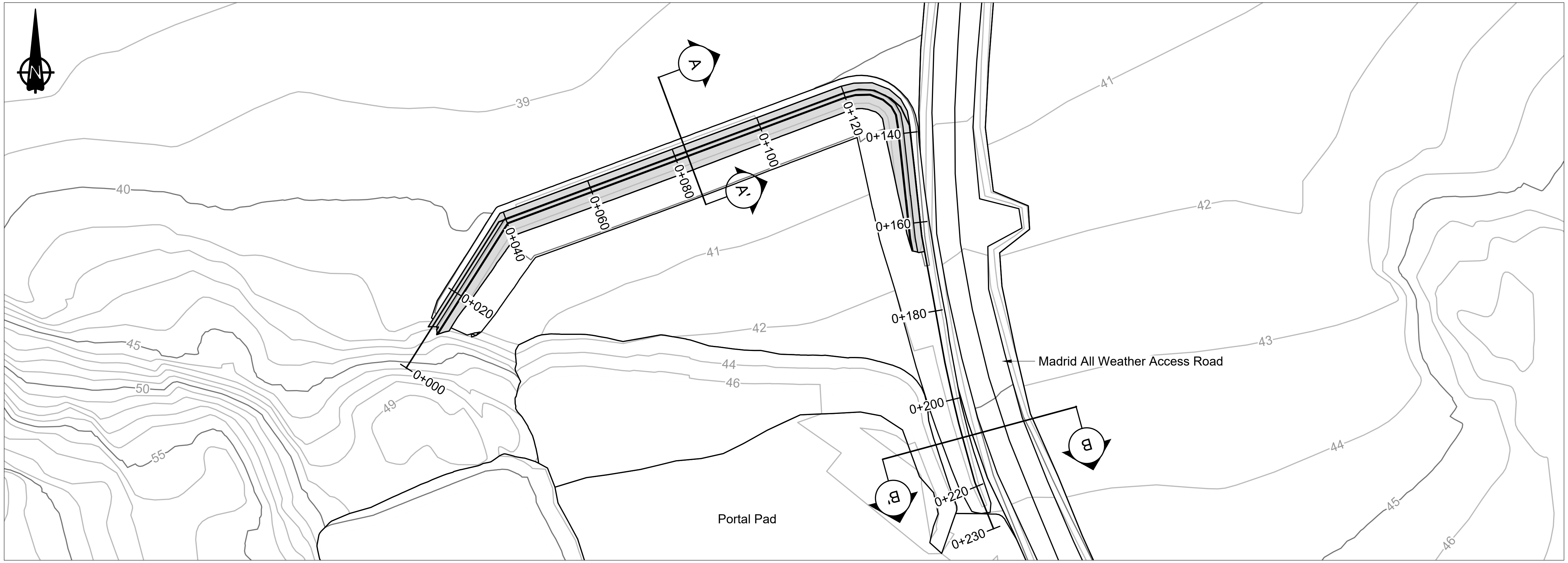
SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: Downstream ROQ Placement

DRAWING NO.: MNP-CWP-07 | SHEET 7 OF 13 | REVISION NO. A

P:\Projects\01_SITES\Hope Bay\ACAD\FR\Madrid Portal Pad CWP\1CT022.055 - MNP - ROQ.dwg



LEGEND

- Liner System
- Bedding Material
- Transition Material
- ROQ Material

NOTES

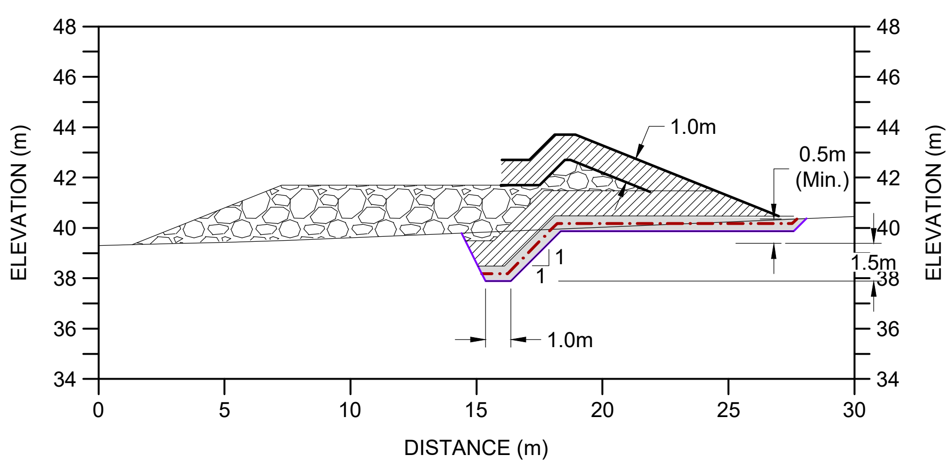
1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
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).

REFERENCES

1. NAD83 UTM Zone 13.
2. 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.

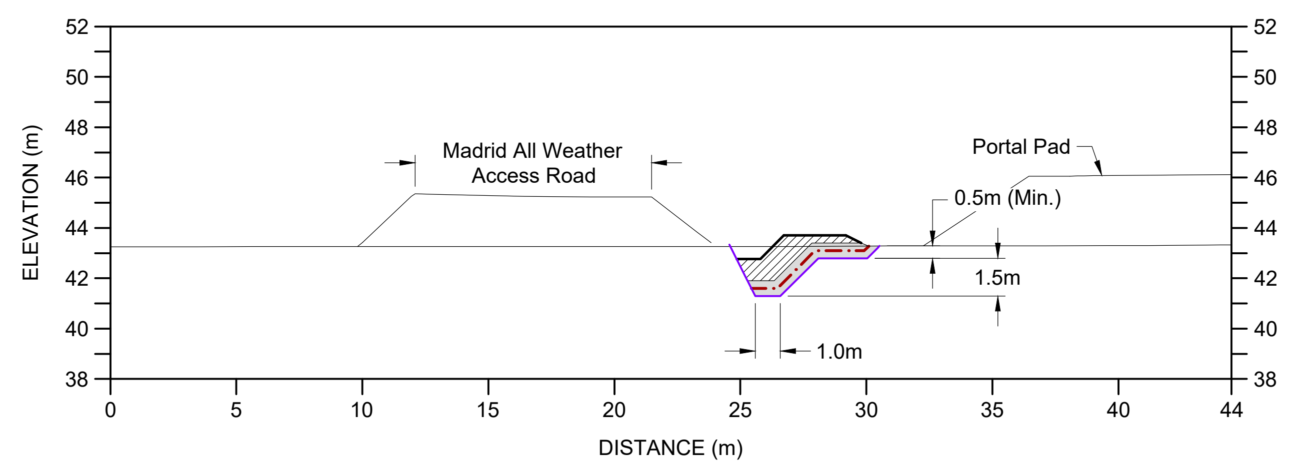
Key Trench Bedding Plan View

0m 10 20 30 40



A / -- **Cross Section A-A'**

0m 3 6 9 12



B / -- **Cross Section B-B'**

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	- -	- -	- -	- -	- -	A	Issued for Regulatory Review	TMAC	JBK	20/12/11

REFERENCE DRAWINGS — REVISIONS

PROFESSIONAL ENGINEERS STAMP (REGISTERED PROFESSIONAL ENGINEER, J.B. KURYLO, LICENSEE, NT/NU)

srk consulting

DESIGN: JBK	DRAWN: TAH	REVIEWED: CWS
CHECKED: TMAC	APPROVED: JBK	DATE: 2020/12/11

FILE NAME: 1CT022.055 - MNP - Berm Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: Slope Transition Placement

DRAWING NO.: MNP-CWP-08 | SHEET: 8 OF 13 | REVISION NO.: A

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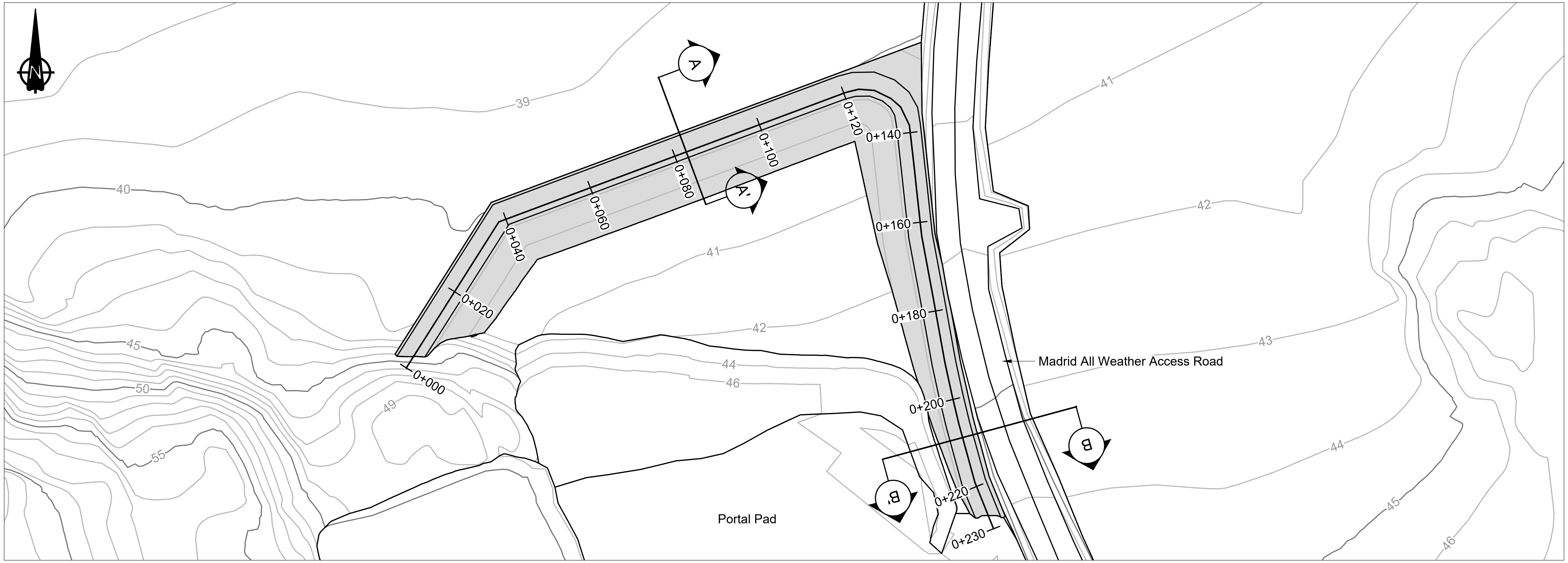
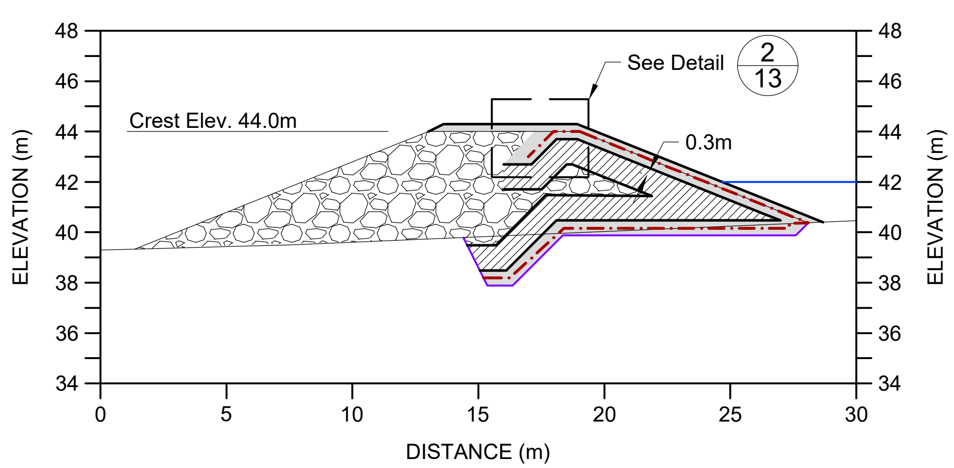


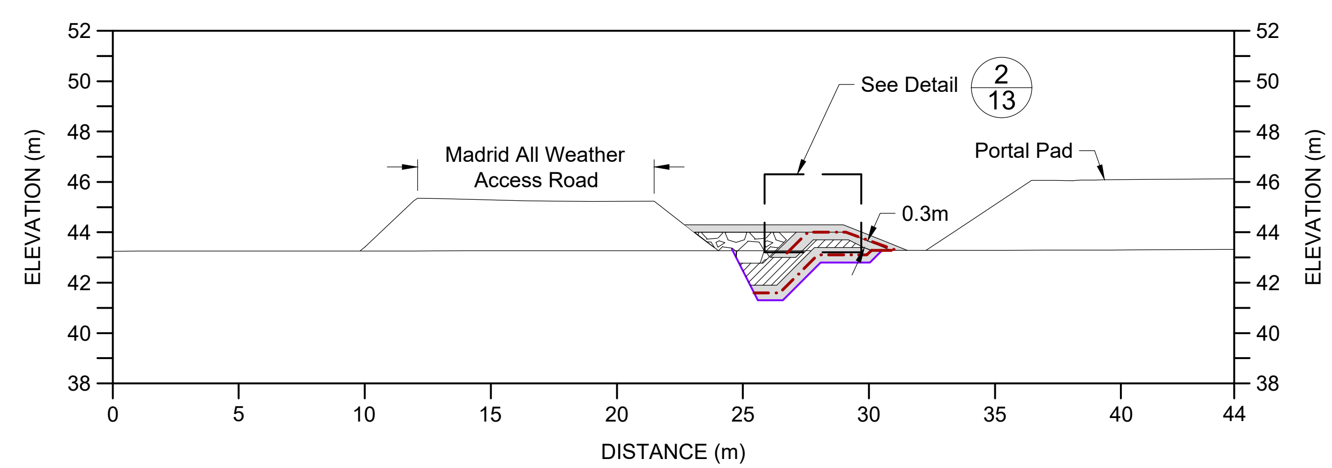
Key Trench Bedding Plan View

0m 10 20 30 40



A
--
Cross Section A-A'

0m 3 6 9 12



B
--
Cross Section B-B'

0m 3 6 9 12

LEGEND

- Liner System
- Full Supply Level (Elev. 42.0m)
- Bedding Material
- Transition Material
- ROQ Material

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
4. The CWP will normally be kept in a dry state with a maximum one-week (i.e. seven-day) residence time for water in the pond.
5. Where the height of the berm exceeds 3.0m, safety berms to barriers are required on the crest. See Typical Berm Barrier Options on drawing MNP-CWP-13.
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. 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.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
--	--	--	--	--	--	--	A	Issued for Regulatory Review	TMAC	JBK	Nov2020

REFERENCE DRAWINGS | REVISIONS

PROFESSIONAL ENGINEERS STAMP

REGISTERED PROFESSIONAL ENGINEER
J.B. KURYLO
LICENSEE
2020/12/11
NT/NU

srk consulting

TMAC RESOURCES

DESIGN: JBK	DRAWN: TAH	REVIEWED: CWS
CHECKED: TMAC	APPROVED: JBK	DATE: 2020/12/11

FILE NAME: 1CT022.055 - MNP - Berm Bedding.dwg

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

DRAWING TITLE: Slope Bedding and Liner Placement

DRAWING NO.: MNP-CWP-09 | SHEET: 9 OF 13 | REVISION NO.: A

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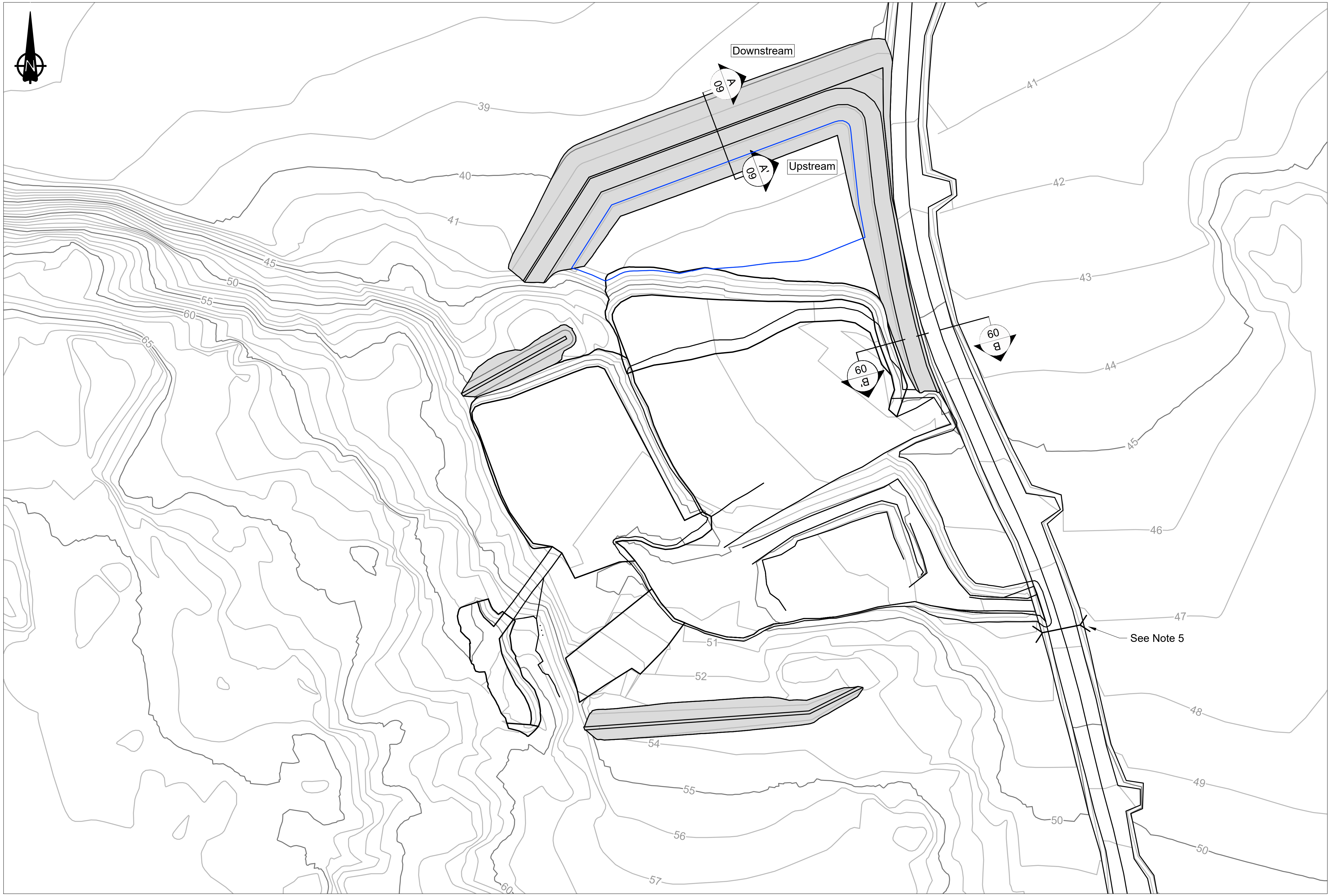


LEGEND

- Proposed Infrastructure
- Max. Ponding Extents (Elev. 42.0m)

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibility to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advise the Construction Manager and Engineer of any differences.
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. The pond has been designed with the capacity to contain at a minimum the contact water from the 1:10 year, 24-hour storm event, and the maximum daily snowmelt without the construction of surface water diversions to further limit the amount of contact water. When the surface water diversion berms are constructed then the primary catchment area reduces the catchment footprint immediately over and surrounding the Madrid North Portal Pad and the design event can then be increased to 1:100 year, 24-hour storm event. When the diversion berms are constructed then a culvert will also be required to be placed around the location shown on the drawing to diversrt clean water to the west side of the Madrid All-Weather Road (AWR).

