TRANSMOUNTAIN

Trans Mountain Expansion Project

SPREAD 5A – GEOTECHNICAL ASSESSMENT
KP852 TRENCHLESS CROSSING (JACKO HILL) REV 0

TMEP Document # 01-13283-S5A-M002-PL-MEM-0243

Rev No.	Prepared by/ Date	Reviewed by/ Date	Approved by/ Date		Reviewed by TMEP	Pages Revised	Issued Type
0	Jessica Thompson, P. Eng. 2023-06-15	Bryan Woods, P.Eng. 2023-06-15	Justin Winter, P.Eng. 2023-06-15		Erez Allouche 2023-06-15		Issued for Use

THURBER ENGINEERING LTD.

June 15, 2023

TEL File: 23560
TEL Doc.No.: 3443

Trans Mountain Pipeline L.P.
Suite 2700, 300 – 5 Avenue SW
Calgary, AB T2P 5J2

Attention: Braden Hergott, Spread 5A – Construction Engineer

GEOTECHNICAL ASSESSMENT
KP852 TRENCHLESS CROSSING (JACKO HILL) REV 0
TRANS MOUNTAIN EXPANSION PROJECT – SPREAD 5A

Dear Braden,

As requested by Trans Mountain Pipeline L.P. (TMP), Thurber Engineering Limited (Thurber) is submitting this report to TMP as input to support a feasibility assessment of a trenchless crossing in the Jacko Lake segment of Spread 5A of the Trans Mountain Expansion Project (TMEP), between approximately KP851+930 and KP852+380 (the crossing) (SSEID 5.19).

This work has been conducted in accordance with our Master Engineering Services Agreement (MESA Contract No. 164089) with Trans Mountain Pipeline L.P.

1. BACKGROUND

The following documents were reviewed by Thurber for the assessment of the proposed trenchless crossing:

- Trans Mountain Expansion Project, Terrain Mapping and Geohazard Inventory (Revision 1), BGC Engineering Inc., August 11, 2014. (BGC, 2014)
- Preliminary trenchless crossing drawings prepared by Universal Pegasus International (UPI) included as Appendix A: 01-13283-M002-XD0016201_A_IFR_2023-06-08_01
- SPREAD 5A – SSEID 005.19 KP 851+800 TO KP 854+900, Preliminary Geotechnical Trenchless Feasibility Assessment Jacko Lake Area, TMEP Doc # 01-13283-S5A-M002-PL-RPT-0028, Thurber Engineering Ltd., March 11, 2021 (Thurber, 2021)
- SPREAD 5A – SSEID 005.19 KP 851+600 TO KP 856+000, Geotechnical Investigation for Microtunneling Installation Jacko Lake Area Rev. 2 TMEP Doc # 01-13283-S5A-M002-PL-MEM-0128, Thurber Engineering Ltd., August 4, 2022 (Thurber, 2022)
- SPREAD 5A – Jacko Lake Pad 5 KP856+190, TMEP Document # 01-13283-S5A-M002-PL-RPT-0058, Thurber Engineering Ltd., April 14, 2023 (Thurber, 2023)

In March 2021, Thurber was requested to provide a desktop feasibility assessments of four (4) proposed trenchless crossings to be completed via horizontal directional drilling (HDD) methodology. Of those four (4) crossings, the proposed crossing through KP852+300 most closely aligns with the crossing being addressed in this report. Further information is available in Section 7.5 of the report TMEP Doc # 01-13283-S5A-M002-PL-RPT-0028 (Thurber, 2021).

In June 2021 Thurber was requested to start a geotechnical investigation program that would run over the course of several years to ultimately provide a micro tunnel feasibility assessment and baseline report for four (4) micro tunnel sections from KP851+600 to KP856+000. The results of that report are in TMEP Doc # 01-13283-S5A-M002-PL-MEM-0128 (Thurber 2022) which is referenced in this report.

In May 2023, Thurber was requested to provide a geotechnical assessment/feasibility report for a proposed trenchless crossing from KP851+930 and KP852+380. TMEP engaged UPI to develop a proposed trenchless crossing path, which was provided as "M002-XD00162 Rev A" by email on May 26, 2023 and is based on Horizontal Directional Drilling (HDD) methodology. An updated drawing titled "M002-XD00162 RA" was received by email on June 2, 2023. Thurber produced a draft report (TMEP Doc # 01-13283-S5A-M002-PL-MEM-0243 Rev A) based on the drawing, uploaded to PIMS on June 5, 2023.

In June 2023 an updated drawing titled "01-13283-M002-XD0016201_A_IFR_2023-06-08_01" was received by Thurber via email from TMEP (June 12, 2023) (see Appendix A). This report is based on the drawing received on June 12.

2. GEOTECHNICAL FIELD INVESTIGATIONS

2.1 Test Hole Drilling Program

Thurber completed twenty-nine (29) test holes and two (2) test pits to date for various Jacko Lake investigations.

Test holes were completed using a variety of drilling methods. The first test hole was started in September of 2021, the most recent test hole (as of the submission of this report) was started in March of 2023. The test pits were completed by SMJV using a tracked hydraulic excavator under the supervision of Thurber field staff.

Detailed field program descriptions can be found in the referenced Thurber reports in Section 1.

The test holes most relevant for the currently proposed HDD crossing have been summarized in Table 1, below. The reference report for both test holes is 01-13283-S5A-M002-PL-MEM-0128 (Thurber 2022); test hole locations are shown on Figures 1, 2 and 3.

Table 1: Test Hole Coordinates and Completion Depth

Test Hole ID	Jacko Lake Log ID	Test Hole Location[1] (UTM NAD 83, Zone 10)		Completion Depth (m)
		Northing (m)	Easting (m)	
SH21-5A-19-TEL-JL-KP851+931	TEL-JL-BH2	5611197	682969	35.3
SH21-5A-19-TEL-JL-KP852+390	TEL-JL-BH14	5610673	682538	55.4

Notes:

1. **Test hole coordinates provided by GeoVerra survey**

The soil stratigraphy, drilling observations and test results from the test holes listed in Table 1 are detailed on the test hole logs in Appendix C and are summarized below. The Modified Unified Soil Classification System (MUSCS) (also attached for reference) was used to describe the soil.

2.2 Geophysical Program

A geophysical survey, consisting of Seismic Refraction (SR) and Electrical Resistivity Tomography (ERT), was undertaken adjacent to the crossing in 2021 by Surface Search Inc. (Surface Search). The location of the geophysical program was field-fit to site constraints (e.g physical access, proximity to existing facilities) as shown on Figure 3.

The main objective of this program was to identify the approximate contact between the surficial soils and the underlying bedrock. The results of this work are described as part of the overall discussion of subsurface conditions in Section 3 and have been projected onto Figure 3. The Surface Search figures are presented in Appendix D. The portion relevant to the current HDD alignment is ERT Line 05 and SR lines 29 to 32.

3. SITE DESCRIPTION

3.1 General

The proposed crossing is located approximately 8 km southwest of Kamloops, BC. The proposed HDD drill path is approximately 450 m long and crosses under glacial hogback feature and two (2) small unnamed drainage courses. The unnamed drainages are approximately 2 m northeast of the entry on the alignment and approximately 26 m southwest of the exit along the proposed alignment. Based on LiDAR bare earth imagery, bedrock appears to be shallow beneath a glacial till veneer between about KP851+800 and KP854+200. The shape of the hogback feature is indicative of a southeast to northwest ice movement, with steeper northwest slopes in the order of 30º and southwest, southeast and northeast slopes generally less than 20º.

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Total overburden cover (rock and soil) on the proposed trenchless profile is a maximum of approximately 60 m at KP852+220 (see Figure 3).

3.2 Regional Geology

The geomorphology of the project area is characterized by glacial landforms. The underlying bedrock has been heavily sculpted and gouged by the Pleistocene ice sheet which moved from the northwest to the southeast, depositing till at its base. The study area was deglaciated between 14,000 to 11,00 year ago.

Surficial landforms mapped by BGC along the pipeline alignment within the study area consist of variable thickness of till overlying bedrock, with minor deposits of glaciofluvial origin as shown in Figure 1. Local organic deposits are also present in low lying areas and drainages to Jacko Lake.

The bedrock geology in the area consists of volcanics, volcanoclastics, and picrite of the Nicola Group Volcanics (Figure 2). The northwest trending, 34 km long, Iron Mask Batholith is intruded into the Nicola Group Volcanics. Several economic mineral deposits are associated with this intrusion including Ajax, Afton, Crescent, and Pothook.

Bedrock geology underlying the proposed HDD alignment in the crossing area consists of the Iron Mask Batholith Hybrid Unit consisting of dioritic intrusive rocks.

The major faults within the Nicola Group Volcanics and the Iron Mask Batholith include the Cherry Creek Tectonic Zone, the Edith Lake Fault Zone and the East Pit Fault. These faults follow a regional northwest - southeast trend. Other faults are related to the contacts between individual geological units, such as the contacts between the Iron Mask Batholith and the Nicola Volcanic Group. Unconfined Compressive Strength (UCS) values for these materials from the Ajax Mine ranged from 26 MPa to 264 MPa (median 149 MPa)

Based on BC geological mapping (2017), the closest mapped fault on the north side of the study area is an unnamed fault about 2.5 km northwest of the proposed drill entry (Figure 2). On the south side, the closest mapped fault is the Cherry Creek Fault which is about 5.5 km southwest of the proposed drill exit. As the possibility of other unmapped faults exists in this area, the potential for any of the proposed trenchless crossings to intersect a fault is considered to be moderate to high.

According to the Klohn Crippen (2011) seismic assessment of the Ajax Mine, the faults in the area are seismically inactive and occurred tens of millions of years ago and there has never been a published case of inland Quaternary surface ruptures associated with an earthquake in BC. Consequently, the main concern with faulting in the area is with respect to constructability of the trenchless crossings which could be affected by drilling fluid losses and/or instability of drill hole walls due to fracturing of the rock or presence of weak gouge material.

3.3 Subsurface Conditions

The following soil units were encountered within the test holes listed in Table 1 completed along or adjacent to the proposed crossing:

Topsoil

A 0.2 m thick topsoil layer was encountered at the surface of SH21-5A-19-TEL-JL-KP851+931.

Fill

A 0.4 m thick sandy clay fill layer was encountered at the surface of SH21-5A-19-TEL-JL-KP852+390.

Clay

Clay was encountered within test holes SH21-5A-19-TEL-JL-KP851+931 and SH21-5A-19-TEL-JL-KP852+390 below the topsoil and fill layers respectively. The clay layer in SH21-5A-19-TEL-JL-KP851+931 extended from the topsoil later to approx. 0.7 mbgs. The clay in SH21-5A-19-TEL-JL-KP852+390 extended from the bottom of the fill to approx. 7.7 mbgs and overlayed diorite bedrock. The clay is low to medium plastic and contains varying amounts of sand and gravel. A lack of sorting and inclusions of granular soils indicate the clay is likely a glacial till deposit.

SPT-N values recorded within the clay in SH21-5A-19-TEL-JL-KP852+390 varied between 40 and refusal, indicating a hard to very hard consistency, which indicates a high degree of overconsolidation which is common of basal till deposits. Based on empirical strength correlations, the SPT-N values in the clay indicate undrained shear strengths of between of 200 kPa to > 400 kPa.

Granular/Cohesionless Till

Within SH21-5A-19-TEL-JL-KP851+931 silty sand and gravel till and silt till was encountered below the topsoil from approximately 0.2 mbgs to approximately 4.5 mbgs and overlayed diorite bedrock. SPTs conducted in the material met refusal (50 blows achieved 45 mm penetration), indicating a very dense consistency. Photos of the sonic soil recovery for SH21-5A-19-TEL-JL-KP851+931 are presented in Appendix E.

Diorite Bedrock

Diorite bedrock was encountered in test holes SH21-5A-19-TEL-JL-KP851+931 and SH21-5A-19-TEL-JL-KP852+390 at depths of approximately 4.6 mbgs and 7.7 mbgs respectively and extended to the termination depths of each test hole. Uniaxial Compressive Strength Tests (e.g. unconfined compressive strength tests (UCS)) in the rock ranged from 12 MPa to 80 MPa in SH21-5A-19-TEL-JL-KP851+931 and from 48 MPa to 196 MPa in SH21-5A-19-TEL-JL-KP852+390, indicating the rock can be described as medium strong to very strong. Rock Quality

Designation (RQD) values ranged from 9 to 79 in SH21-5A-19-TEL-JL-KP851+931 and 15 to 89 in SH21-5A-19-TEL-JL-KP852+390. Several zones of broken core were noted in both test holes. A lower recovery zone between approx. 21 mbgs and 24 mbgs was noted in SH21-5A-19-TEL-JL-KP851+931, but otherwise recovery is generally greater than 95%. Two (2) runs with recovery at or below 95% were noted in SH21-5A-19-TEL-JL-KP852+390. Photos of the rock core are presented in Appendix E.

It should be noted that rock strength testing on other samples collected for the Jacko Lake Microtunnel assessment indicated strengths on the order of 220 MPa. Further, samples from the Ajax Mine in the Iron Mask Batholith ranged from 26 MPa to 264 MPa.

Groundwater

Two vibrating wire piezometers were installed in SH21-5A-19-TEL-JL-KP852+390 at depths of approximately 7.5 m near the clay/bedrock contact and 50 m within the bedrock. Equivalent water depth readings were taken between December 9, 2021 and May 30, 2022, which showed the water levels consistently within about 2 m below the ground surface within the clay and greater than 50 m depth in the bedrock. Therefore, there appears to be a low likelihood for groundwater inflows to the HDD drill hole.

3.4 Geophysical Surveys

The interpreted ERT and SR survey profiles are provided in the Surface Search report in Appendix D. The alignment of the surveys is shown on the plan view in Figure 3; the survey lines were very close to the proposed entry point at the northeast end of the crossing and diverges approximately 40 m northeast from the proposed exit point. The ground profile along the geophysical survey lines is therefore different than the ground profile along the proposed crossing, but is shown on Figure 3 to generally illustrate the relative shallow soil depth identified across Jacko Hill and at the entry/exit points.

4. HDD FEASIBILITY ASSESSMENT

4.1 Ground Conditions

<u>Entry and Upstream Tie-In</u>

Based on test hole SH21-5A-19-TEL-JL-KP851+931, conditions on the proposed HDD entry (northeast) side of the crossing are anticipated to be cohesionless primarily granular soils over bedrock. Given the presence of relatively shallow unconsolidated coarse-grained soils an entry pit could be excavated to the bedrock surface to avoid drill collapse in the cohesionless material. If an entry pit is not excavated to bedrock, surface casing will likely need to extend along the drill path to at least the bedrock interface. Thurber recommends the surface casing extend far enough to provide a seal with the bedrock.

Unsupported excavations into cohesionless material should be battered 2H:1V or flatter to provide adequate short-term stability for safe worker entry. All temporary excavations should be completed in compliance with provincial safety regulations (e.g. WorkSafe BC).

<u>Drill Path</u>

Outside of the entry and exit areas, the majority of the drill path is anticipated to be within diorite bedrock from the Iron Mask Batholith hybrid unit. The possibility exists of encountering highly fractured zones, faults and joints along the drill path. HDD within the bedrock is considered to have low to moderate risk of failure of completion of the crossing.

Based on the above, it is anticipated that an HDD crossing of this feature is feasible but potentially difficult to construct, mostly due to the potential to encounter highly fractured bedrock.

<u>Exit Pit and Downstream Tie-In</u>

Based on test hole SH21-5A-19-TEL-JL-KP852+390, exit conditions on the southwest side of the crossing are anticipated to be predominantly clay which are anticipated to be favorable for an HDD exit and casing should not be required. Temporary excavations within the expected hard to very hard clay should be sloped no steeper than 1H:1V. If encountered, excavations in coarse grained soils should be sloped no steeper than 1.25H:1V above the water table and 2H:1V below the water table. All temporary excavations should be completed in compliance with provincial safety regulations (e.g. WorkSafe BC).

5. RECOMMENDATIONS

The following is a summary of Thurber's recommendations for construction of the proposed HDD crossing:

- To reduce the risk of collapse of the granular cohesionless soils at the drill entry an entry pit extending to the bedrock surface could be utilized to avoid drill collapse in the cohesionless material. Alternatively casing should be installed such that it creates a seal with the bedrock. Given the relative shallow depth to bedrock it should be feasible to trench the casing to bedrock from the ground surface. This would also allow the casing to be notched into the bedrock.

- If entry casing is utilized (instead of an entry pit extending to bedrock) and does not extend into the bedrock per above recommendations and the hole cannot be adequately supported with heavy drilling fluid, the drill may require intervention in the case of hole collapse.

- The size of the larger drill diameter should be determined in discussions with HDD drilling contractor based on their proposed means and methods.

- The anticipated bedrock hardness and fractured nature should be considered in the planning of the HDD and the equipment selection. The rock is expected to be highly abrasive to the bits, and weighted drilling mud may be required to maintain hole stability in fracture zones. Mud additives may also be required to maintain or regain mud circulation in fracture zones.

Closure

We trust that the information provided herein meets your present requirements. If you have any questions or wish to discuss any aspects of the enclosed geotechnical assessment further, please contact the undersigned at your convenience.

Yours truly,
Thurber Engineering Ltd.