REFERENCES

1. NAD83 UTM Zone 13.
2. 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

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	- -	- -	- -	- -	- -	A	Issued for Regulatory Review	TMAC	JBK	Nov 2020

REFERENCE DRAWINGS | REVISIONS

PROFESSIONAL ENGINEERS STAMP

REGISTERED PROFESSIONAL ENGINEER
J.B. KURYLO
LICENSEE
NT/NU
2020/12/

srk consulting

DESIGN: JBK	DRAWN: TAH	REVIEWED: CWS
CHECKED: -TMAC	APPROVED: JBK	DATE: November 2020

FILE NAME: 1CT022.055 - MNP - Final.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.055

Madrid North Portal Contact Water Pond

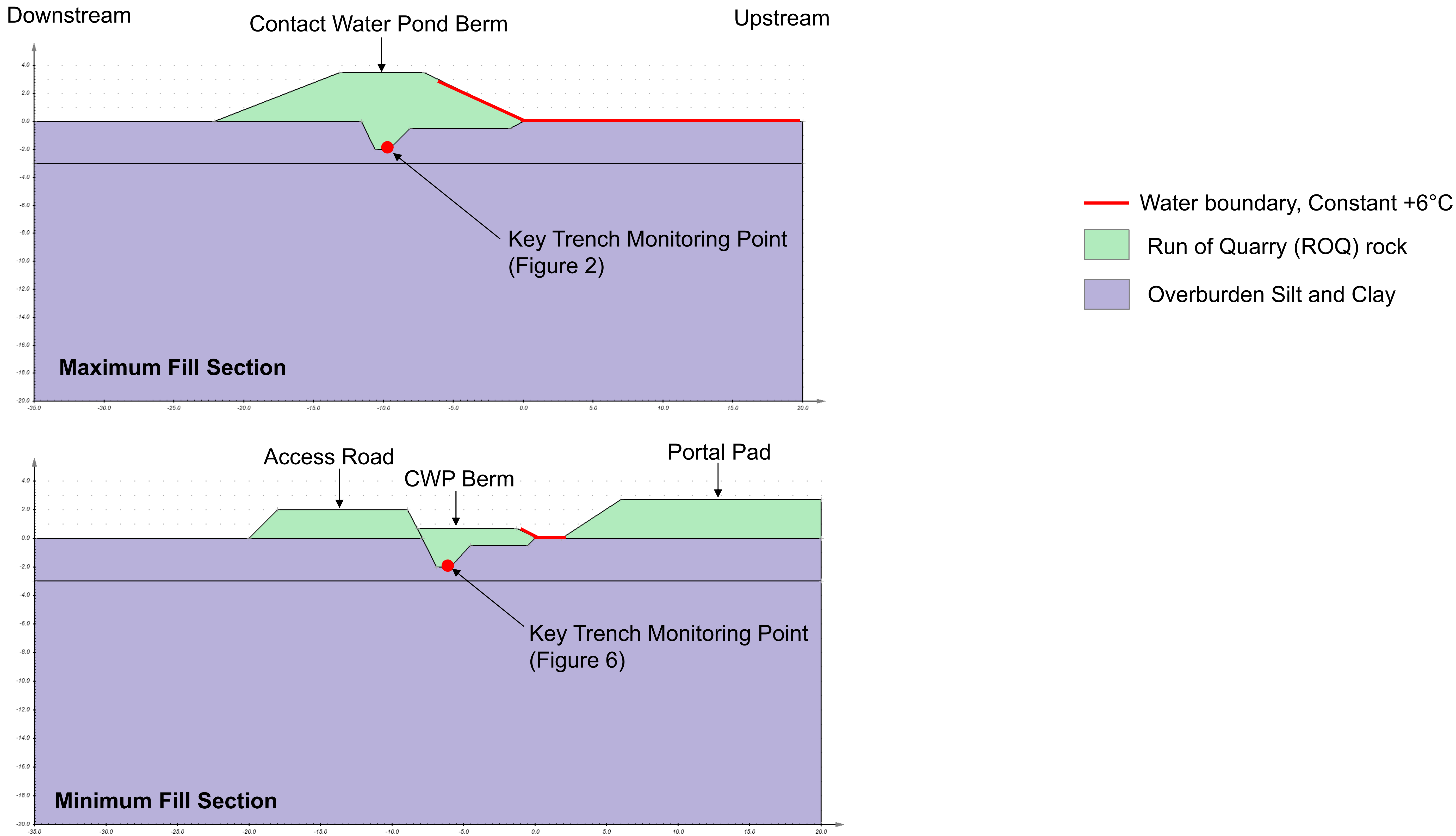
DRAWING TITLE:

Final Arrangements

DRAWING NO.: MNP-CWP-10 | SHEET: 10 OF 13 | REVISION NO.: A

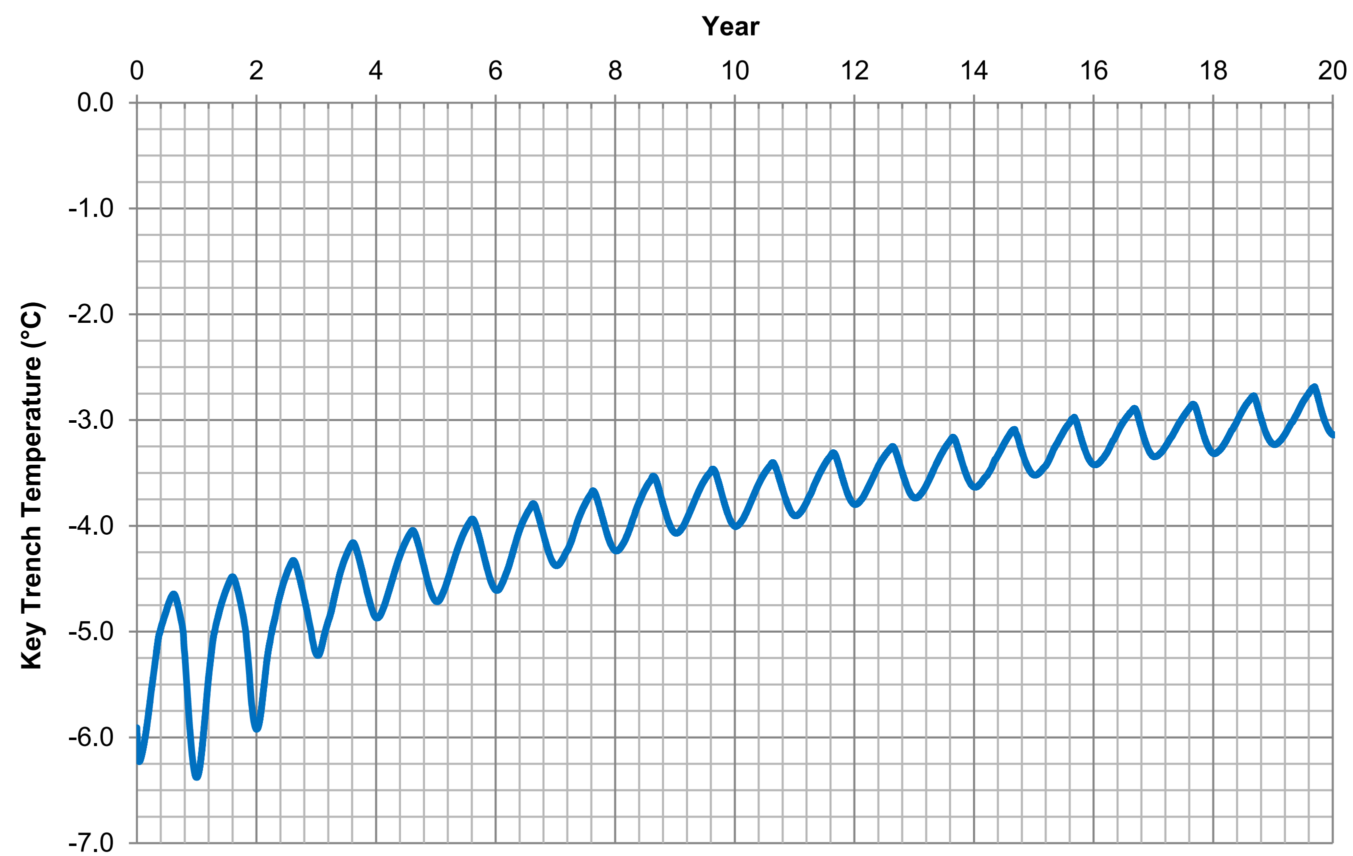
P:\Projects\01_SITES\Hope.Bay\ACAD\IFR\Madrid Portal Pad CWP\1CT022.055 - MNP - Final.dwg

Attachment 2 Thermal Modeling Results



Notes:
1. Thermal model sections based on representative maximum and minimum fill sections
2. Contact water pond (CWP)

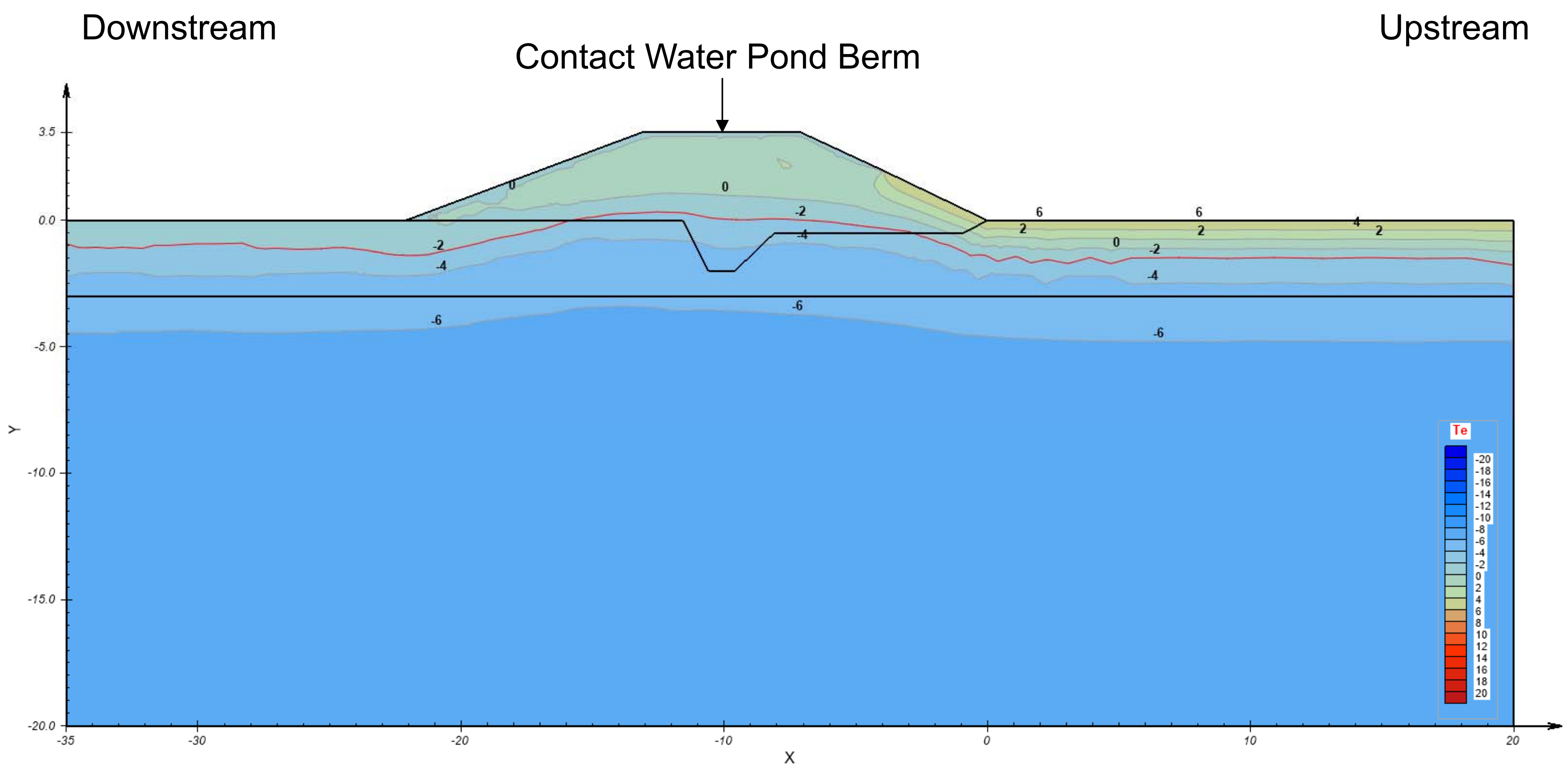
srk consulting	MAC RESOURCES	Contact Water Pond Berm Thermal Modeling
Job No: 1CT022.055	HOPE BAY PROJECT	**Thermal Model Geometry**
Filename: Madrid_CWP_ThermalModel_Results.pptx		Date: Nov. 2020 · Approved: CWS · Figure: 1



Notes:

1. Model section represents key trench temperature over 20-year design life
2. Model results for maximum berm thickness of 3.5 m
3. Based on constant +6°C water temperature applied to full supply level in the model

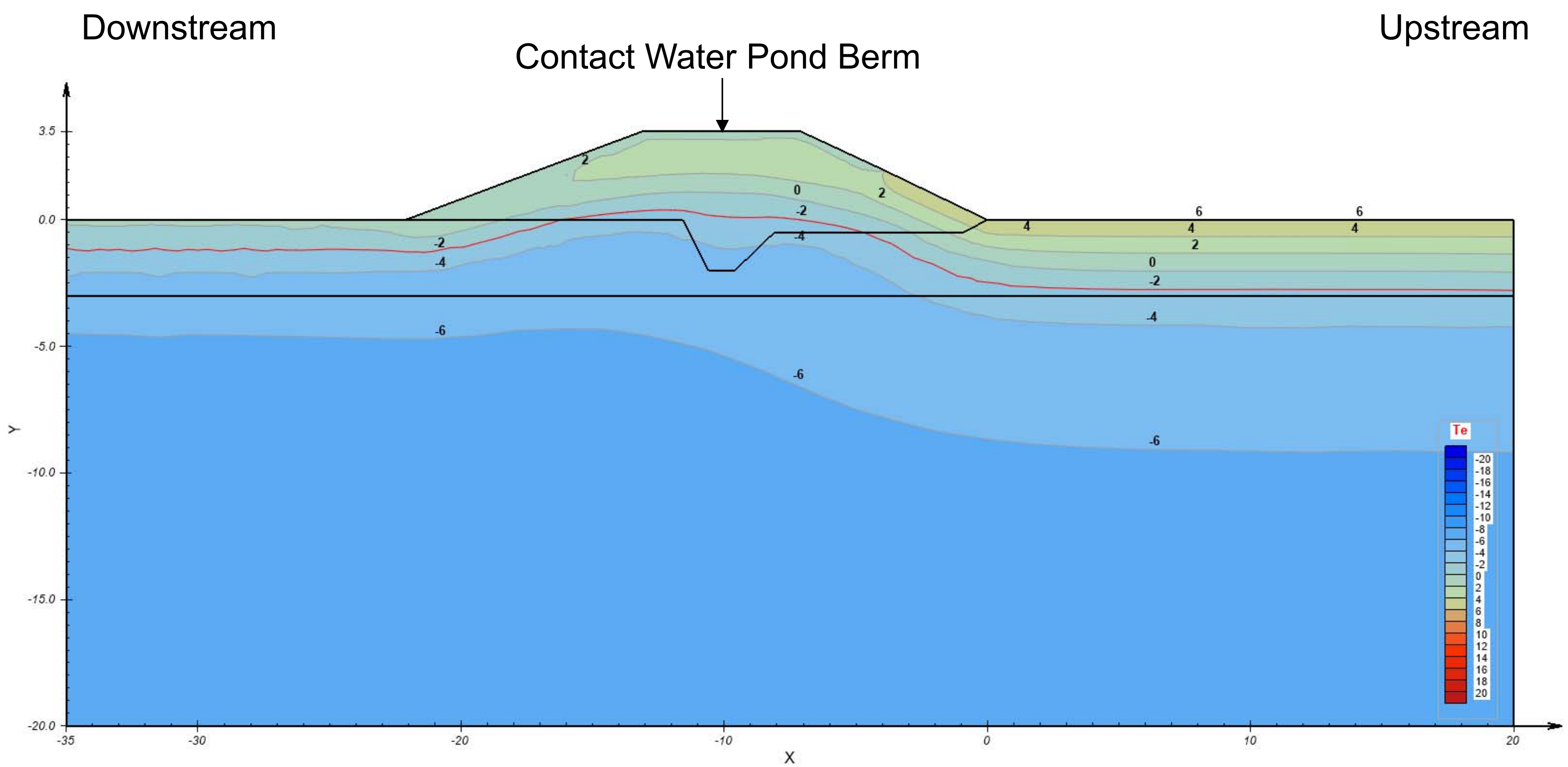
srk consulting	TMAC RESOURCES	Contact Water Pond Berm Thermal Modeling
		Maximum Section – Key Trench Temperature
Job No: 1CT022.055 Filename: Madrid_CWP_ThermalModel_Results.pptx	HOPE BAY PROJECT	Date: Nov. 2020 / Approved: CWS / Figure: 2



Notes:

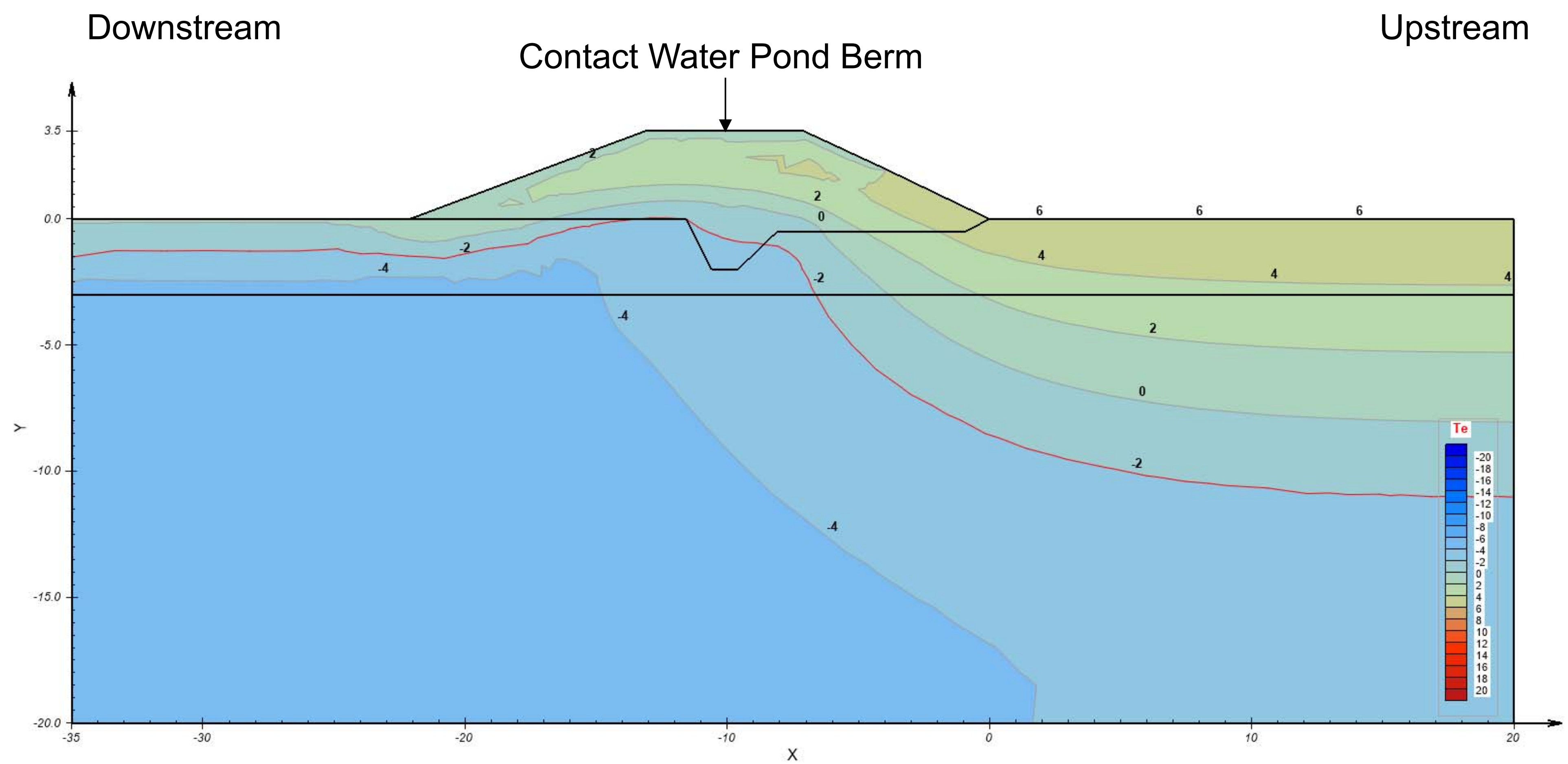
1. Model section represents maximum position of -2°C isotherm (solid red line) during Year 1
2. Model results for maximum berm thickness of 3.5 m
3. Based on constant +6°C water temperature applied to full supply level in the model

Job No: 1CT022.055 Filename: Madrid_CWP_ThermalModel_Results.pptx	HOPE BAY PROJECT	Contact Water Pond Berm Thermal Modeling **Maximum Section – Model Results, Year 1** Date: Nov. 2020 · Approved: CWS · Figure: 3



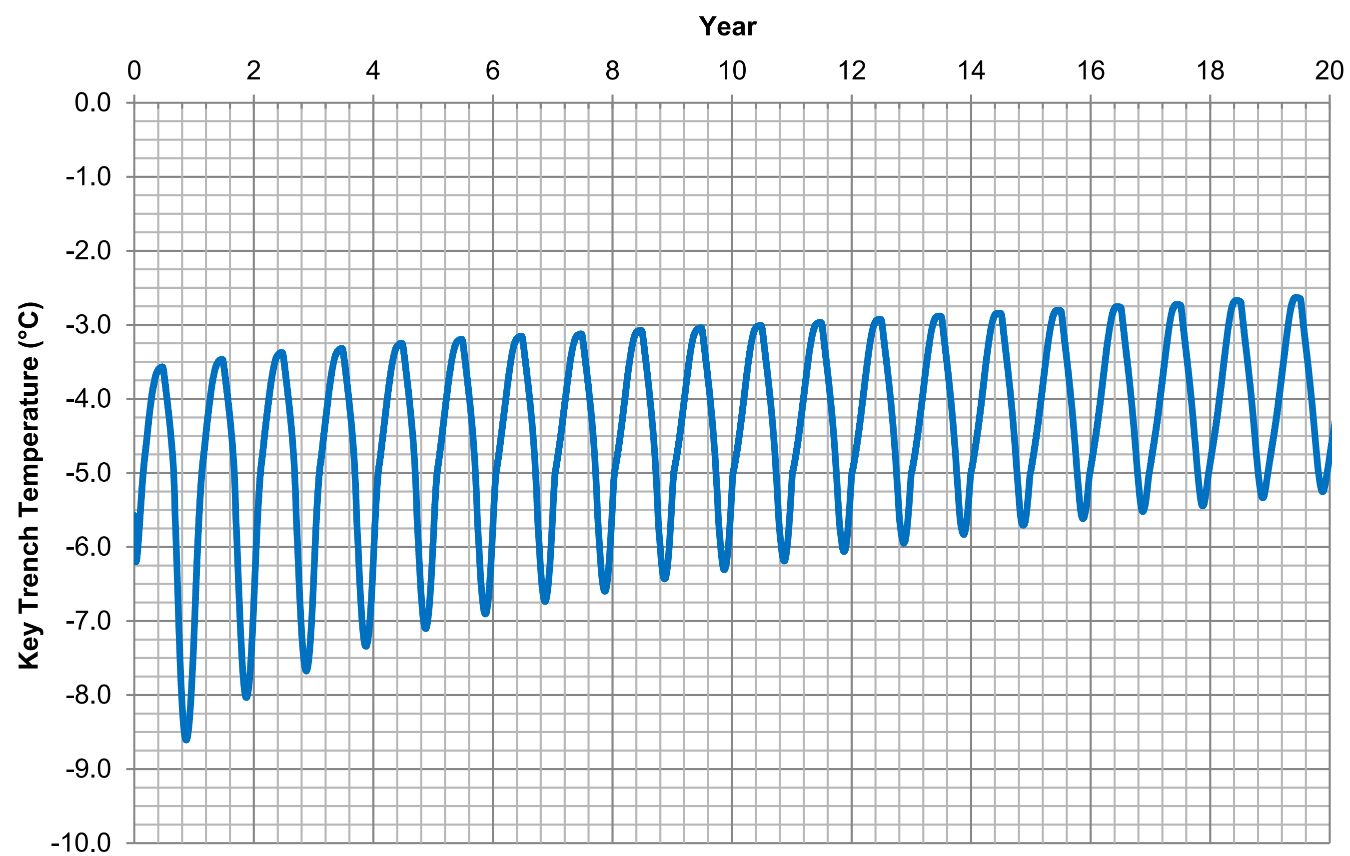
Notes:
1. Model section represents maximum position of -2°C isotherm (solid red line) during Year 2
2. Model results for maximum berm thickness of 3.5 m
3. Based on constant +6°C water temperature applied to full supply level in the model

Job No: 1CT022.055	HOPE BAY PROJECT	Contact Water Pond Berm Thermal Modeling
Filename: Madrid_CWP_ThermalModel_Results.pptx		**Maximum Section – Model Results, Year 2**
		Date: Nov. 2020 / Approved: CWS / Figure: **4**



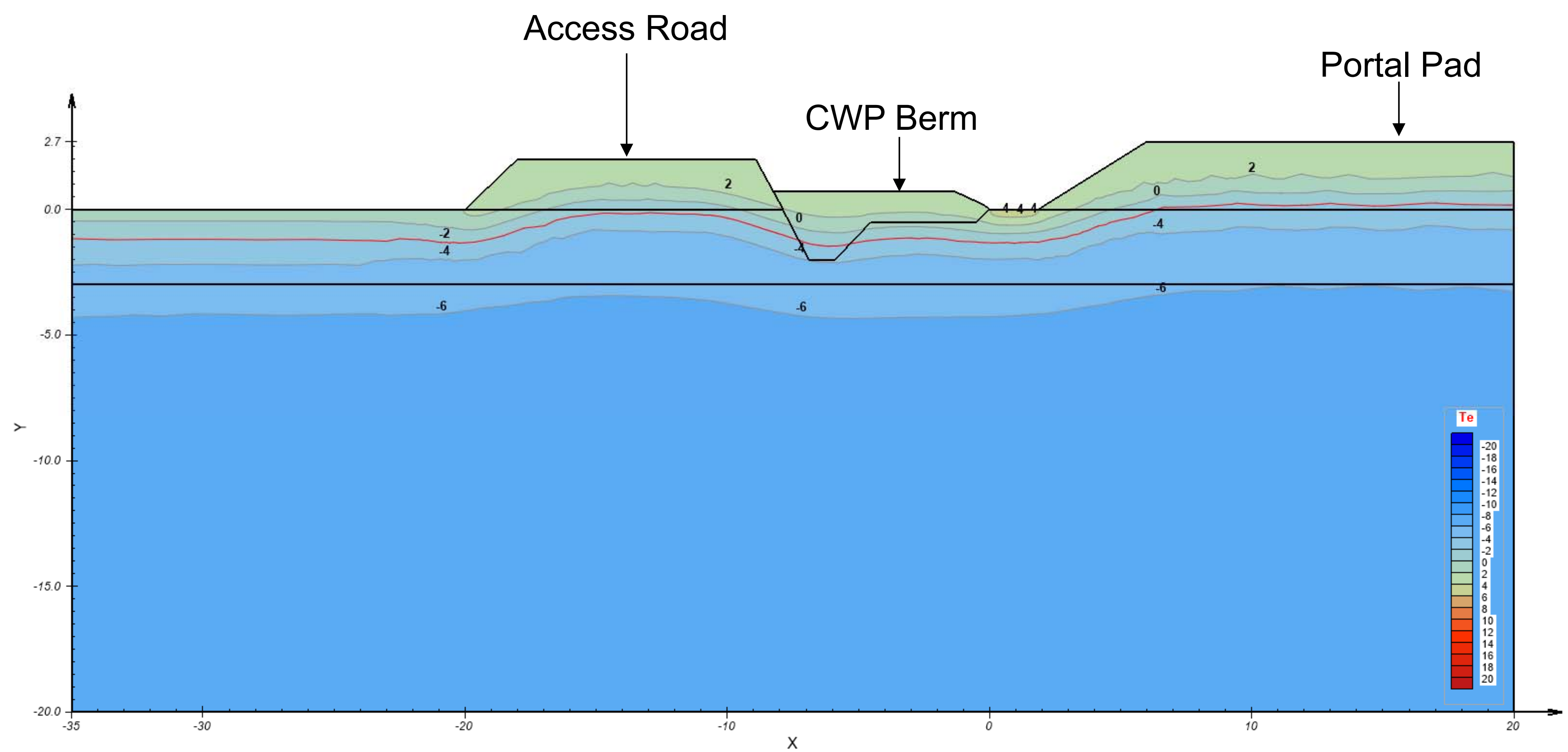
Notes:
1. Model section represents maximum position of -2°C isotherm (solid red line) during Year 20
2. Model results for maximum berm thickness of 3.5 m
3. Based on constant +6°C water temperature applied to full supply level in the model

srk consulting	MAC RESOURCES	Contact Water Pond Berm Thermal Modeling
Job No: 1CT022.055 Filename: Madrid_CWP_ThermalModel_Results.pptx	HOPE BAY PROJECT	**Maximum Section – Model Results, Year 20**
		Date: Nov. 2020 | Approved: CWS | Figure: 5



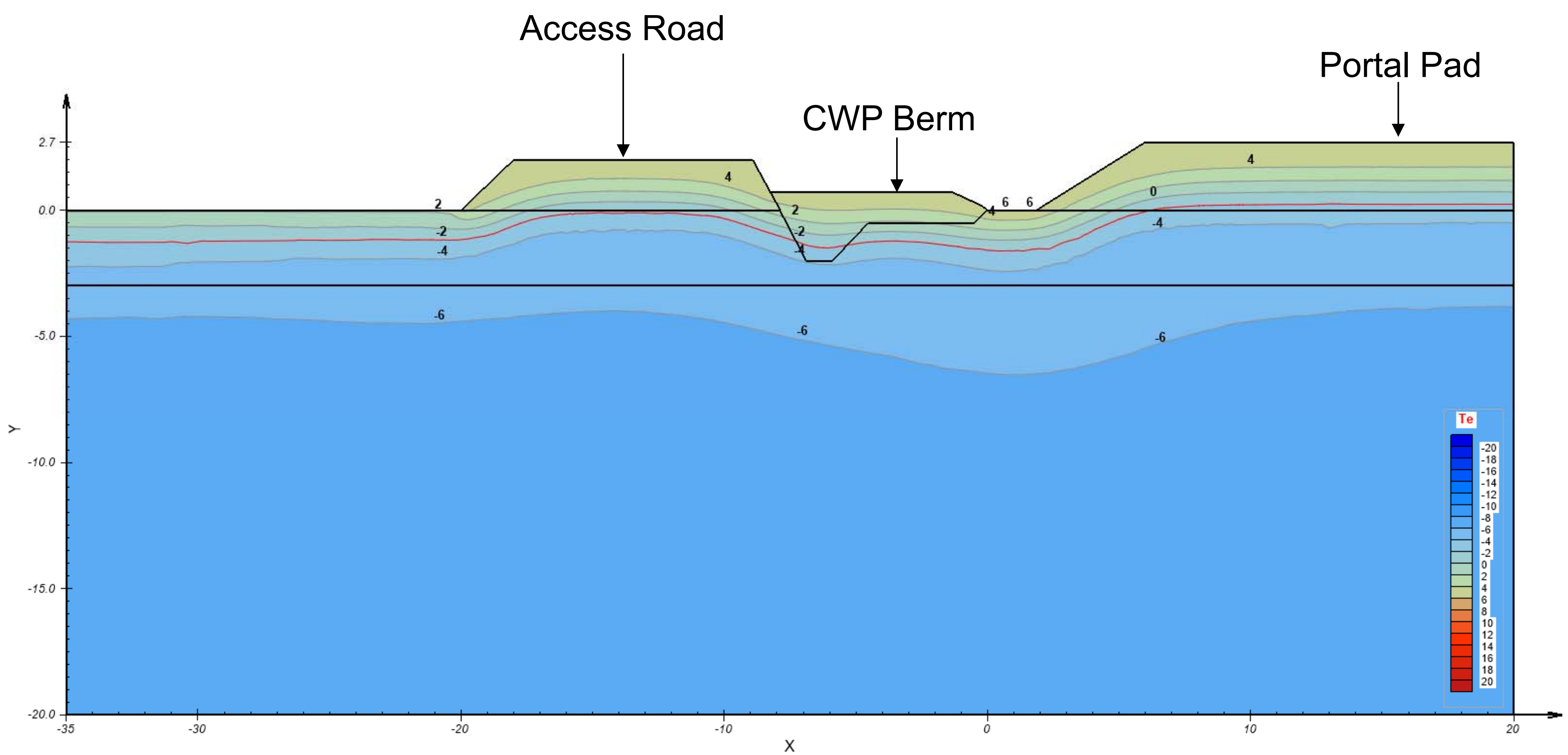
Notes:
1. Model section represents key trench temperature over 20-year design life
2. Model results for minimum berm thickness
3. Based on constant +6°C water temperature applied to full supply level in the model

srk consulting	TMAC RESOURCES	Contact Water Pond Berm Thermal Modeling
Job No: 1CT022.055 Filename: Madrid_CWP_ThermalModel_Results.pptx	HOPE BAY PROJECT	**Minimum Section – Key Trench Temperature**
		Date: Nov. 2020 · Approved: CWS · Figure: 6