Bryan Woods, P.Eng.
Review Engineer

PROFESSIONAL
PROVINCE OF
J. L. THOMPSON
52432
BRITISH COLUMBIA
ENGINEER
June 15, 2023

Jessica Thompson, P. Eng.
Geotechnical Engineer

Thurber Engineering Ltd.
Permit to Practice #1001319

Attachments:

Appendix A: 01-13283-M002-XD0016201_A_IFR_2023-06-08_01
Appendix B: Figures
Appendix C: Test Hole Logs
Appendix D: Surface Search Geophysics Figures
Appendix E: Sonic Soil Recovery (SH21-5A-19-TEL-JL-KP851+931) and Rock Core Photos

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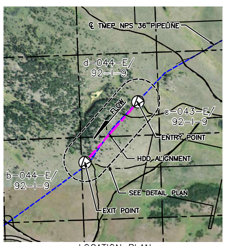
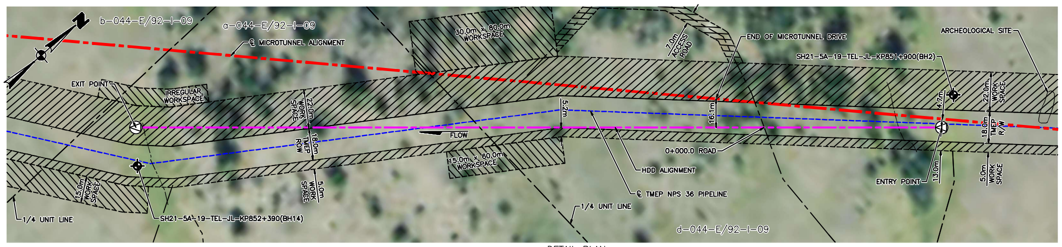
Appendix A

01-13283-M002-XD0016201_A_IFR_2023-06-08_01



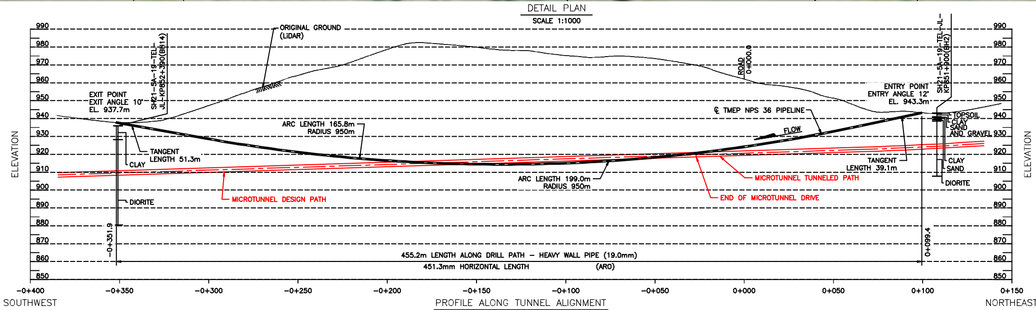
LOCATION PLAN

SCALE 1:10000
d-044-E/92-I-9
CITY OF KAMLOOPS
NAD83 UTM ZONE 10N
APPROX. TMEP KP 852.3



DETAIL PLAN

SCALE 1:1000



PROFILE ALONG TUNNEL ALIGNMENT

SCALE 1:1000

GENERAL NOTES

A1. ALL DIMENSIONS AND ELEVATIONS ARE IN METRES UNLESS OTHERWISE SHOWN. ALL ELEVATIONS ARE GEODETIC. ALL CHAINAGES ARE HORIZONTAL.
A2. DRAWING SCALES ARE ONLY CORRECT WHEN PLOTTED AT FULL SIZE (A1).
A3. ALL WORK IN CLOSE PROXIMITY TO POWER LINES MAY BE SUBJECT TO ELECTROSTATIC AND ELECTROMAGNETIC INDUCED VOLTAGES. CONTRACTOR SHALL BE RESPONSIBLE FOR MONITORING AND IMPLEMENTING MITIGATION PROCEDURES. CONTRACTOR SHALL IMPLEMENT THESE PRECAUTIONS AS WELL AS THOSE SPECIFIED BY TRANS MOUNTAIN REPRESENTATIVE.
A4. THE CONTRACTOR SHALL ENSURE ALL UTILITIES ARE PROTECTED AND MAINTAINED THROUGH THE CONSTRUCTION PROCESS.
A5. THE CONTRACTOR SHALL ENSURE THAT COPIES OF THE CROSSING AGREEMENTS ARE KEPT ON SITE FOR THE FULL DURATION OF THE CONSTRUCTION ACTIVITIES. CONTRACTOR SHALL ADHERE TO ALL REQUIREMENTS OF THE CROSSING AGREEMENTS.
A6. SURVEYED BASE PLANS ARE BASED ON BASE PLAN 38290-BASE-92I9E R5 DATED MAY 31, 2022, PROVIDED BY GEOVERRA SURVEY (BC) LTD. PARTNERSHIP. THE GROUND PROFILE WAS BASED ON SURVEY DWG 01-13283-M002-XD0510101.DWG DATED MAY 18, 2022, PROVIDED BY ADIT ENGINEERING. THE IMAGERY IS SUPPLIED BY AEROQUEST MAPCON, DATED 2019.
A7. CONSTRUCTION SHALL BE COMPLETED IN ACCORDANCE WITH CSA Z662 (CURRENT VERSION), AND THE MOST RECENT VERSIONS OF ALL PROVINCIAL AND FEDERAL REGULATIONS, ENVIRONMENTAL PROTECTION PLAN (EPP), CONTRACT DOCUMENTS, AND THE AUTHORITIES HAVING JURISDICTION.
A8. THE CONTRACTOR SHALL SUPPLY AND ADHERE TO THE CONTRACTOR SUPPLIED AND APPROVED DRILLING EXECUTION PLAN.
A9. AS PER 01-13283-SG-M002-PL-DCN-0005, THE PIPELINE WILL BE TESTED AND OPERATED BASED ON POINT-SPECIFIC MAXIMUM OPERATING PRESSURE (BASED ON THE APPROVED FINAL HYDROSTATIC TEST). MINIMUM TEST PRESSURE WILL BE BASED ON ELEVATION PROFILES BETWEEN PUMP STATIONS.

CONSTRUCTION NOTES

B1. CONSTRUCTION METHOD FOR THIS CROSSING IS THE HORIZONTAL DIRECTIONAL DRILL METHOD (HDD). FOR HDD CONSTRUCTION SPECIFICATIONS REFER TO THE CONTRACT DOCUMENTS.
B2. THE CONTRACTOR SHALL VERIFY ALL TOPOGRAPHICAL SURVEY INFORMATION AND CONFIRM THE DEPTH AND LOCATION OF ALL BURIED FACILITIES IN THE FIELD PRIOR TO CONSTRUCTION.
B3. THE CONTRACTOR SHALL SUPPLY A DRILL RIG WITH A MINIMUM OF 400,000 LBF (1,779kN) PUSH/PULL WITH APPROPRIATE ASSOCIATED EQUIPMENT AS OUTLINED IN THE SPECIFICATIONS. THE THEORETICAL PULL FORCE FOR THIS CROSSING IS 320,000 LBF (1,423 kN) WITHOUT BUOYANCY CONTROL AND 260,000 LBF (1,157 kN) WITH 100% BUOYANCY CONTROL.
B4. THE CONTRACTOR SHALL SUPPLY AN ELECTRONIC DRILLING RECORDER (EDR) TO MONITOR AT A MINIMUM, TANK/PIT VOLUME, FLOW (PUMP AND RETURN), PRESSURE (ANNULAR/STANDPIPE), RATE OF PENETRATION, PUSH/PULL FORCE, ROTARY TORQUE, AND ROTATIONAL SPEED, PROVIDE THIS ELECTRONIC INFORMATION TO TRANS MOUNTAIN REPRESENTATIVE AND ALSO SUBMIT AS A PART OF THE AS-BUILT RECORDS REQUIRED AT THE END OF THE PROJECT.
B5. THE CONTRACTOR SHALL SUPPLY AND USE AN APPROVED ANNULAR PRESSURE TOOL WITH THE CONTRACTOR SUPPLIED ANNULAR PRESSURE MODEL.
B6. ALL EQUIPMENT SHALL BE SUPPLIED IN GOOD WORKING ORDER MAINTAINED AND SERVICED. ANY EQUIPMENT NOT OPERATIONAL OR FULFILLING THE REQUIREMENTS OUTLINED IN THE CONTRACT DOCUMENTS SHALL BE REPAIRED OR REPLACED.
B7. SURFACE CASING, IF REQUIRED TO ASSIST/SECURE DRILLING FLUID CIRCULATION OR TO PREVENT HOLE COLLAPSING NEAR THE SURFACE, SHOULD BE DETERMINED BY CONTRACTOR AND APPROVED BY TRANS MOUNTAIN REPRESENTATIVE.
B8. THE CONTRACTOR SHALL SUPPLY A CASING PLAN (IF REQUIRED) WHICH SHALL INCLUDE SIZE OF CASING, INSTALLATION METHOD, CLEANOUT PROCEDURE, REMOVAL PROCEDURE, AND A DESCRIPTION OF THE CENTRALIZING CASING TO BE USED.
B9. THE PILOT HOLE SHALL BE INSTALLED AS CLOSE AS PRACTICAL TO THE PROPOSED DESIGN DRILL PATH WITH THE DESIGN INFORMATION SHOWN ON THE DRAWING. HORIZONTAL DEVIATION GREATER THAN ±2.0 m SHALL BE APPROVED BY TRANS MOUNTAIN REPRESENTATIVE PRIOR TO COMPLETION OF DRILL. DRILL PATH VERTICAL DEVIATION SHALL BE WITHIN ±2.0 m RADIAL DISTANCE OF THE DESIGN DRILL PATH. UNDER NO CIRCUMSTANCES SHALL THE PIPELINE BE INSTALLED OUTSIDE THE LEGAL PIPELINE EASEMENT.
B10. MINIMUM DEPTH OF COVER TO BE THE GREATER OF THIS DRAWING OR AS SPECIFIED IN CROSSING AGREEMENTS.
B11. THE DESIGN RADIUS FOR THE CROSSING IS 950 m. THE PILOT HOLE SHALL ADHERE TO THE FOLLOWING TOLERANCES:
- THE SINGLE JOINT RADIUS SHALL NOT BE LESS THAN 600.0 m.
- THE THREE JOINTS RADIUS SHALL NOT BE LESS THAN 800.0 m.