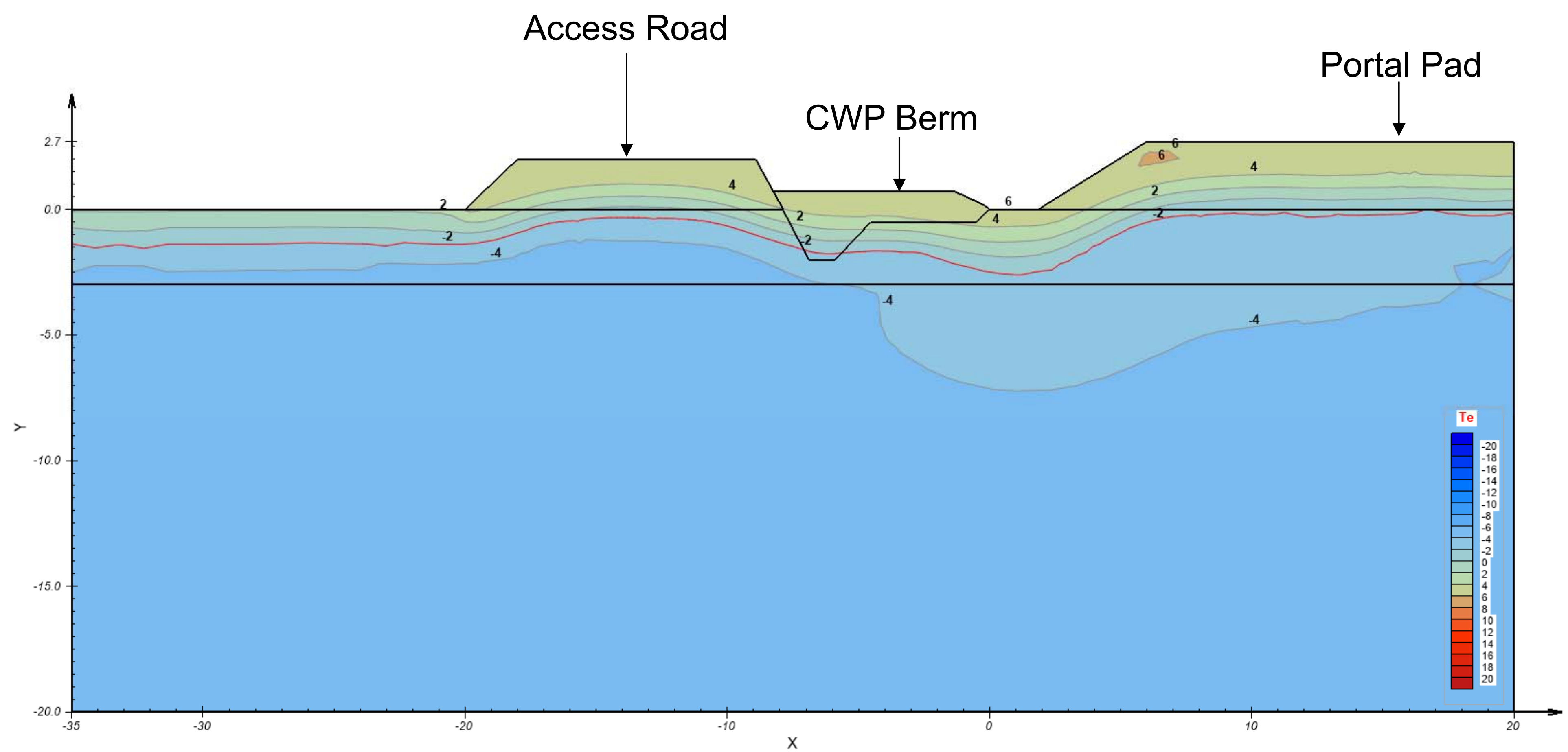
Notes:
1. Model section represents maximum position of -2°C isotherm (solid red line) during Year 1
2. Model results for minimum berm thickness
3. Based on constant +6°C water temperature applied to full supply level in the model
4. Contact water pond (CWP)

srk consulting	MAC RESOURCES	Contact Water Pond Berm Thermal Modeling
		Minimum Section Section – Model Results, Year 1
Job No: 1CT022.055 Filename: Madrid_CWP_ThermalModel_Results.pptx	HOPE BAY PROJECT	Date: Nov. 2020 · Approved: CWS · Figure: 7



Notes:
1. Model section represents maximum position of -2°C isotherm (solid red line) during Year 2
2. Model results for minimum berm thickness
3. Based on constant +6°C water temperature applied to full supply level in the model
4. Contact water pond (CWP)

Job No: 1CT022.055	HOPE BAY PROJECT	Contact Water Pond Berm Thermal Modeling
Filename: Madrid_CWP_ThermalModel_Results.pptx		**Minimum Section Section – Model Results, Year 2**
		Date: Nov. 2020
		Approved: CWS
		Figure: 8



Notes:
1. Model section represents maximum position of -2°C isotherm (solid red line) during Year 20
2. Model results for minimum berm thickness
3. Based on constant +6°C water temperature applied to full supply level in the model
4. Contact water pond (CWP)

srk consulting	TMAC RESOURCES	Contact Water Pond Berm Thermal Modeling
		Minimum Section Section – Model Results, Year 20
Job No: 1CT022.055 Filename: Madrid_CWP_ThermalModel_Results.pptx	HOPE BAY PROJECT	Date: Nov. 2020 / Approved: CWS / Figure: 9

Attachment 3 Slope Stability Checks

Madrid North Portal CWP

Preliminary Stability Analysis Checks

December 2020 – Rev 00

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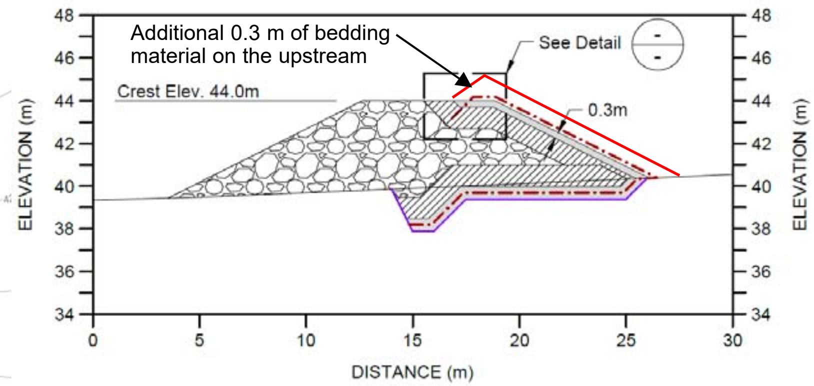
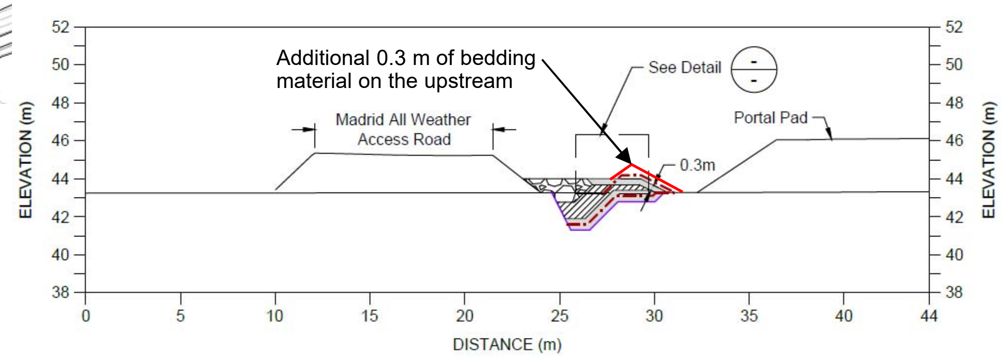
Plan and Section Views

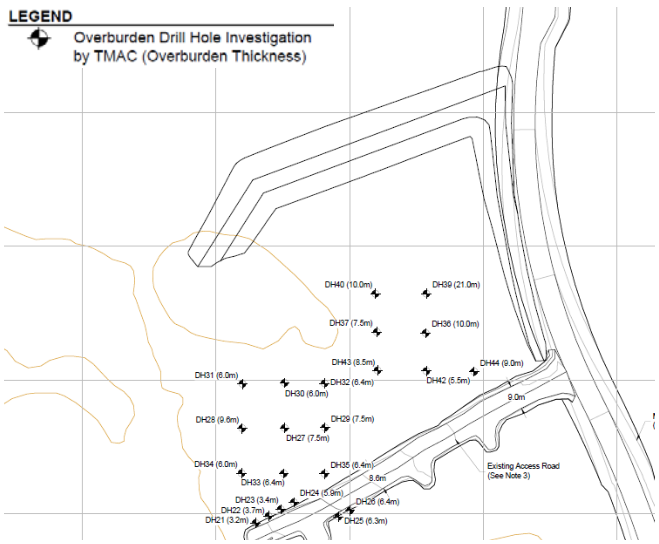


A Cross Section A-A'

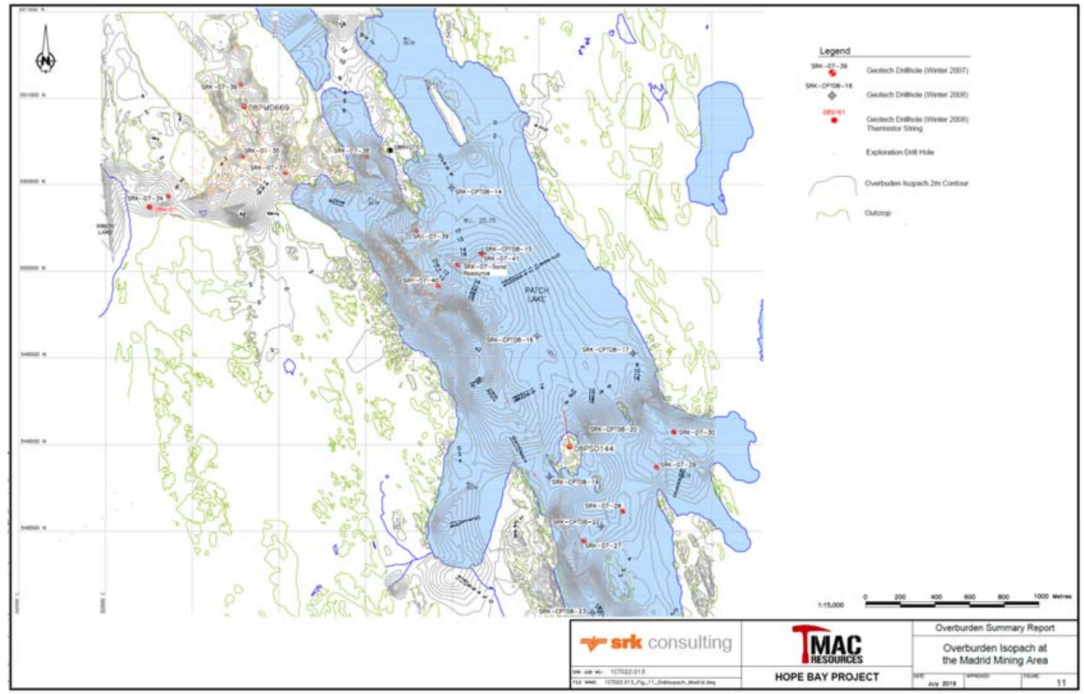


B Cross Section B-B'

Bedrock Surface



From Madrid North Portal Pad As-built Drawings



Based on Madrid Area Isopach (prepared in July 2019), Overburden thickness is:

- Below Section A-A': **22 m**
- Below Section B-B': **12-14 m**

Did not model the bedrock in stability analysis models

- Since bedrock depth >> dam height

The dam alignment is not within isopach prepared for Madrid North Portal Pad (prepared in August 2019) – See the next slide

To be confirmed with drilling investigation from Jan 2021

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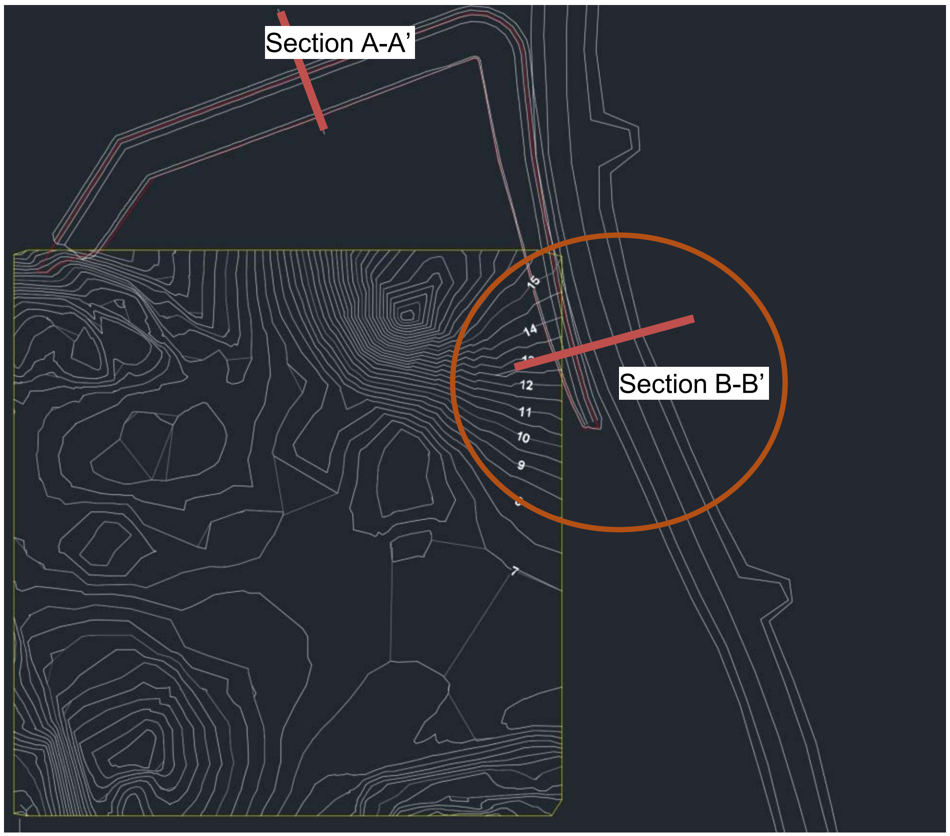
August 2019 Isopach



The dam alignment is not within isopach prepared for Madrid North Portal Pad (prepared in August 2019)

Overburden thickness below Section B-B' is ~13 m

Material Properties

Equation: Spencer, GLE/M-P
Search method: Non-circular Auto-Refine
Min. failure depth: 0.5 m

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Base Case

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 26		17	Mohr-Coulomb	6	26	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 38		20	Mohr-Coulomb	0	38	Water Surface	Custom	1

Sensitivity Case

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Liner

- Modeled as a "Weak Layer"

The **Weak Layer** option in *Slide* 2018 allows you to define a weak layer using only a polyline. A weak layer polyline has assigned strength properties. Since a weak layer polyline has no physical thickness, it is intended to be used for modeling interfaces, joints or very thin weak layers with negligible thickness, along which sliding might occur.

Before we proceed we should clarify what we mean by a "weak layer".

Weak layer modeled as a thin material layer

This method of modeling weak layers is commonly used, and works very well in most circumstances. The advanced search algorithms in *Slide* can locate critical slip surfaces even in thin irregular weak layers, with excellent results in most cases.

However, there are some limitations to this method.

- For very thin weak layers (thickness approaching zero), or irregular non-linear weak layers, even the best search algorithms may have trouble locating slip surfaces within such layers. In some cases, the user may be forced to define a search polyline inside a finite weak layer, to focus the search within the weak layer.
- If a weak layer represents an interface with zero thickness, then the user is forced to create a thin material layer to model the interface, using two material boundaries, since you cannot create a zero-thickness material. For example, when modeling a geomembrane interface in landfill.