B12. THE MAKE-UP SECTION WILL LIKELY BE PLACED ON EXIT SIDE.

ENVIRONMENTAL NOTES

C1. DISPOSAL OF DRILLING FLUID AND CUTTINGS WILL BE CONDUCTED IN A MANNER THAT ADHERES TO BRITISH COLUMBIA OIL AND GAS HANDBOOK – DRILLING WASTE MANAGEMENT CHAPTER.
C2. TO MINIMIZE THE POTENTIAL FOR INADVERTENT FLUID RELEASE TO SURFACE, CONTRACTOR SHALL ENSURE THAT MUD PRESSURE IS KEPT TO THE MINIMUM REQUIREMENT FOR CUTTINGS RETURN AND FOR MAINTAINING A CLEAN HOLE AND IN ACCORDANCE WITH THE CONTRACTOR SUPPLIED ANNULAR PRESSURE MODEL.
C3. FRAC WALKS SHALL BE CONDUCTED EVERY 4 HOURS (AS A MINIMUM), OR IMMEDIATELY AFTER A LOSS OF FLUID EVENT.
C4. SUITABLE EMERGENCY SPILL KITS ARE REQUIRED TO BE MAINTAINED ON SITE AT ALL TIMES.

GEOTECHNICAL INFORMATION

D1. THIS DESIGN WILL BE REVISED WHEN GEOTECHNICAL REPORT IS AVAILABLE.

LEGEND

- ℄ TMEP NPS 36 PIPELINE
- ℄ HDD ALIGNMENT
- ℄ MICROTUNNEL ALIGNMENT
- GEOTECHNICAL BOREHOLE

BOREHOLE LOCATION (NAD83 UTM ZONE 10N)

	EASTING	NORTHING
SH21-5A-19-TEL-JL-KP851+900(BH2)	682809.0	5611043.0
SH21-5A-19-TEL-JL-KP852+390(BH14)	682538.1	5610672.8

HDD FEATURE COORDINATES (NAD83 UTM ZONE 10N)

	EASTING	NORTHING
ENTRY	682818.4	5611026.0
0+000	682752.9	5610951.2
EXIT	682521.3	5610686.4

PROJECT PIPE SPECIFICATIONS

PRODUCT	LOW VAPOUR PRESSURE (LVP) LIQUID HYDROCARBONS	
CLASS LOCATION DESIGNATION	N/A	
DESIGN PRESSURE	9,930 kPa	
MAXIMUM OPERATING PRESSURE	VARYING POINT-SPECIFIC PRESSURE (SEE NOTE A9)	
MINIMUM TEST PRESSURE	VARYING POINT-SPECIFIC PRESSURE (SEE NOTE A9)	
MINIMUM OPERATING TEMPERATURE	5 °C	
MAXIMUM OPERATING TEMPERATURE	38 °C	
PIPELINE DATA	CARRIER PIPE	
	LINE PIPE	HEAVY WALL PIPE
OUTSIDE DIAMETER OF PIPE (mm)	914.4 (NPS 36)	914.4 (NPS 36)
PIPE WALL THICKNESS (mm)	–	19.0
MINIMUM YIELD STRENGTH (MPa)	483	483
PIPE MATERIAL	STEEL, CSA Z245.1 (GRADE 483, CAT II)	
COATING	FUSION BOND EPOXY (FBE), ABRASION RESISTANT OVERCOAT (ARO)	
CATHODIC PROTECTION	IMPRESSED CURRENT	

NOT FOR CONSTRUCTION

THE CURRENT DESIGN FOR SPREAD 5A IS BASED ON THE FOLLOWING:
- PROJECT ROUTE AND FOOTPRINT SSEID REVISION 005.19.5
- SPREAD 5A CROSSING LIST 01-13283-S5A-M002-PL-RPT-0001 REVISION 24
- THIRD PARTY DESIGN RECOMMENDATIONS THAT DO NOT ADVERSELY IMPACT THE SYSTEM INTEGRITY

UPI HAS NOT VERIFIED INFORMATION PROVIDED BY TMC, GEOTECHNICAL, SURVEY AND OTHER THIRD PARTIES, AND THEREFORE ASSUMES NO LIABILITY FOR THIS INFORMATION

PERMIT TO PRACTICE
UPI PROJECTS CANADA LTD.
PERMIT NUMBER: 1001209
THE ASSOCIATION OF PROFESSIONAL ENGINEERS AND GEOSCIENTISTS OF THE PROVINCE OF BRITISH COLUMBIA

UPI DWG. No.: 19731-505-HDW-00162

CLIENT ACCEPTANCE

NO.	REFERENCE DRAWING TITLE	REFERENCE DRAWING NO.	NO	DATE	REVISION	DRN	CHK	ENG	APPR
1	ALIGNMENT SHEET	M002-PA0311701	A	23/06/08	ISSUED FOR REVIEW, AFE 01-13283	BF	RGR	PL	HB

TRANS MOUNTAIN

TRANS MOUNTAIN EXPANSION PROJECT
PLANS AND PROFILES
JACKO HILL
d-044-E/92-I-9

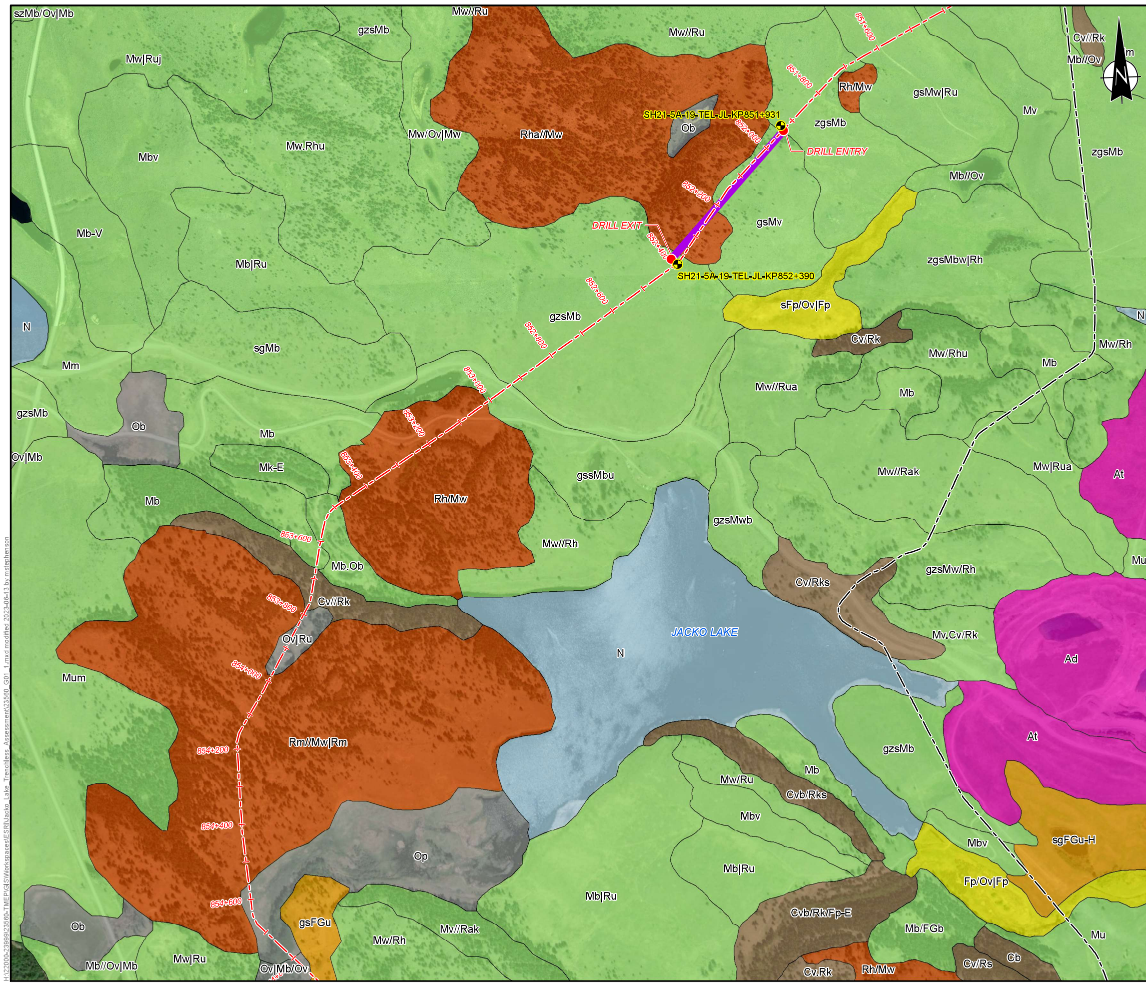
DRAWN BY	CHECKED BY	APPROVED BY	SHEET SIZE	SCALE	DATE
BF	RGR	HB	A1	AS SHOWN	23/05/11

PROJECT CODING AFE	FACILITY ID	DOCUMENT NO	SHT NO	REV
01-13283	M002	XD00162	01	A

THURBER

Appendix B

Figures



LEGEND:

- TEST HOLE LOCATION (APPROXIMATE)
- PROPOSED PIPELINE CENTRELINE (SSEID005,19)
- PROPOSED DRILL CROSSING
- PROPOSED DRILL ENTRY/EXIT
- EXISTING TMEP ALIGNMENT

PRIMARY SURFICIAL MATERIAL:

- ANTHROPOGENIC
- COLLUVIAL
- FLUVIAL
- GLACIOFLUVIAL
- MORAINAL
- WATER
- ORGANIC
- BEDROCK OUTCROP

TERRAIN LABEL KEY:

EXAMPLE LABEL: **sgMw // Cv | Rk – E**

sg – SOIL TEXTURE
M – PRIMARY SURFICIAL MATERIAL
w – PRIMARY SURFICIAL EXPRESSION

// – MATERIAL SPLIT

C – SECONDARY SURFICIAL MATERIAL
v – SECONDARY SURFICIAL EXPRESSION

| – OVERLYING

Rk – UNDERLYING MATERIAL AND EXPRESSION

E – GEOMORPHIC PROCESS

NOTES:

1 DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 23560 DATED JUNE 2023 AND IS SUBJECT TO ANY LIMITATIONS DESCRIBED THEREIN.