To check upstream stability, **liner** was modeled as:

- **Weak layer**
- **Thin layer**

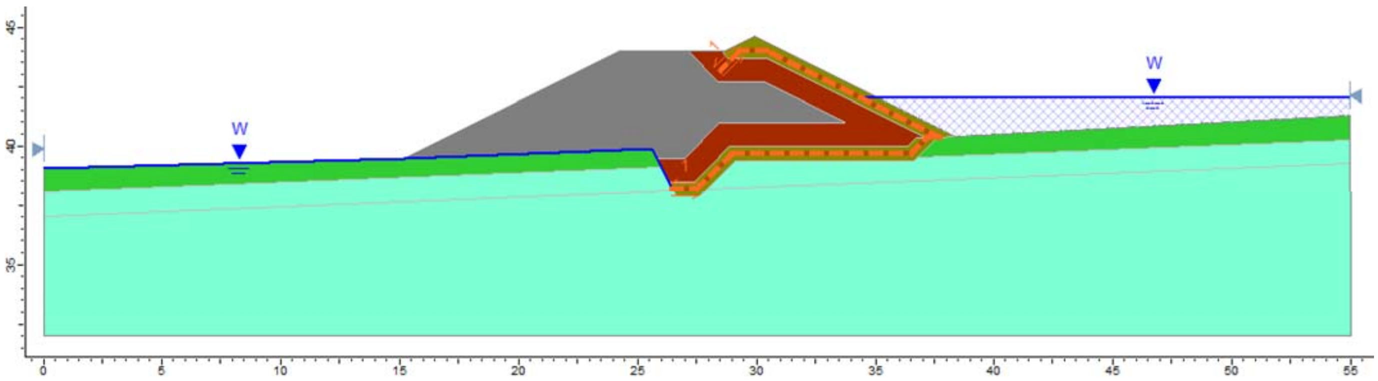
To understand the sensitivity of **Thin layer** liner, models were also run without a liner

Liner system to be modeled as a support (with tensile strength) to compare the results

The **Weak Layer** polyline option has the following attributes:

- A weak layer is defined by a polyline.
- The polyline is assigned material (strength) properties.
- The search algorithms in *Slide* will attempt to "follow" the weak layer polyline, to generate slip surfaces along the polyline (in this sense, a weak layer polyline behaves as a search focus object).
- A weak layer polyline is an independent modeling entity, and does NOT get intersected with any other model boundaries.
- A weak layer polyline can NOT be used as a material boundary. If you require a material boundary at the same location as a weak layer boundary, then you will have to add a material boundary AND a weak layer polyline at the same location.

Section A-A' Downstream Stability



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Downstream Stability Summary

Scenario	FOS		
	Frozen Foundation	1 m Thawed Foundation	2 m Thawed Foundation
Base Case **2.0H:1.0V** Side Slopes	1.7	1.4	1.4
Sensitivity Case **2.0H:1.0V** Side Slopes	1.6	1.6	1.6
Base Case **2.5H:1.0V** Side Slopes	2.1	1.6	1.6
Sensitivity Case **2.5H:1.0V** Side Slopes	2.0	2.0	1.9

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

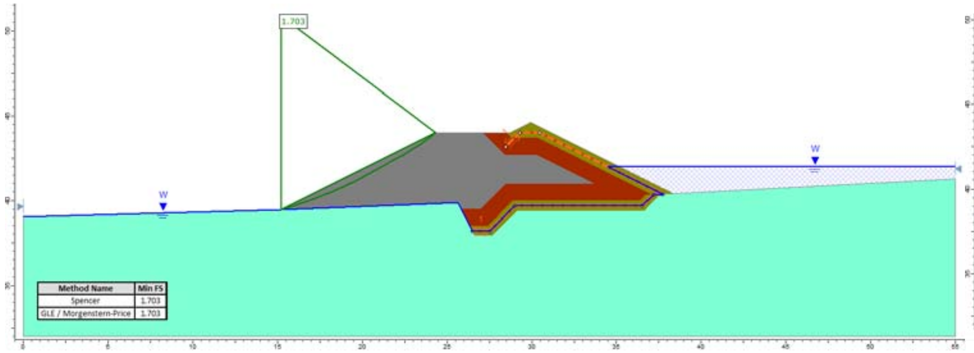
Base case

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 26		17	Mohr-Coulomb	6	26	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 38		20	Mohr-Coulomb	0	38	Water Surface	Custom	1

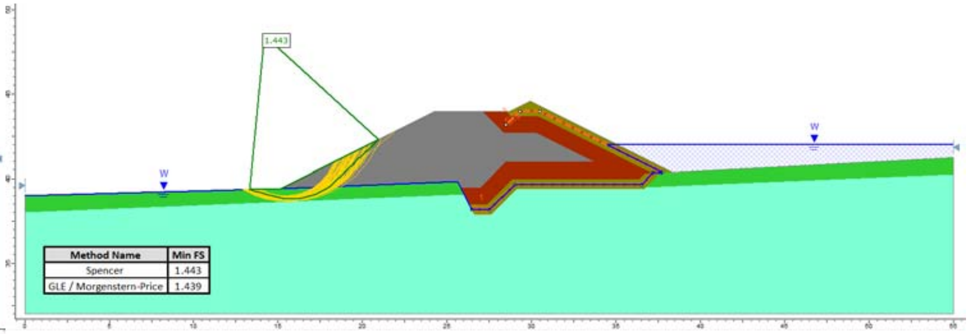
Sensitivity Case

srk consulting

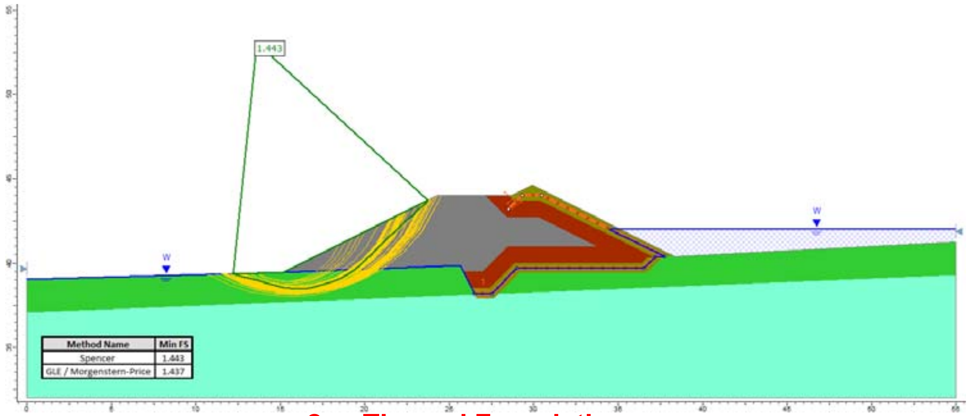
Base Case - Section A-A’ Downstream – 2.0H:1.0V



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.7	1.4	1.4

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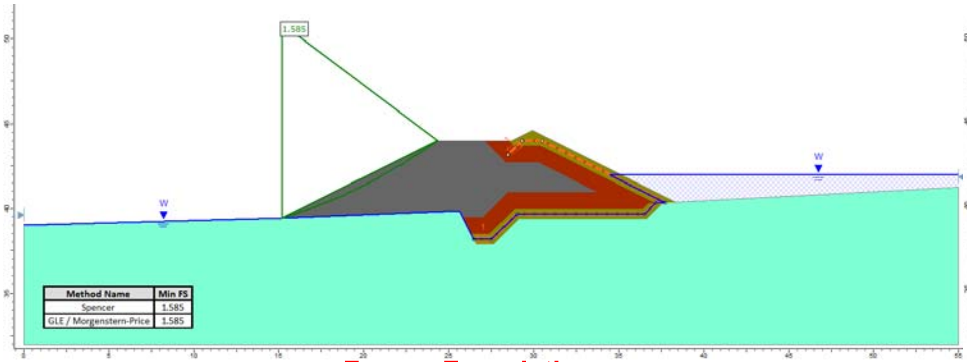
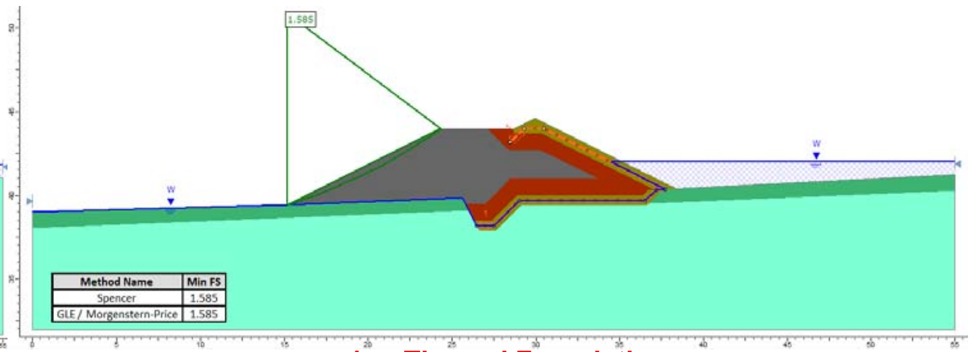
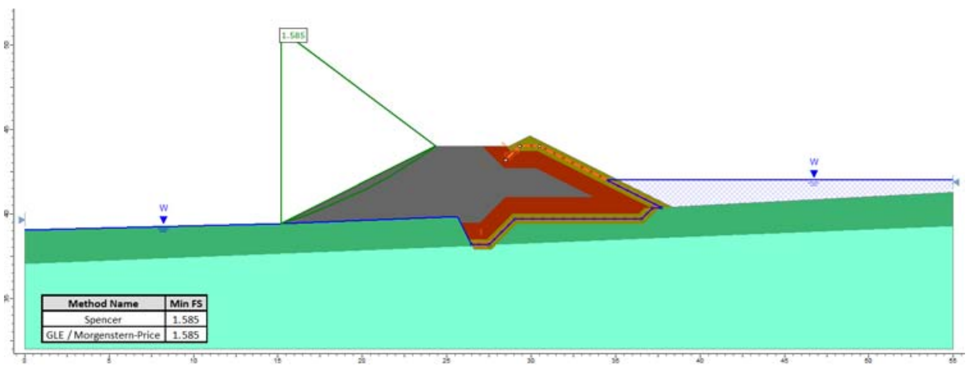
Sensitivity Case - Section A-A’ Downstream – 2.0H:1.0V



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 26		17	Mohr-Coulomb	6	26	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 38		20	Mohr-Coulomb	0	38	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.6	1.6	1.6

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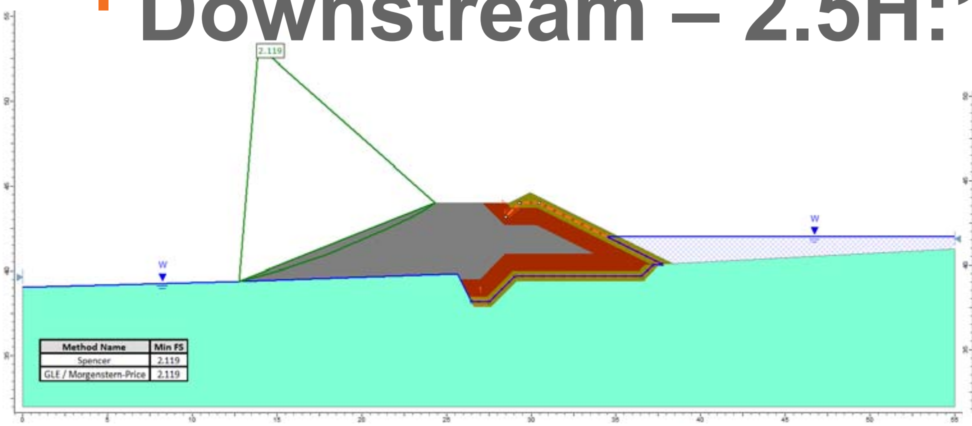
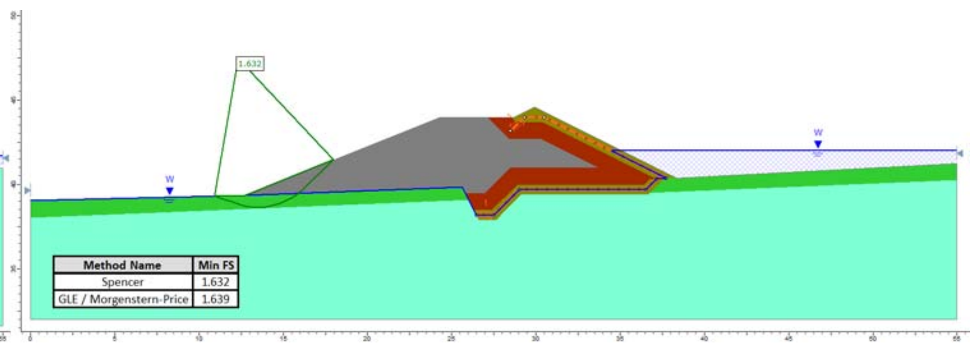
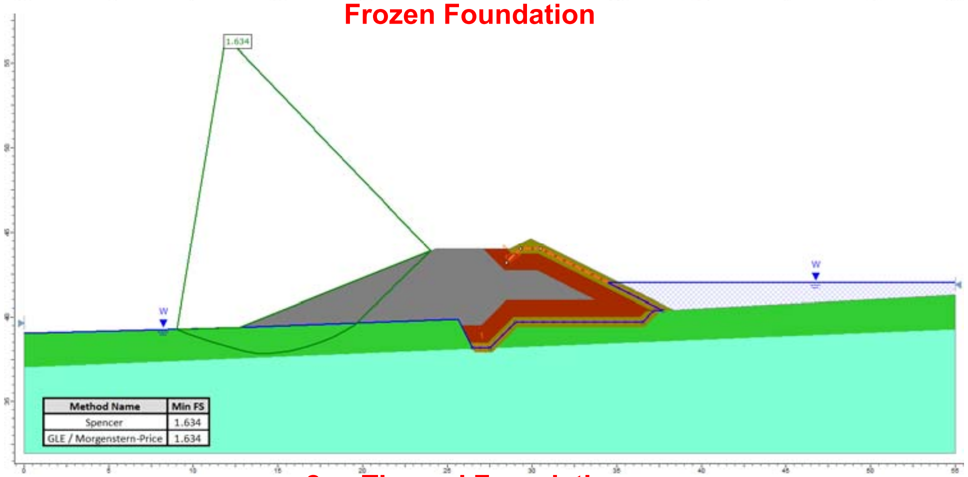
Base Case - Section A-A'
Downstream – 2.5H:1.0V



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	2.1	1.6	1.6

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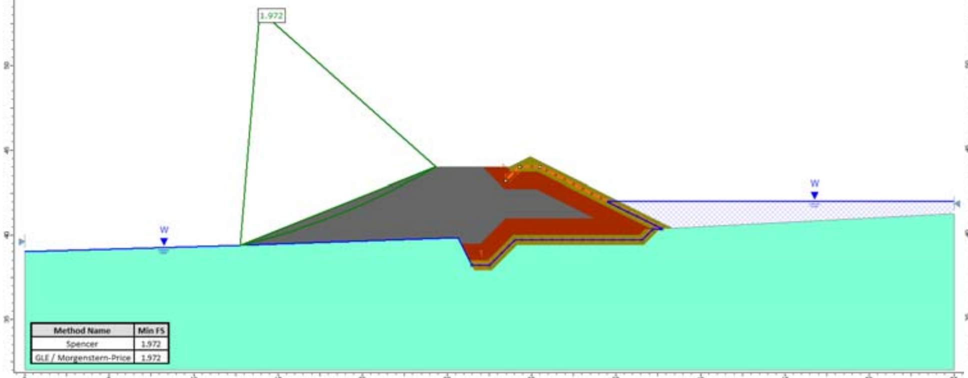
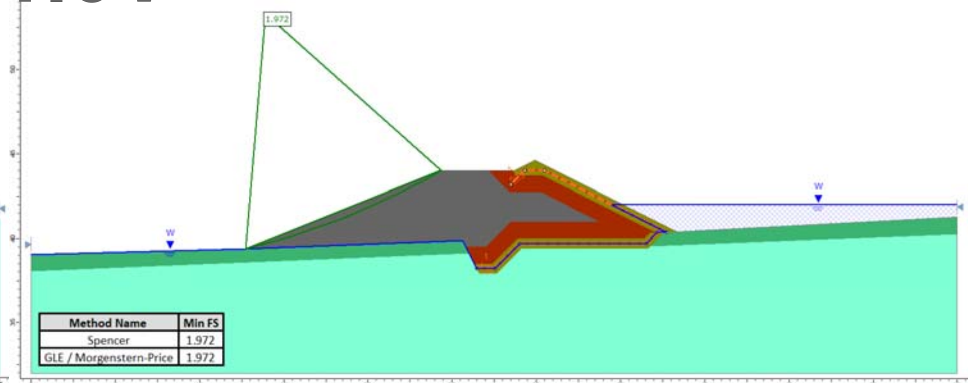
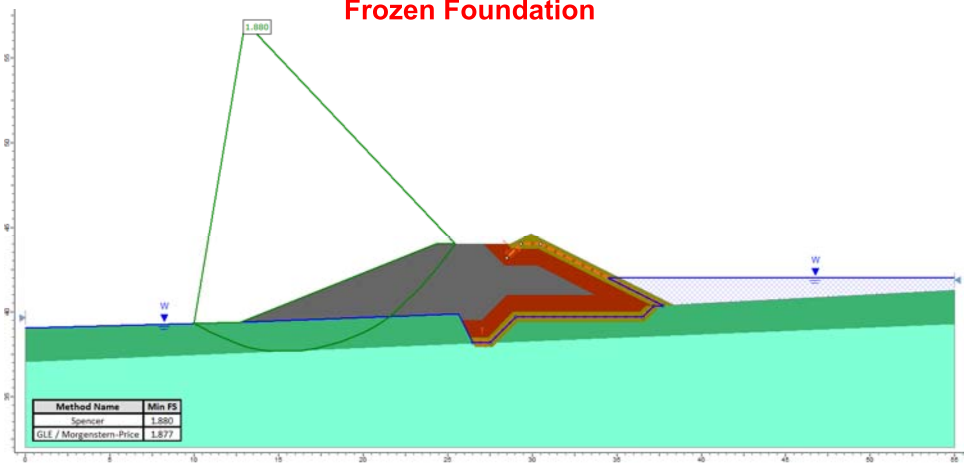
Sensitivity Case - Section A-A' Downstream – 2.5H:1.0V



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 26		17	Mohr-Coulomb	6	26	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 38		20	Mohr-Coulomb	0	38	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	2.0	2.0	1.9

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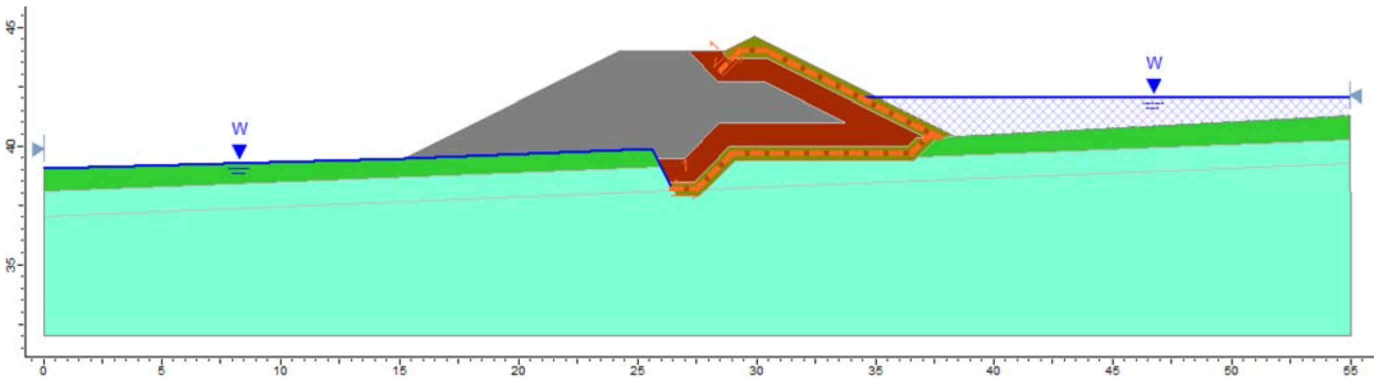
Section A-A' Upstream Stability



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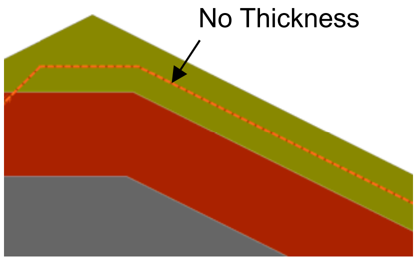
Upstream Stability Summary

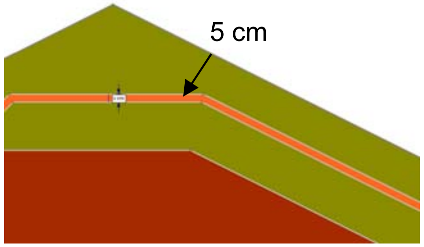
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Scenario	FOS		
	Frozen Foundation	1 m Thawed Foundation	2 m Thawed Foundation
Liner as **Weak Layer** **2.0H:1.0V**	1.2	1.2	1.2
Liner as **Weak Layer** **2.5H:1.0V**	1.4	1.4	1.4
Liner as **Weak Layer** **2.0H:1.0V** **No Bedding Upstream** **(no failure planes through liner)**	12.2	11.4	5.4
Liner as **Thin Layer** **2.0H:1.0V**	1.4	1.4	1.4
No Liner **2.0H:1V**	1.4	1.4	1.4
No Liner **2.5H:1V**	1.6	1.6	1.6
No Liner **2.0H:1V** No Pond	1.5	1.5	1.5

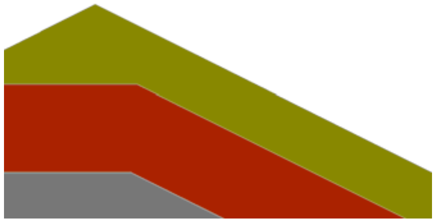
Base Case



Liner as Weak Layer

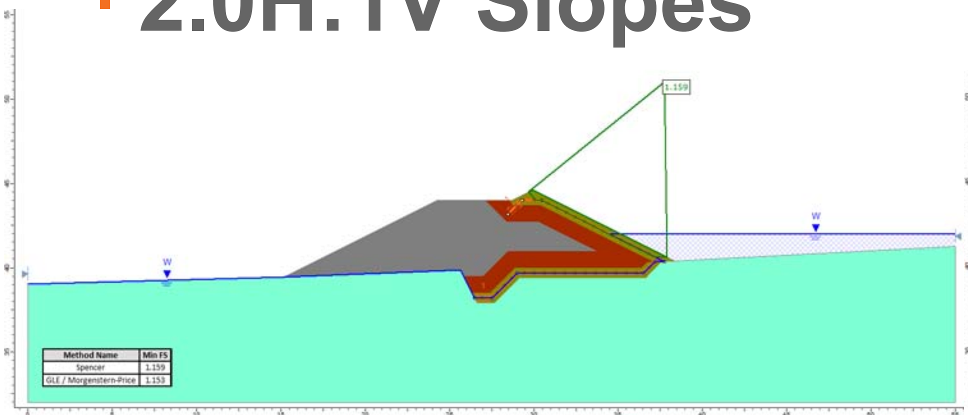


Liner as Thin Layer

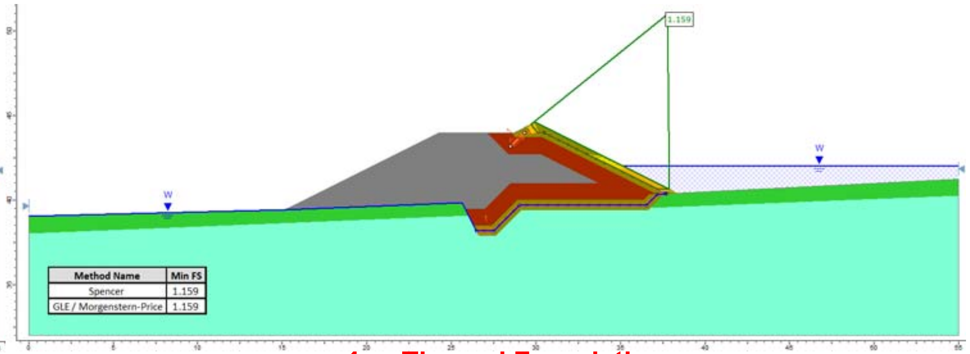


Section A-A' – Liner as Weak Layer 2.0H:1V Slopes

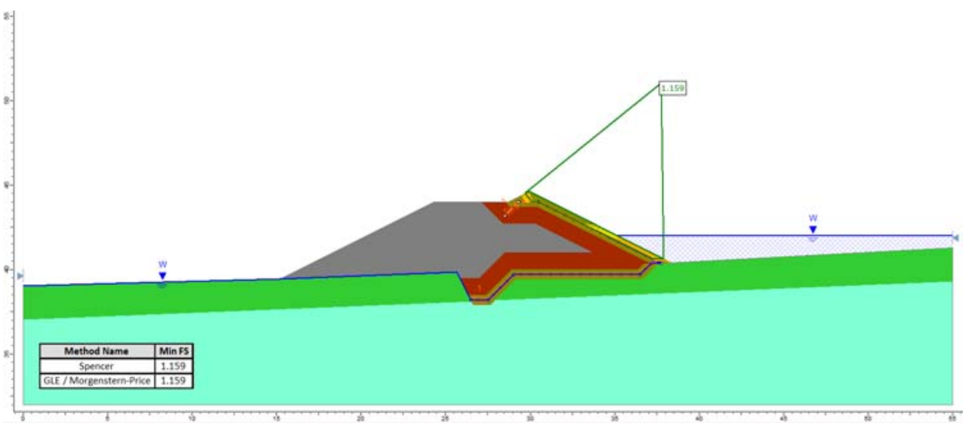
Failure planes along liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

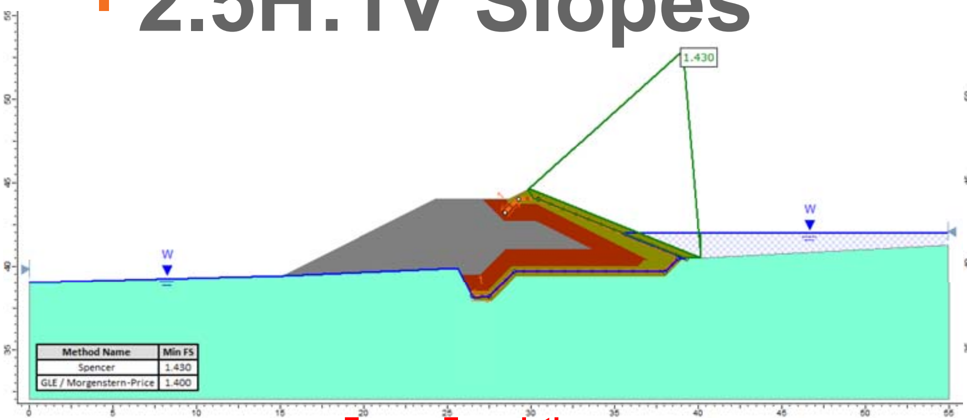
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.2	1.2	1.2

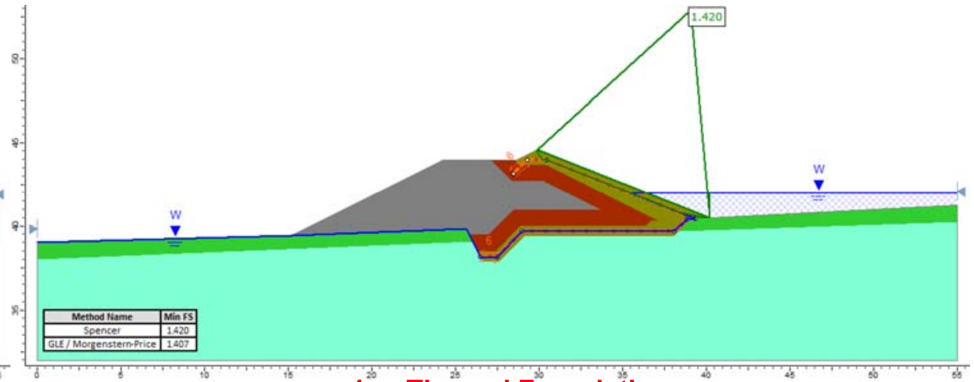
srk consulting

Section A-A' – Liner as Weak Layer 2.5H:1V Slopes

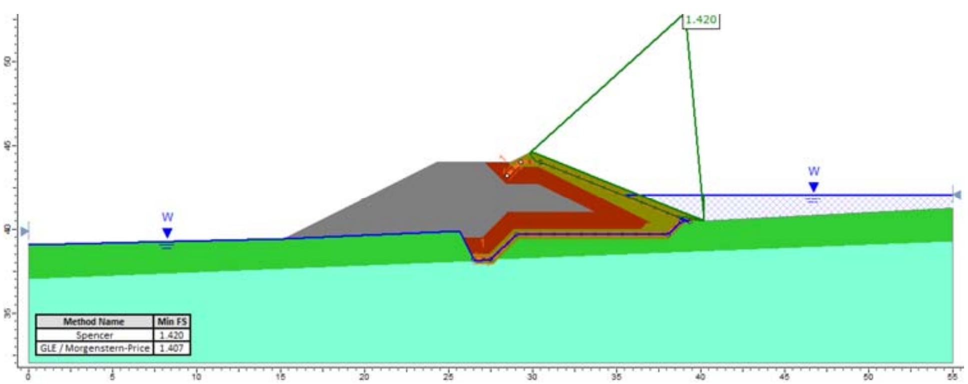
Failure planes along liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.4	1.4	1.4

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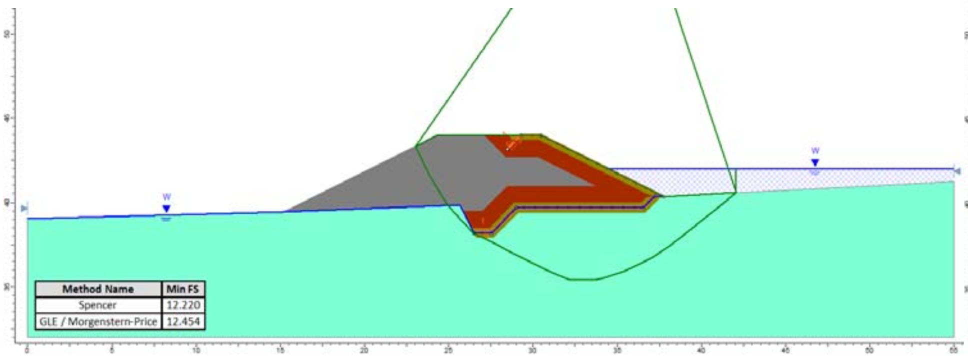
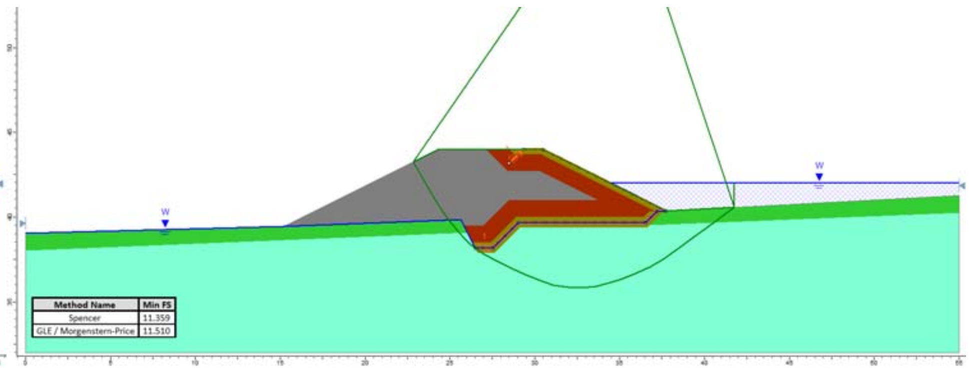
Section A-A' – No Upstream Bedding 2.0H:1V Slopes

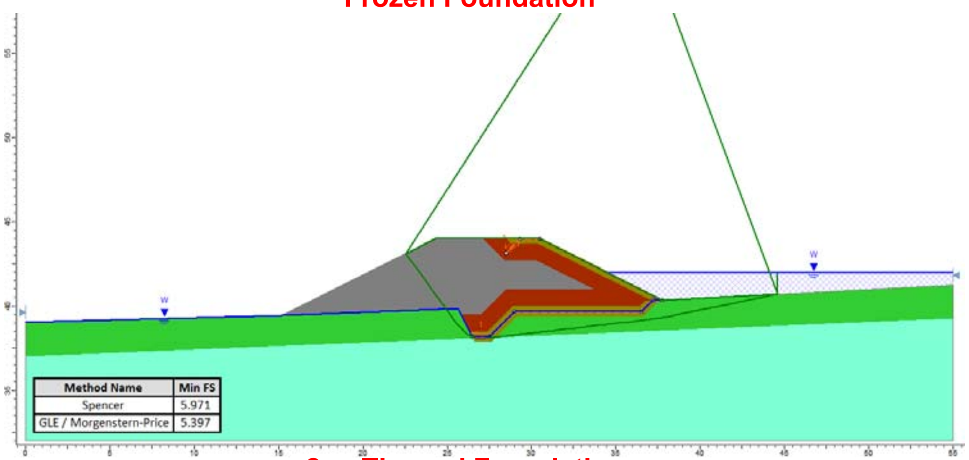
Failure planes not through liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	12.2	11.4	5.4

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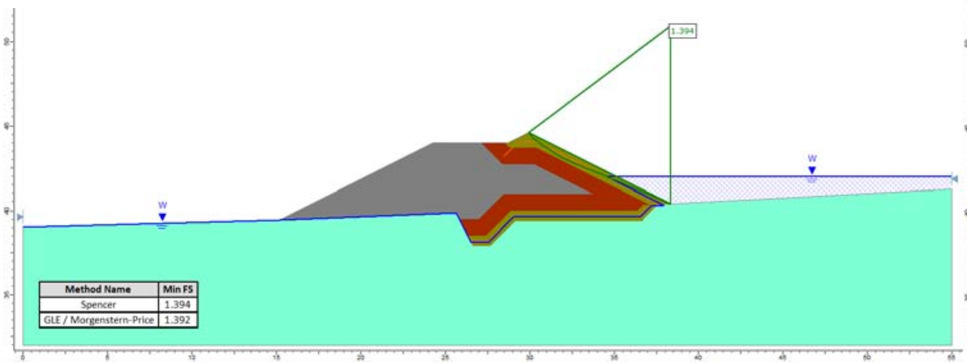
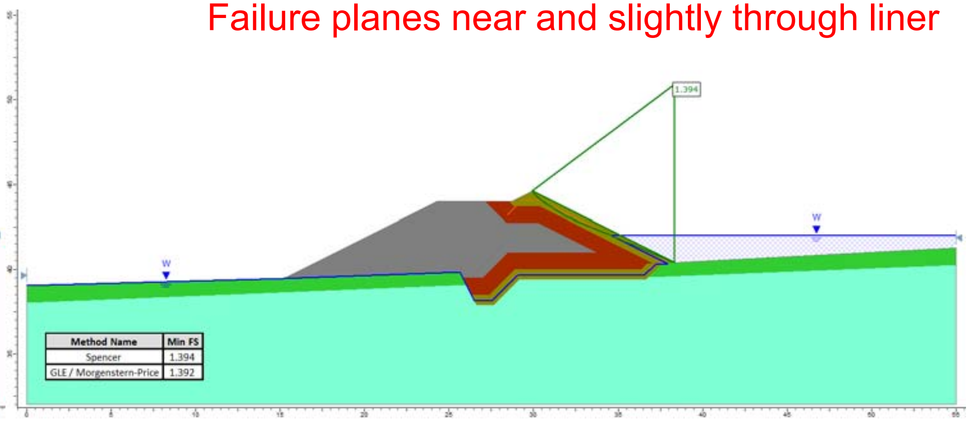
Section A-A' – Liner as Thin Layer 2.0H:1V Slopes