2 PROPOSED ALIGNMENT AND PROPOSED EASEMENT PROVIDED BY TRANSMOUNTAIN PIPELINE L.P. VIA PIMS ON JANUARY 31, 2020 (TMC DOCUMENT #01-13283-S5A-M002-PL-GIS-0004 RA).

3 EXISTING TMEP ALIGNMENT SUPPLIED BY CLIENT "TMPL Existing.kml" RECEIVED JULY 2017.

4 PROPOSED HDD DRILL PATH FROM CLIENT SUPPLIED FILE "M002-XD0016201_A_IFR_2023-06-08.pdf" EMAIL JUNE 12, 2023.

5 AIR PHOTO FROM WORLD IMAGERY SERVICE (ACCESSED MAY 30, 2023, AQUISITION DATE (MAY 21, 2021)

6 TERRAIN POLYGONS FROM BGC PROVIDED BY TRANSMOUNTAIN ON AUGUST 13, 2019.

400 200 0 400 m

UTM 10 NAD 83

TRANSMOUNTAIN

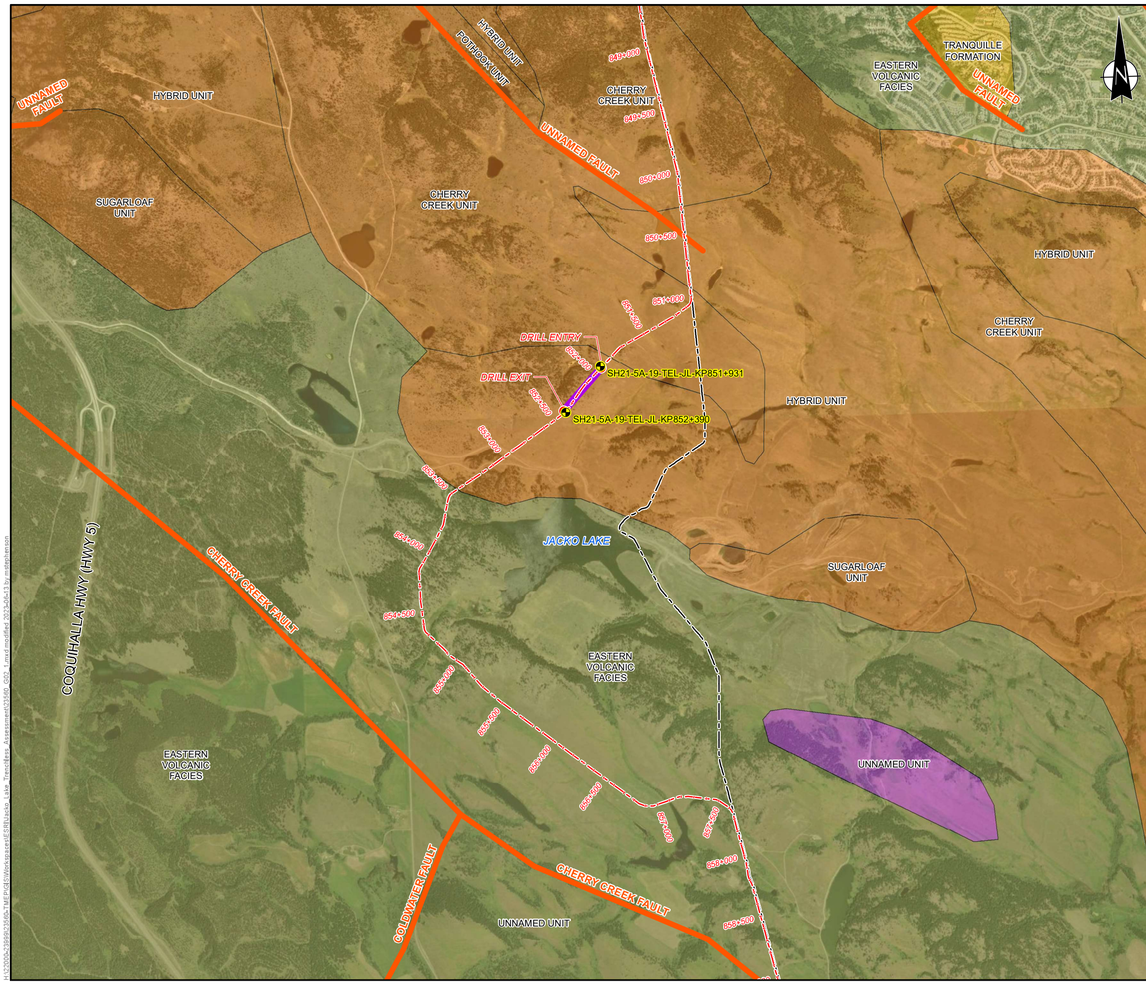
TRANS MOUNTAIN EXPANSION PROJECT - SPREAD 5A
JACKO HILL HDD FEASIBILITY ASSESSMENT

JACKO LAKE SURFICIAL GEOLOGY AND PROPOSED DRILL PATH

FIGURE 1

DRAWN BY	MRS
DESIGNED BY	JLT
APPROVED BY	BW
SCALE	1:10,000
DATE	MAY 30, 2023
FILE No.	23560_G01_1

THURBER ENGINEERING LTD.



LEGEND:

- TEST HOLE LOCATION (APPROXIMATE)
- PROPOSED PIPELINE CENTRELINE (SSEID005.19)
- PROPOSED DRILL CROSSING
- PROPOSED DRILL ENTRY/EXIT
- EXISTING TMEP ALIGNMENT
- BEDROCK FAULT

BEDROCK GROUP (LABEL DENOTES BEDROCK FORMATION)

- IRON MASK BATHOLITH
- KAMLOOPS GROUP
- NICOLA GROUP
- UNNAMED

NOTES:

1. DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 23560 DATED JUNE 2023 AND IS SUBJECT TO ANY LIMITATIONS DESCRIBED THEREIN.
2. PROPOSED ALIGNMENT AND PROPOSED EASEMENT PROVIDED BY TRANSMOUNTAIN PIPELINE L.P. VIA PIMS ON JANUARY 31, 2020 (TMC DOCUMENT #01-13283-S5A-M002-PL-GIS-0004 RA).
3. EXISTING TMEP ALIGNMENT SUPPLIED BY CLIENT "TMPL Existing.kml" RECEIVED JULY 2017.
4. PROPOSED HDD DRILL PATH FROM CLIENT SUPPLIED FILE "M002-XD0016201_A_IFR_2023-06-08.pdf" EMAIL JUNE 12, 2023.
5. AIR PHOTO FROM WORLD IMAGERY SERVICE (ACCESSED MAY 30, 2023, AQUISITION DATE (MAY 21, 2021)
6. BEDROCK GEOLOGY AND FAULTS FROM CUI, Y., MILLER, D., NIXON, G., AND NELSON, J., 2015. BRITISH COLUMBIA DIGITAL GEOLOGY. BRITISH COLUMBIA GEOLOGICAL SURVEY, OPEN FILE 2015-2.

500 250 0 500 m

UTM 10 NAD 83

TRANSMOUNTAIN

TRANS MOUNTAIN EXPANSION PROJECT - SPREAD 5A
JACKO HILL HDD FEASIBILITY ASSESSMENT

JACKO LAKE BEDROCK GEOLOGY

FIGURE 2

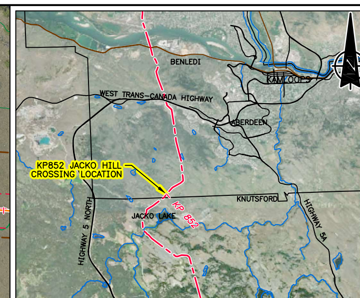
DRAWN BY	MRS
DESIGNED BY	JLT
APPROVED BY	BW
SCALE	1:30,000
DATE	MAY 30, 2023
FILE No.	23560_G02_1

THURBER ENGINEERING LTD.