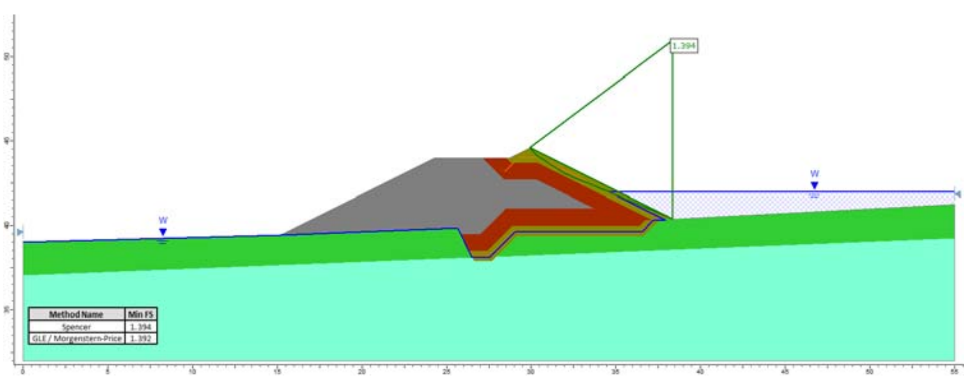
Failure planes near and slightly through liner



Frozen Foundation



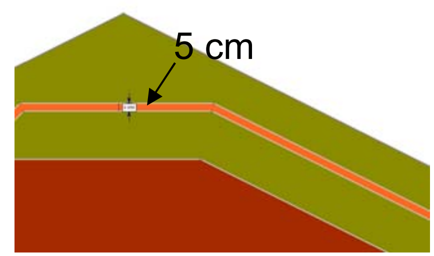
1 m Thawed Foundation



2 m Thawed Foundation

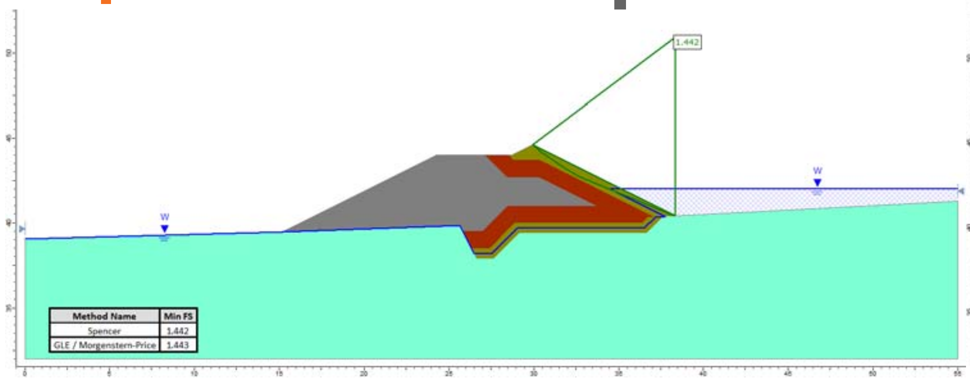
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.4	1.4	1.4

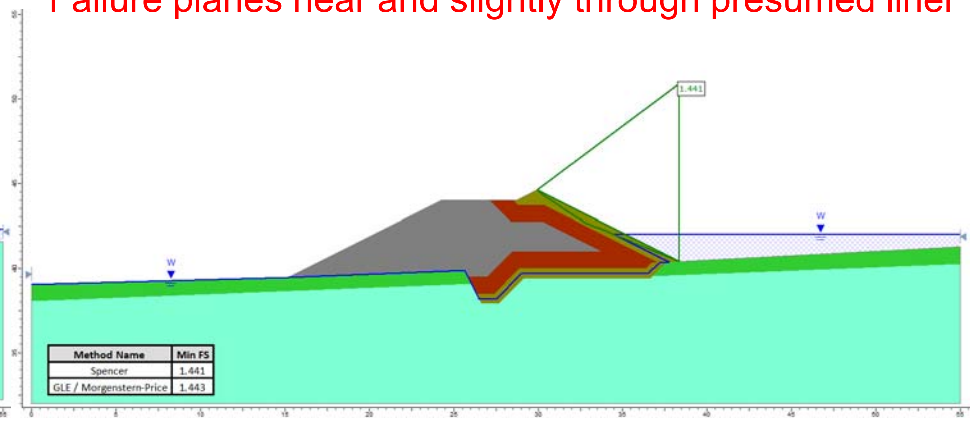


Section A-A’ – No Liner 2.0H:1V Slopes

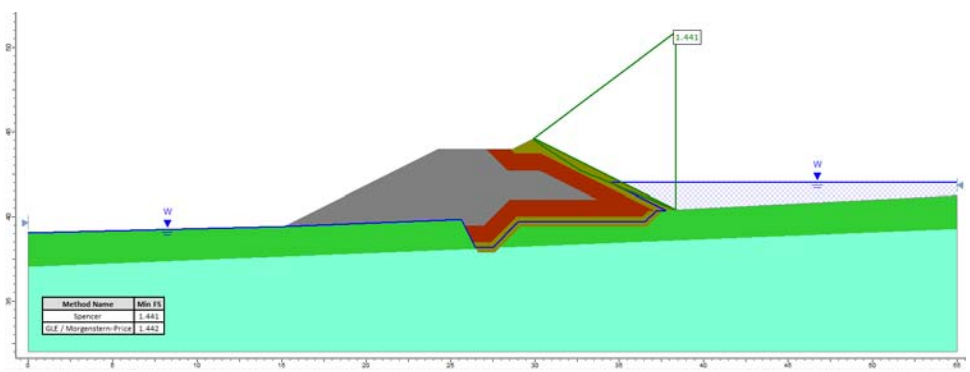
Failure planes near and slightly through presumed liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.4	1.4	1.4

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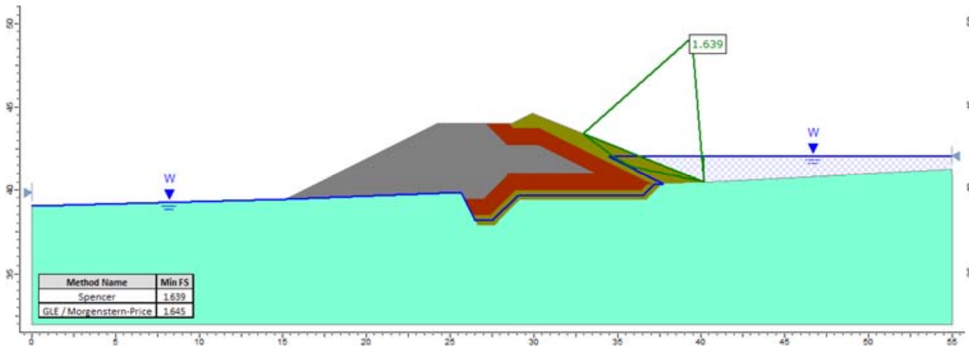
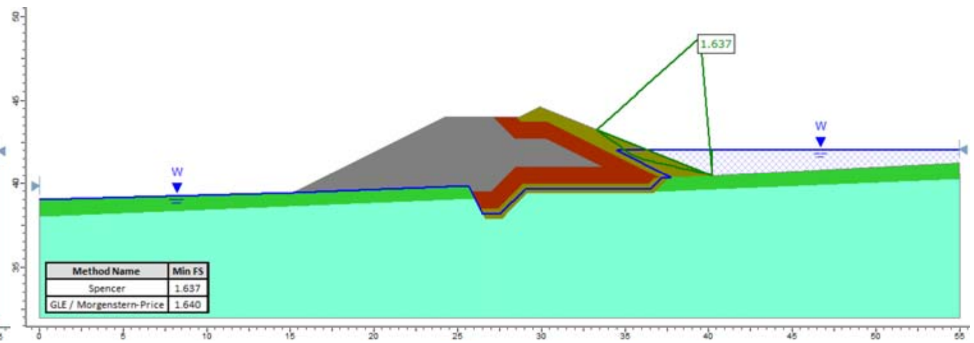
Section A-A' – No Liner
2.5H:1V Slopes

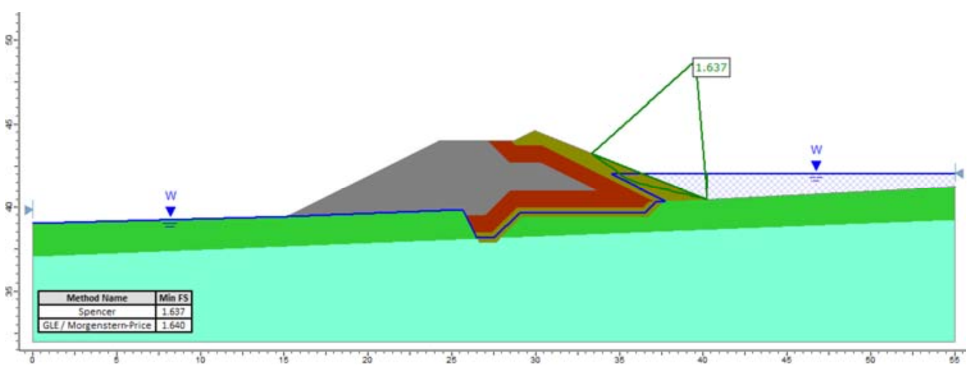
Failure planes near and slightly through presumed liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.6	1.6	1.6

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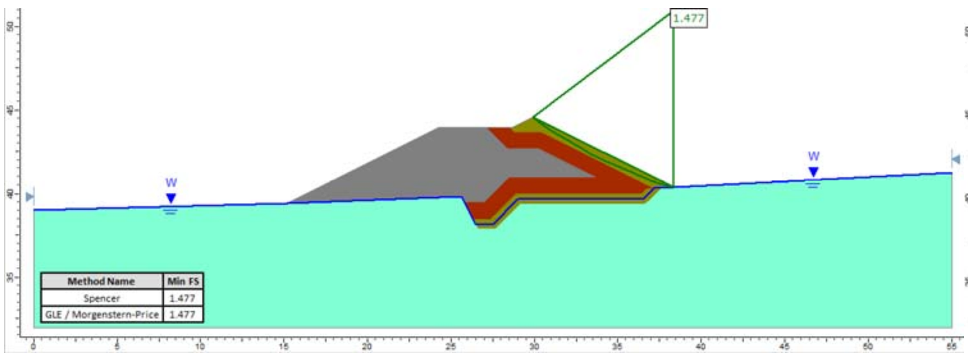
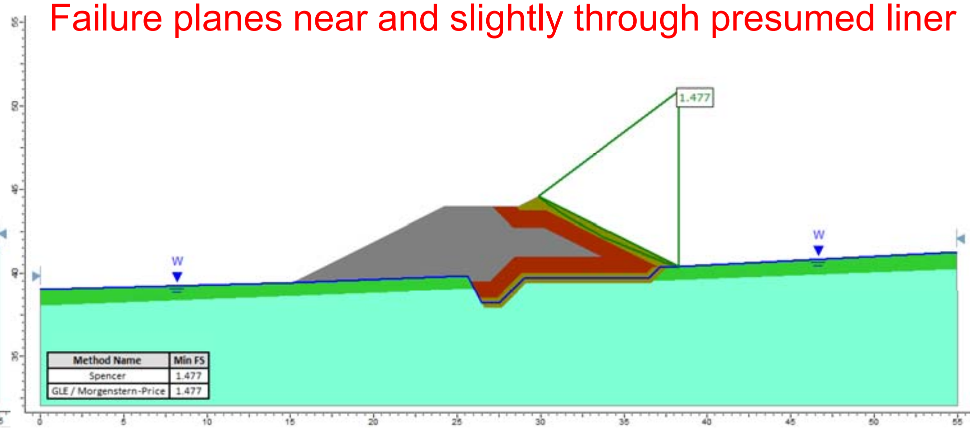
Section A-A' – No Liner, No Pond 2.0H:1V Slopes

Failure planes near and slightly through presumed liner

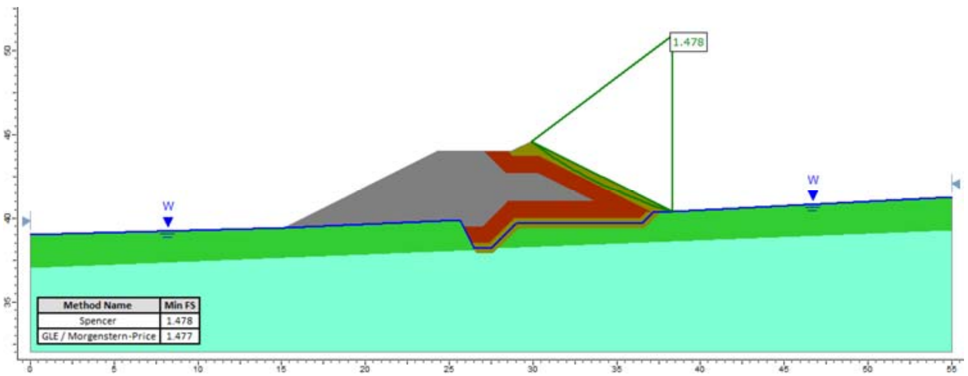


Frozen Foundation



1 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1



2 m Thawed Foundation

Thaw Depth (m)	0	1	2
FOS	1.5	1.5	1.5

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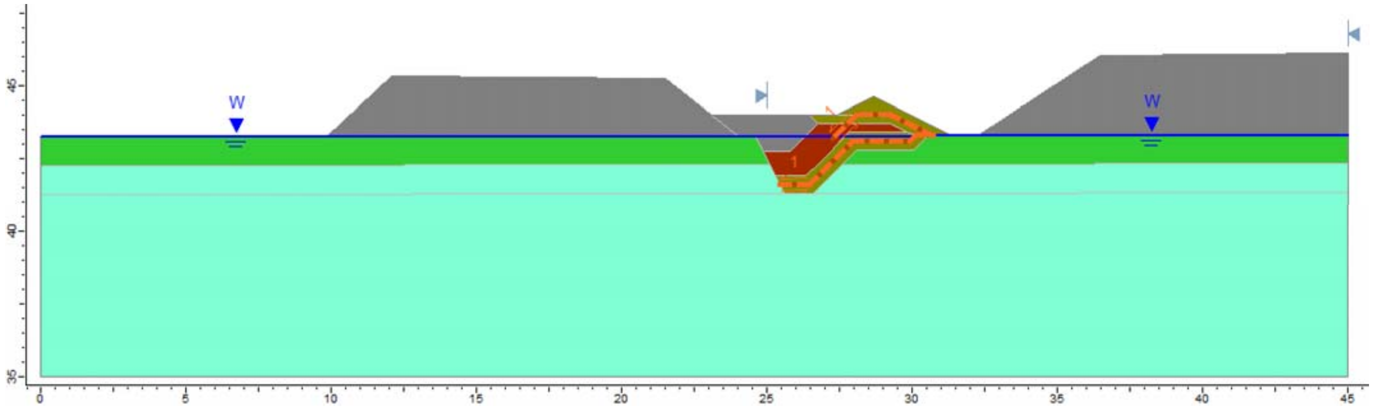
Section B-B' Stability



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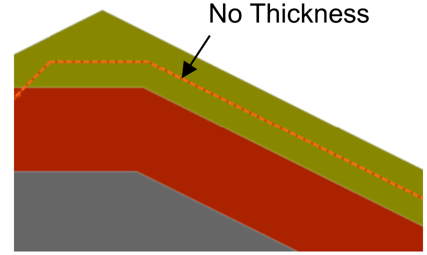
Downstream Stability Summary

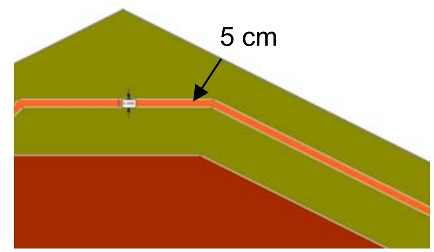
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Scenario	FOS		
	Frozen Foundation	1 m Thawed Foundation	2 m Thawed Foundation
Liner as **Weak** Layer **2.0H:1.0V**	1.6	1.4	1.4
Liner as **Weak** Layer **2.5H:1.0V** **(no failure planes through liner)**	1.8	1.8	1.8
Liner as **Thin** Layer **2.0H:1.0V**	1.6	1.4	1.4
No Liner **2.0H:1.0V**	1.7	1.4	1.4
No Liner **2.5H:1.0V**	2.0	1.7	1.7

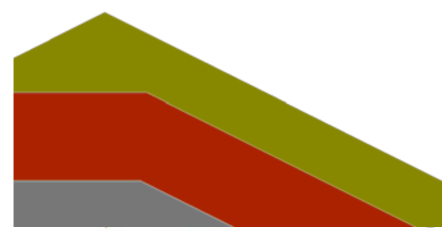
Base Case



Liner as Weak Layer



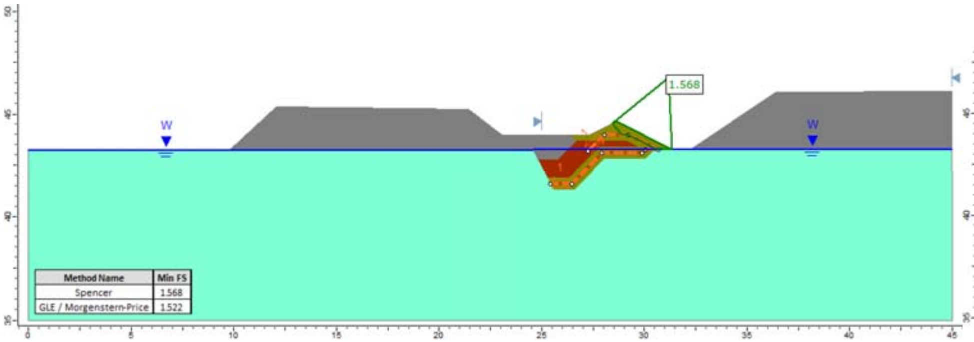
Liner as Thin Layer



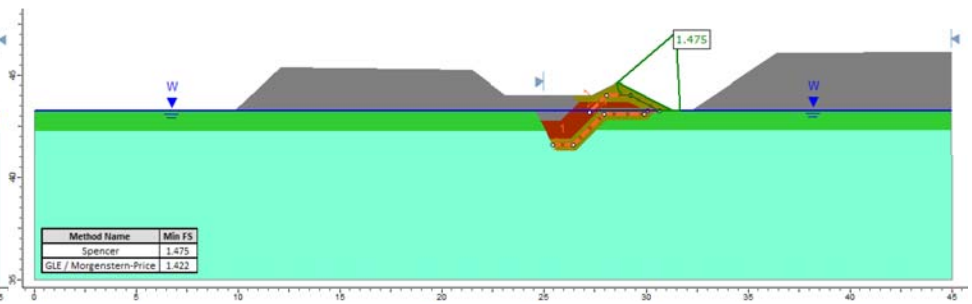
No Liner

Section B-B' – Liner as Weak Layer 2.0H:1.0V Slopes

Failure planes along liner

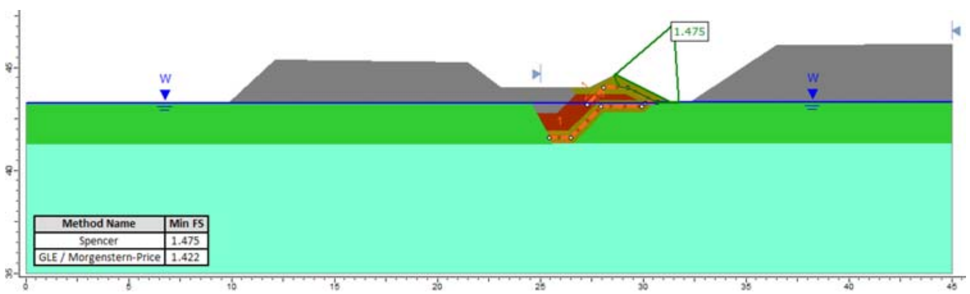


Frozen Foundation



1 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1



2 m Thawed Foundation

Thaw Depth (m)	0	1	2
FOS	1.6	1.4	1.4

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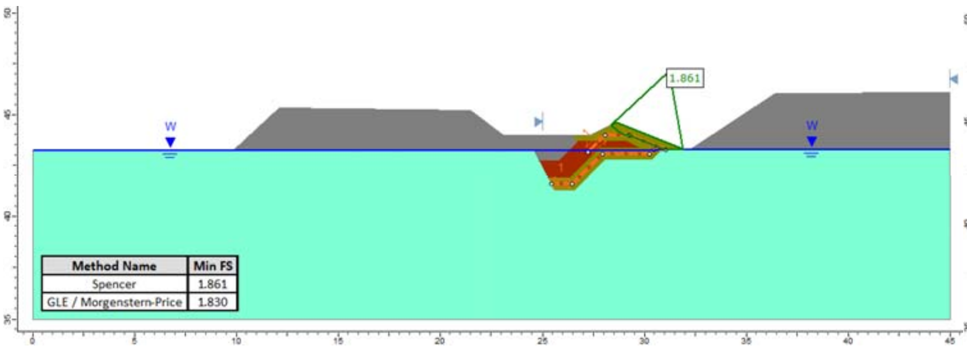
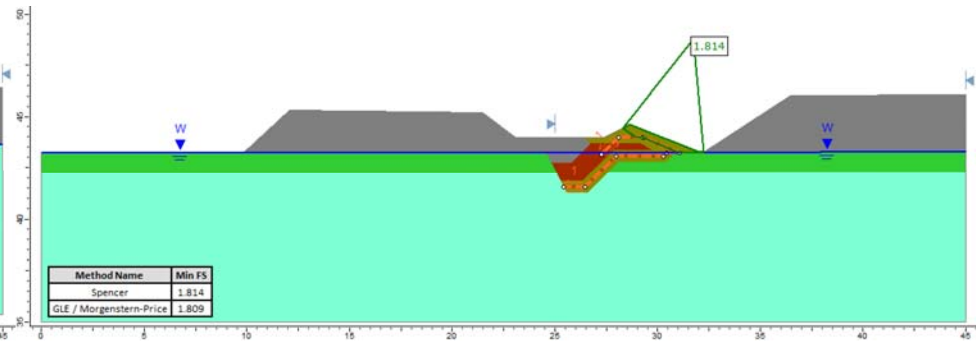
Section B-B' – Liner as Weak Layer
2.5H:1.0V Slopes

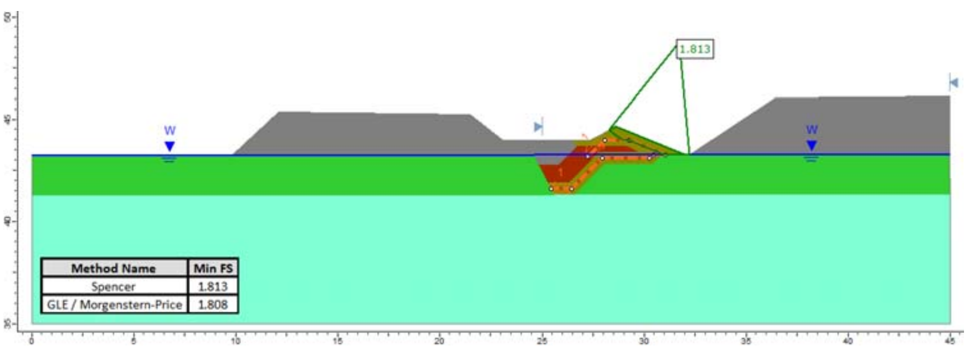
Failure planes along liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.8	1.8	1.8

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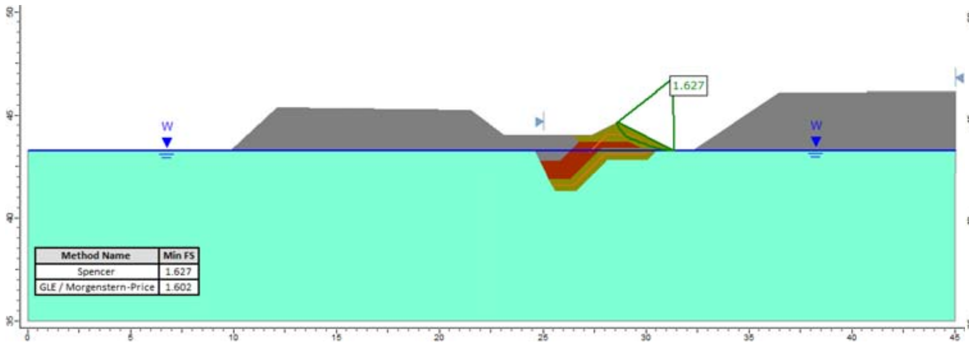
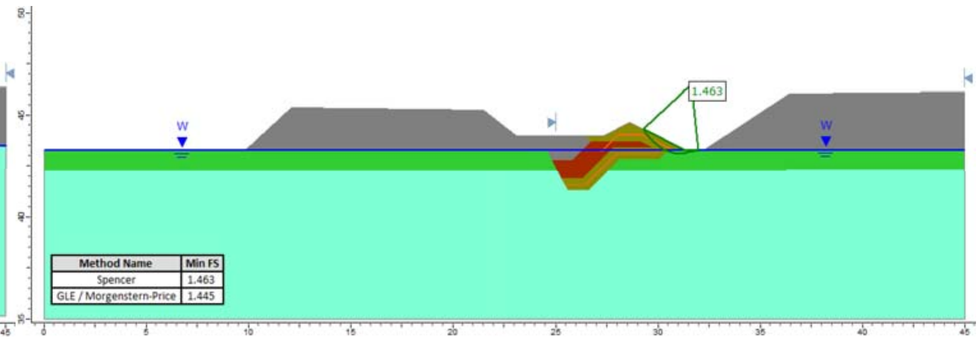
Section B-B' – Liner as Thin Layer 2.0H:1.0V Slopes

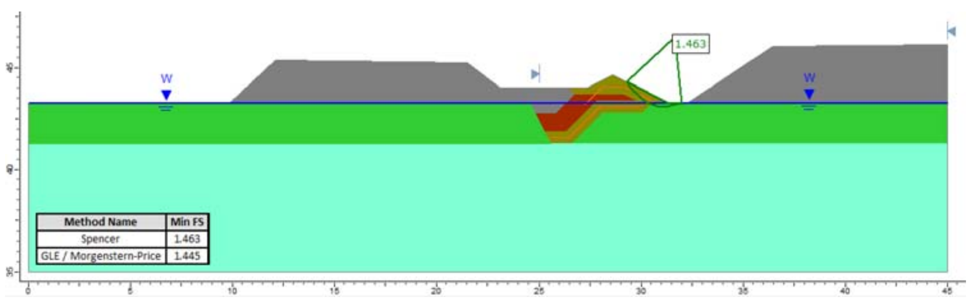
Failure planes near and slightly through liner



Frozen Foundation



1 m Thawed Foundation



2 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1

Thaw Depth (m)	0	1	2
FOS	1.6	1.4	1.4

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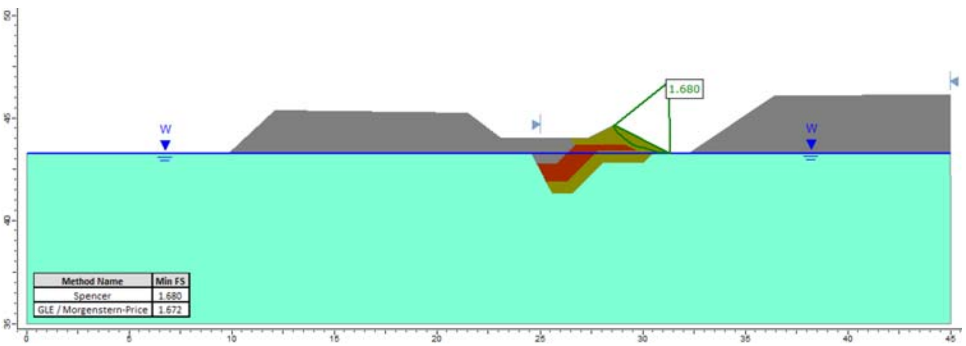
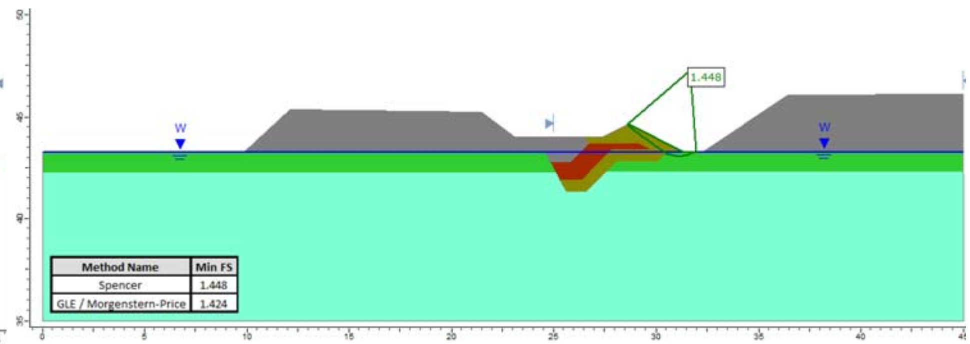
Section B-B' – No Liner 2.0H:1.0V Slopes

Failure planes near and slightly through presumed liner

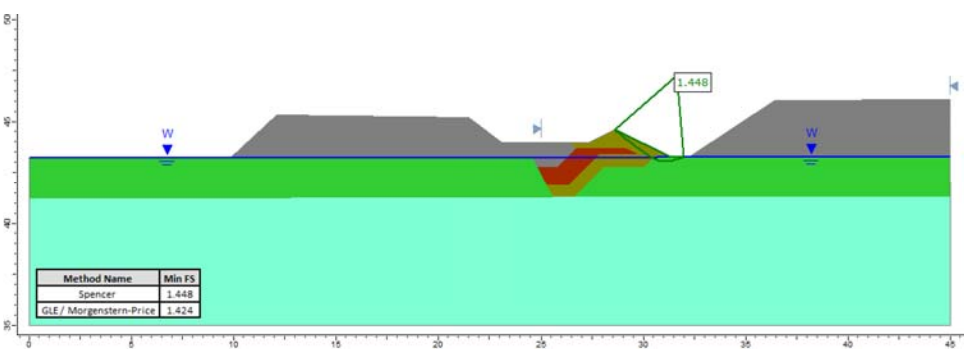


Frozen Foundation



1 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1



2 m Thawed Foundation

Thaw Depth (m)	0	1	2
FOS	1.7	1.4	1.4

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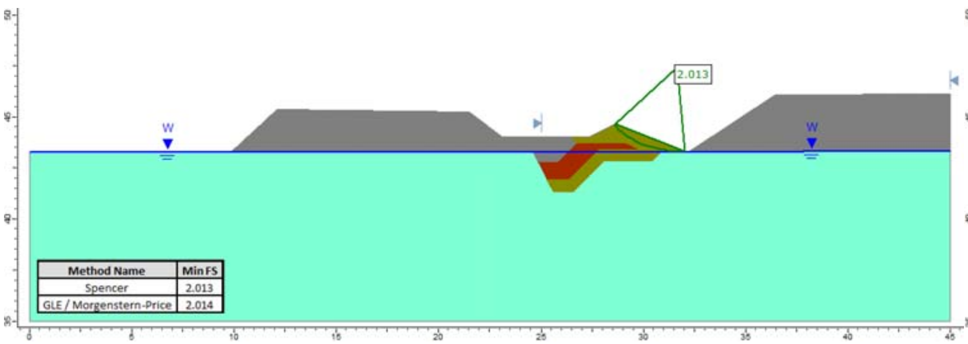
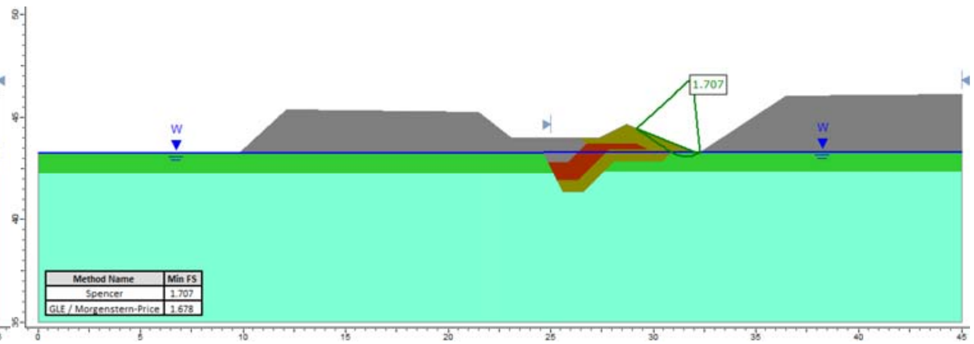
Section B-B' – No Liner
2.5H:1.0V Slopes

Failure planes near and slightly through presumed liner

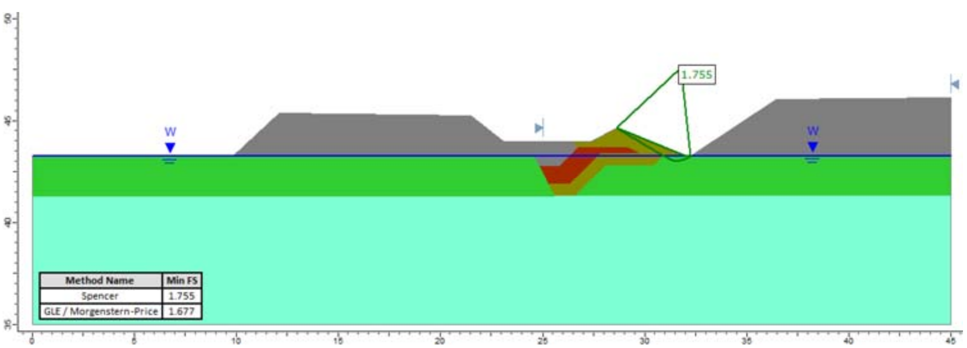


Frozen Foundation



1 m Thawed Foundation

Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Water Surface	Hu Type	Hu
Marine Clay (Frozen)		17	Mohr-Coulomb	112	26	Water Surface	Custom	1
Marine Clay (Thawed) - 30		17	Mohr-Coulomb	0	30	Water Surface	Custom	1
HDPE Liner		10	Mohr-Coulomb	0	28	Water Surface	Custom	1
Bedding Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
Transition Material		18	Mohr-Coulomb	0	36	Water Surface	Custom	1
ROQ (Thawed) - 40		20	Mohr-Coulomb	0	40	Water Surface	Custom	1



2 m Thawed Foundation

Thaw Depth (m)	0	1	2
FOS	2.0	1.7	1.7

srk consulting

Conclusion: Overall slopes of the Madrid North CWP reduced to 2.5H:1V for both the upstream and downstream slopes. Final design arrangement shown in Attachment 1.