KP852 JACKO HILL CROSSING PLAN VIEW

0 25 50 100 150 m

SCALE 1:2000 (UTM NAD83Z10)



SITE LOCATION PLAN

0 2.5 5.0 10.0 15.0 km

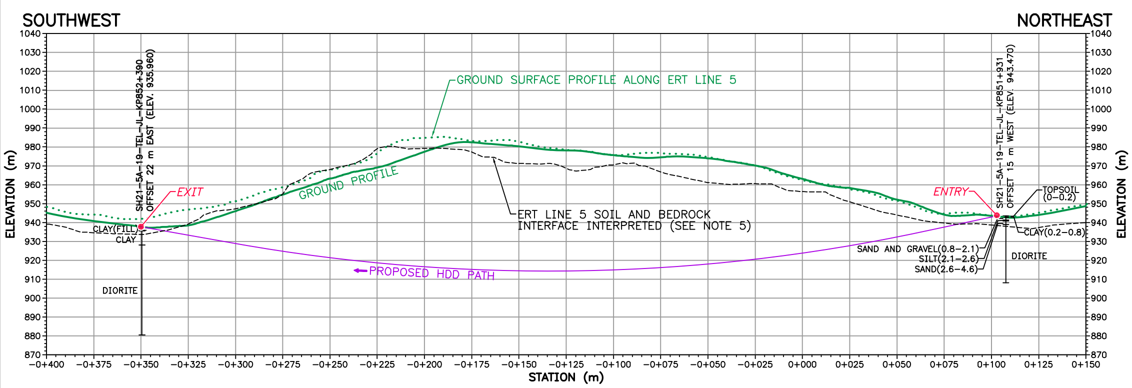
SCALE: 1:200,000 (UTM NAD83Z10)

LEGEND:

- TEST HOLE LOCATION (APPROXIMATE)
- PROPOSED PIPELINE ALIGNMENT (SSEID 5.19)
- PROPOSED HDD PATH
- PROPOSED RIGHT-OF-WAY
- PROPOSED WORKSPACE
- TOPOGRAPHY: (CONTOUR INTERVAL 5.0 m)
  - MAJOR CONTOUR
  - MINOR CONTOUR

NOTES:

1. DRAWING MUST BE USED IN CONJUNCTION WITH THE ATTACHED REPORT REFERENCE 23560 DATED JUNE 2023 AND IS SUBJECT TO ANY LIMITATIONS DESCRIBED THEREIN.
2. AIR PHOTO SUPPLIED BY CLIENT 0.15 m PIXEL (DECEMBER 2018 – MAY 2019).
3. TOPOGRAPHY AND GROUND PROFILES DERIVED FROM CLIENT SUPPLIED LiDAR/DEM.
4. PROPOSED HDD PATH FROM CLIENT SUPPLIED FILE "01-13283-M002-XD0016201_A_IFR_2023-06-08_01.pdf" EMAILED JUNE 12, 2023.
5. GEOPHYSICS LINE FROM SURFACE SEARCH INC. SUPPLIED FILE "21318 TMEP Kamloops Geophysics Jacko Lake Re-Route June 2022 (New Alignment).dwg" EMAILED JUNE 16, 2022.
6. REFER TO ATTACHED TEST HOLE LOGS FOR LITHOLOGY DETAILS.



KP852 JACKO HILL CROSSING PROFILE VIEW

SCALE HORIZONTAL 1:2000
VERTICAL 1:2000

TRANS MOUNTAIN

TRANS MOUNTAIN EXPANSION PROJECT - SPREAD 5A
JACKO HILL HDD FEASIBILITY ASSESSMENT

TEST HOLE LOCATION PLAN AND PROFILE

FIGURE 3

DRAWN BY	CHN
DESIGNED BY	JLT
APPROVED BY	BW
SCALE	AS NOTED
DATE	MAY 29, 2023
FILE No.	23560-M08

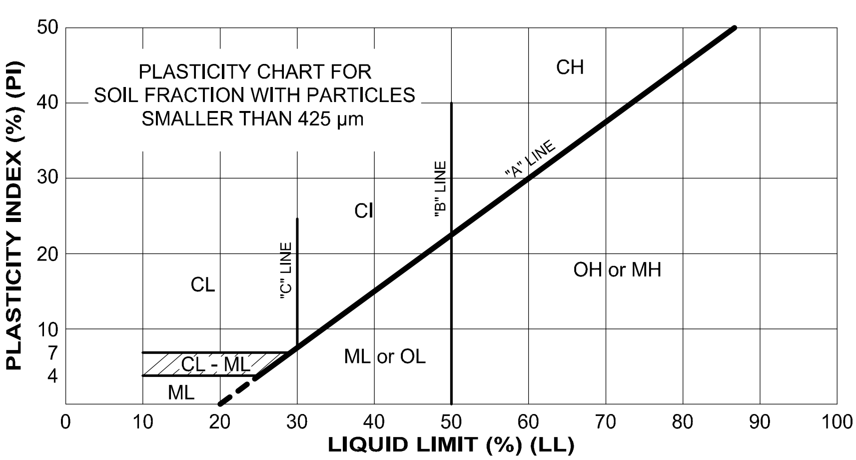
THURBER ENGINEERING LTD.

THURBER

Appendix C

Test Hole Logs

MAJOR DIVISION			SYMBOL	THURBER LOG SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
COARSE-GRAINED SOILS (MORE THAN HALF BY WEIGHT LARGER THAN 75 µm)	**GRAVELS** MORE THAN HALF COARSE GRAINS LARGER THAN 4.75 mm	CLEAN GRAVELS (LITTLE OR NO FINES)	GW		WELL GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES	Determine percentages of gravel and sand from grain size curve. Depending on percentages of fines (fraction smaller than 75 µm) coarse grained soils are classified as follows: Less than 5% GW, GP, SW, SP; More than 12% GM, GC, SM, SC; 5% to 12% Use dual symbols	$C_u = \frac{D_{60}}{D_{10}} > 4$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3
			GP		POORLY GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR GW
		GRAVELS WITH FINES (APPRECIABLE AMOUNT OF FINES)	GM		SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4 — Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			GC		CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7
	SANDS MORE THAN HALF COARSE GRAINS SMALLER THAN 4.75 mm	CLEAN SANDS (LITTLE OR NO FINES)	SW		WELL GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		$C_u = \frac{D_{60}}{D_{10}} > 6$; $C_c = \frac{(D_{30})^2}{D_{10} \times D_{60}} = 1$ to 3
			SP		POORLY GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES		NOT MEETING ALL GRADATION REQUIREMENTS FOR SW
		SAND WITH FINES (APPRECIABLE AMOUNT OF FINES)	SM		SILTY SANDS, SAND-SILT MIXTURES		ATTERBERG LIMITS BELOW "A" LINE I_p LESS THAN 4 — Above "A" line with I_p between 4 and 7 are borderline cases requiring use of dual symbols
			SC		CLAYEY SANDS, SAND-CLAY MIXTURES		ATTERBERG LIMITS ABOVE "A" LINE I_p MORE THAN 7
FINE-GRAINED SOILS (MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm)	**SILTS** BELOW "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 50\%$	ML		INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	CLASSIFICATION IS BASED ON PLASTICITY CHART (see below)	
		$w_L > 50\%$	MH		INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS, FINE SANDY OR SILTY SOILS		
	CLAYS ABOVE "A" LINE NEGLIGIBLE ORGANIC CONTENT	$w_L < 30\%$	CL		INORGANIC CLAYS OF LOW PLASTICITY, GRAVELLY, SANDY, OR SILTY CLAYS, LEAN CLAYS		
		$30\% < w_L < 50\%$	CI		INORGANIC CLAYS OF MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS		
		$w_L > 50\%$	CH		INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS		
	ORGANIC SILTS & CLAYS BELOW "A" LINE	$w_L < 50\%$	OL		ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW AND MEDIUM PLASTICITY		
		$w_L > 50\%$	OH		ORGANIC CLAYS OF HIGH PLASTICITY, ORGANIC SILTS		
HIGHLY ORGANIC SOILS			PT		PEAT AND OTHER HIGHLY ORGANIC SOILS	STRONG COLOUR OR ODOUR, AND OFTEN FIBROUS TEXTURE	



NOTES:

DUAL SYMBOL - A dual symbol is two symbols separated by a hyphen (e.g. GP-GM, SW-SC, CL-ML)

For coarse-grained soils, a dual symbol is used when the soil has between 5% and 12% clay and silt.

For fine-grained soils, a dual symbol is used when the Liquid Limit and Plasticity Index values plot in the CL-ML area of the plasticity chart.

MODIFIED UNIFIED SOIL CLASSIFICATION SYSTEM

THURBER ENGINEERING LTD.

1. PARTICLE SIZE CLASSIFICATION OF MINERAL SOILS

DESCRIPTION	APPARENT PARTICLE SIZE
BOULDERS	> 200 mm
COBBLES	75 mm to 200 mm
GRAVEL coarse fine	19 mm to 75 mm 4.75 mm to 19 mm
SAND coarse medium fine	2 mm to 4.75 mm 0.475 mm to 2 mm 0.075 mm to 0.475 mm
SILT	Non-plastic particles, not visible to the naked eye
CLAY	Plastic particles, not visible to the naked eye

2. TERMS DESCRIBING CONSISTENCY (Cohesive Soils Only)

DESCRIPTION	UNDRAINED SHEAR STRENGTH	APPROXIMATE STANDARD PENETRATION TEST Number of blows per 300 mm
Very Soft	< 10 kPa	< 2
Soft	10 to 25 kPa	2 to 4
Firm	25 to 50 kPa	4 to 8
Stiff	50 to 100 kPa	8 to 15
Very Stiff	100 to 200 kPa	15 to 30
Hard	200 to 300 kPa	30 to 50
Very Hard	> 300 kPa	> 50

3. TERMS DESCRIBING DENSITY (Cohesionless Soils Only)

DESCRIPTION	STANDARD PENETRATION TEST Number of blows per foot (300 mm)
Very Loose	< 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	> 50

4. PROPORTION OF MINOR COMPONENTS BY WEIGHT (Coarse Grained Soils Only) *

DESCRIPTION	PERCENT BY WEIGHT
and	35 to 50 %
y / ey	20 to 35 %
some	10 to 20 %
trace	< 10 %

EXAMPLE: SAND, silty, trace of gravel = Sand with 20 to 35% silt and up to 10% gravel, by dry weight. (Percentages of secondary materials are estimates based on visual and tactile assessment of samples).

** Fine grained soils classification is based on plasticity chart*

5. LEGEND FOR TEST HOLE LOGS

SYMBOL FOR SAMPLE TYPE

- Shelby Tube
- Block Sample
- SPT
- Rock Core
- DCPT
- No Recovery
- Grab

- ● MC - Moisture Content (% by weight) as determined by Sample
- PL LL Atterberg Limit, PL = Plastic Limit, LL = Liquid Limit
- Groundwater Level
- ▲ Cpen - Shear Strength determined by Pocket Penetrometer
- ◆ UCS - Unconfined Compressive Strength by Unconfined Compression Test
- ■ SPT - Standard Penetration Test (Number of blows per 300 mm)
- ✚ DCPT - Dynamic Cone Penetration Test (Number of blows per 300 mm)
- □ Becker Blow Count (Number of blows per 300 mm)
- Cvane - Shear Strength determined by Field Vane Test

6. SPECIAL SYMBOLS

- OVERBURDEN / FILL (UNDIFFERENTIATED)
- TOPSOIL
- BEDROCK (UNDIFFERENTIATED)
- CONGLOMERATE
- SANDSTONE
- SILTSTONE
- CLAYSTONE / MUDSTONE
- CLAY SHALE
- LIMESTONE / DOLOMITE
- METAMORPHIC ROCK
- GRANITIC ROCK
- VOLCANIC ROCK
- COAL / OIL SAND

SYMBOLS AND TERMS USED ON TEST HOLE LOGS

THURBER ENGINEERING LTD.

Descriptions follow the form “Rock type, weathering / alteration, bedding thickness, grain size, strength, colour”.
Example: SANDSTONE, slightly weathered, thinly bedded, fine grained, weak, light grey.

CORE CONDITION

Total Core Recovery (TCR)
The percentage of drill core recovered, regardless of quality or length, measured relative to the total length of the core run.

Solid Core Recovery (SCR)
The percentage of drill core recovered at full diameter, regardless of length, measured relative to the total length of the core run.

Rock Quality Designation (RQD)
The percentage of solid drill core greater than 100 mm in length, as measured along the core axis, measured relative to the total length of the core run.

FRACTURE INDEX (FI)
The number of naturally occurring discontinuities (physical separation) per metre of rock core. Mechanically induced breaks caused by drilling are not included.

ROCK DESCRIPTION

WEATHERING

Term	Description
Fresh	No visible sign of weathering
Faintly	Discolouration of major discontinuities
Slightly	Along discontinuities and part of mass
Moderately	Through mass but not friable
Highly	Mass partly friable with corestones
Completely	Entirely decomposed, structure visible
Residual	Entirely decomposed, no structure

GRAIN SIZE

Term	Description
Very coarse grained	> 60 mm
Coarse grained	2 mm - 60 mm
Medium grained	60 microns to 2 mm
Fine grained	2 microns - 60 microns
Very fine grained	< 2 microns

Note: Grains > 60 microns diameter are visible to the naked eye

BEDDING THICKNESS

Term	Description
Very thickly bedded	> 2000 mm
Thickly bedded	600 - 2000 mm
Moderately bedded	200 - 600 mm
Thinly bedded	60 - 200 mm
Very thinly bedded	20 - 60 mm
Thickly laminated	6 - 20 mm
Thinly laminated	2 - 6 mm

COLOUR

Shade	Secondary	Primary
Light	Pinkish	Pink
Dark	Reddish	Red
	Yellowish	Yellow
	Brownish	Brown
	Olive	Olive
	Greenish	Green
	Bluish	Blue
	Greyish	Grey
		Black
		White

ROCK STRENGTH

Term	Description	Class	* UCS (MPa)
Extremely weak	Indented with thumbnail	R0	0.25 - 1
Very weak	Crumbles under firm blows with hammer, can be peeled with knife	R1	1 - 5
Weak	Shallow indentation can be made with firm hammer blow, difficult to peel with knife	R2	5 - 25
Medium strong	Single firm hammer blow to fracture, cannot be cut or peeled by knife	R3	25 - 50
Strong	More than one hammer blows to fracture	R4	50 - 100
Very Strong	Many hammer blows to fracture	R5	100 - 250
Extremely strong	Specimen can only be chipped with a hammer, rings when struck by a hammer	R6	> 250

* UCS = Unconfined Compressive Strength

DISCONTINUITY DATA

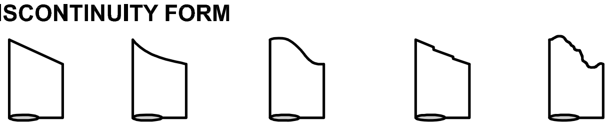
AZIMUTH
The angle measured clockwise relative to True North, in which a test hole is directed. The azimuth ranges from 0° to 360°. For vertical test holes, an azimuth does not exist.

DIP ANGLE
The angle of the discontinuity relative to the axis of the core. In a vertical borehole a discontinuity with a 90° is horizontal.

DISCONTINUITY TYPE

Term	Description
Joint	Stress induced, planar, one or more sub-parallel sets
Vein	Mineral infill or healed discontinuity
Fault	Discontinuity with signs of significant movement e.g. breccia, slickensides
Bedding	The surface that separates one stratum, layer or bed from another
Contact	The surface along which one rock type touches another

DISCONTINUITY FORM



Planar (PL) Curved (C) Undulating (U) Stepped (ST) Irregular (I)

DISCONTINUITY ROUGHNESS

Slickensided (K) Polished (PO) Smooth (S) Rough (R) Very rough (VR)

DISCONTINUITY INFILL

Term	Description
Clean	Clean, unaltered, unstained discontinuity surface
Partially coated	Partially thin coverage of infill material across the core diameter, which coats but does not fill the discontinuity roughness
Completely coated	Complete thin coverage of infill material across the core diameter which does not fill the discontinuity roughness
Filled	Infill material is thick enough to fill the discontinuity surface roughness
Stained	Chemical alteration of the discontinuity surface through oxidation, carbonation, and solution and has no coatings or infilling

ROCK CORE DESCRIPTION

THURBER ENGINEERING LTD.

Descriptions of rock mass should include detailed description of the discontinuities and the state of weathering and alteration. Discontinuity description should include type, number of sets, location, orientation (dip/dip/direction), fracture spacing, separation of fracture surfaces, infilling, persistence (continuous length) and surface roughness and shape. Example: "Columnar jointed with vertical columns and one set of horizontal joints, spacing of vertical joints is very wide, spacing of horizontal joints wide, joints lengths are 3 to 5 m (10 to 16 ft) vertically and 0.5 m to 1m (1.5 to 3 ft) horizontally; joint aperture is open and the fracture infilling is very soft clay. The vertical columnar joints are smooth, while the horizontal joints are very rough."

TYPE

Joint - break with no visible displacement
Fault - fracture with recognizable displacement
Cleavage plane
Bedding plane
Schistocity plane
Weakness zone
Fissure
Tension crack
Foliation

SPACING

Perpendicular distance between adjacent discontinuities

Extremely wide	>6 m
Very wide	2 m - 6 m
Wide	600 - 2 m
Moderate	200 - 600 mm
Close	60 - 200 mm
Very close	20 - 60 mm
Extremely close	<20 mm

ORIENTATION

Dip, dip direction and trend of lineation expressed as degrees

PERSISTENCE

Modal trace length for each set

Very low	<1 m
Low	1 - 3 m
Medium	3 - 10 m
High	10 - 20 m
Very high	>20 m

BLOCK SIZE

Term	*Block size*	*Equivalent discontinuity spacings in blocky rock*
Very large	>8 m^3	Very wide to extremely wide
Large	0.2 - 8 m^3	Wide
Medium	0.008 - 0.2 m^3	Moderate
Small	0.0002 - 0.008 m^3	Close
Very small	<0.0002 m^3	Less than close

APERTURE

<0.1 mm	Very tight	"Closed" features
0.1 - 0.25 mm	Tight	
0.25 - 0.5 mm	Partly open	
0.5 - 2.5 mm	Open	"Gapped" features
2.5 - 10 mm	Moderately wide	
>10 mm	Wide	
1 - 10 cm	Very wide	"Open" features
10 - 100 cm	Extremely wide	
>1 m	Cavernous	

FORM

Overall shape of the discontinuity

Curved
Irregular
Planar
Stepped
Undulating

ROUGHNESS

		JRC - joint roughness coefficient
Polished	Shiney smooth and slippery in all directions	0 - 2
Slickensided	Polished in one direction and showing evidence of significant movement	2 - 4
Smooth	Smooth to the touch	4 - 10
Slightly rough	Asperities on the fracture surfaces are visible and can be distinctly felt	10 - 12
Medium rough	Asperities are clearly visible and fracture surface feels abrasive	12 - 16
Rough	Large angular asperities van be seen and distincly felt	16 - 20
Very rough	Highly irregular jagged surfaces	>20
Defined ridges	Supplemental - used with above terms	
Small steps	Supplemental - used with above terms	

Mapping Symbols

45 Joint dip and strike direction

Horizontal joint

Vertical joint and strike direction

45 Bedding dip and strike direction

45 Foliation dip and strike derection

Rock Mass Descriptive Terms

massive	=	few joints or very wide spacing
blocky	=	approximately equidimensional
tabular	=	one dimension considerably smaller than the other two
columnar	=	one dimension considerably larger than the other two
irregular	=	wide variations of block size and shape
crushed	=	heavily jointed to "sugar cube"
aperture	=	the perpendicular distance separating the adjacent rock walls of an open discontinuity
width	=	the perpendicular distance separating the adjacent rock walls of a filled discontinuity

Drill Core Descriptive Terms (all measurements on rock core are taken along the centerline axis of the core)

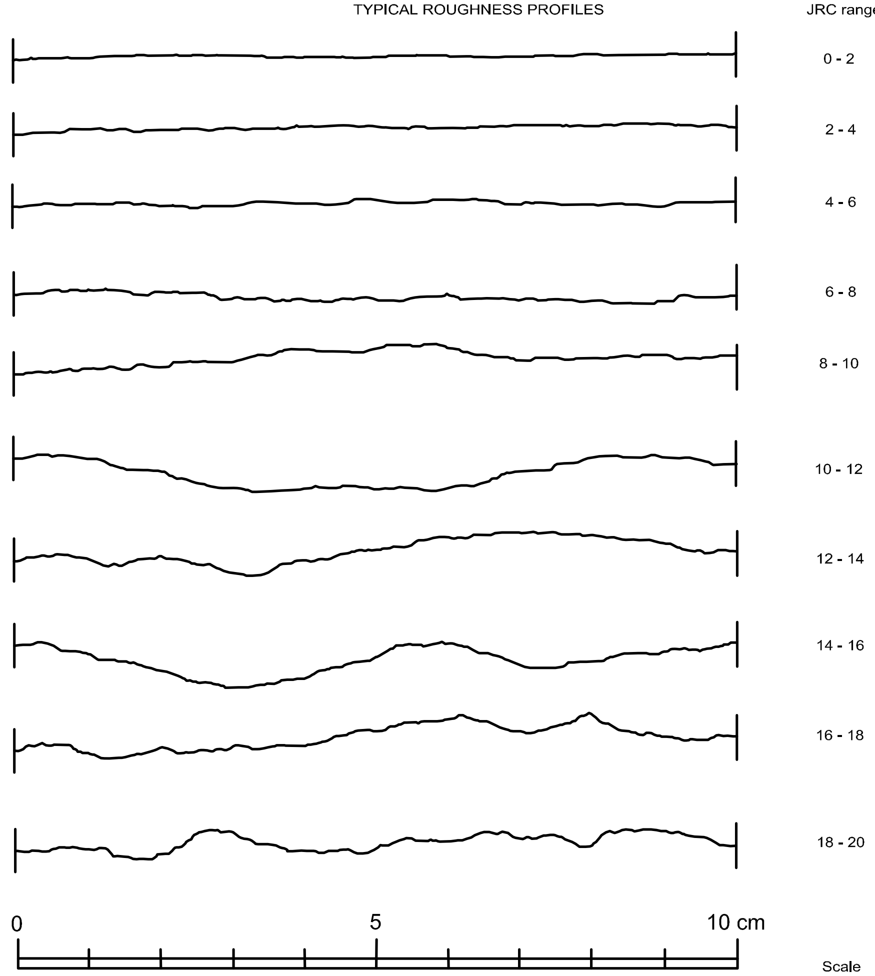
Total Core Recovery (TCR)
The percentage of drill core recovered, regardless of quality or length, measured relative to the total length of the core run.

Rock Quality Designation (RQD)
The percentage of solid drill core greater than 100 mm in length, as measured along the core axis, measured relative to the total length of the core run.

Solid Core Recovery (SCR)
The percentage of drill core recovered at full diameter, regardless of length, measured relative to the total length of the core run.

Fracture Index (FI)
The number of naturally occurring discontinuities (physical separation) per metre of rock core. Mechanically induced breaks caused by drilling are not included.

TYPICAL ROUGHNESS PROFILES



ROCK MASS DESCRIPTION

THURBER ENGINEERING LTD.

Descriptions follow the form “Rock type, weathering / alteration, bedding thickness, grain size, strength, colour”.
Example: SANDSTONE, slightly weathered, thinly bedded, fine grained, weak, light grey.

COLOUR

Shade Primary	Secondary	Primary
Light	Pinkish	Pink
Dark	Reddish	Red
	Yellowish	Yellow
	Brownish	Brown
	Olive	Olive
	Greenish	Green
	Bluish	Blue
		White
	Greyish	Grey
		Black

GRAIN SIZE

Term	Particle Size	Retained on Sieve Size	Equivalent Soil Grade
Very coarse grained	>60 mm	2 inch	Coarse gravel, cobbles, boulders
Coarse grained	2 - 60 mm	No. 8	Gravel
Medium grained	60 microns - 2 mm	No. 200	Sand
Fine grained	2 - 60 microns		Silt
Very fine grained	<2 microns		Clay

Note: grains >60 microns are visible to the naked eye.

TEXTURE/FABRIC

Crystalline
Granular
Glassy

WEATHERING / ALTERATION

Term	Description
Fresh	No visible sign of rock material weathering.
Faintly weathered	Discoloration on major discontinuity surfaces.
Slightly weathered	Discoloration indicates weathering of rock material and discontinuity surfaces. All the rock material may be discolored by weathering and may be somewhat weaker than in its fresh condition
Moderately weathered	Less than half of the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones.
Highly weathered	More than half the rock material is decomposed and/or disintegrated to a soil. Fresh or discoloured rock is present either as a continuous framework or as corestones.
Completely weathered	All rock material is decomposed and/or disintegrated to soil.The original mass structure is still largelt intact.
Residual soil	All rock material is converted to soil. The mass structure and material fabric are destroyed. There is a large change in volume, but the soil has not been significantly transported.

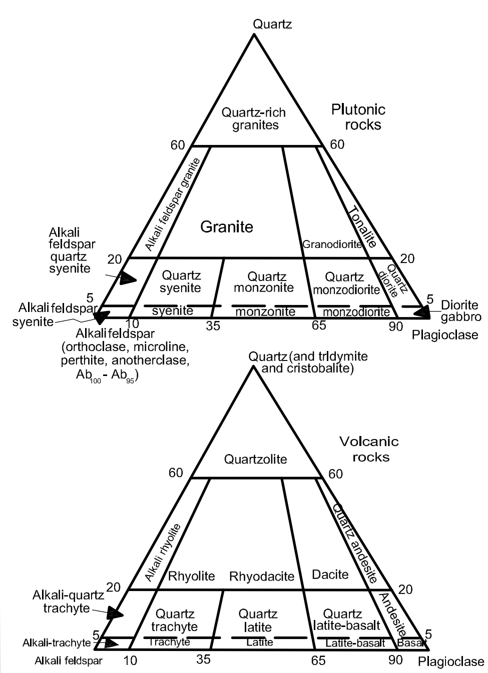
ROCK STRENGTH

Term	Grade	Unconfined compressive strength (MPa)	Unconfined compressive strength (psi)	Field estimation of strength
Very soft clay[1]	S1	<0.025	<4	Easily penetrated several inches by fist.
Soft clay[1]	S2	0.025 - 0.05	4 - 7	Easily penetrated several inches by thumb.
Firm clay[1]	S3	0.05 - 0.10	7 - 15	Can be penetrated several inches by thumb with moderate effort.
Stiff clay[1]	S4	0.10 - 0.25	15 - 35	Readily indented by thumb but penetrated only with great effort.
Very stiff clay[1]	S5	0.25 - 0.50	35 - 70	Readily indented by thumbnail.
Hard clay[1]	S6	>.50	>70	Indented with difficulty by thumbnail.
Extremely weak rock	R0	.25 - 1	36 - 150	Indented by thumbnail.
Very weak rock	R1	1 - 5	150 - 750	Crumbles under firm blows with point of geological hammer, can be peeled by a pocket knife.
Weak rock	R2	5 - 25	750 - 3,500	Can be peeled by a pocket knife with difficulty, shallow indentations made by firm blow with point of geological hammer.
Medium strong rock	R3	25 - 50	3,500 - 7,500	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with single firm blow of geological hammer.
Strong rock	R4	50 - 100	7,500 - 15,000	Specimen requires more than one blow of geological hammer to fracture it.
Very strong rock	R5	100 - 250	15,000 - 36.000	Specimen requires many blows of a geological hammer to fracture it.
Extremely strong rock	R6	>250	>36,000	Specimen can only be chipped with a geological hammer.

[1]These soil strengths are as recommended by ISRM but should only be used to describe highly weathered rock, residual soils or rock discontinuity filling, they do not correspond to ASTM D2488 consistency criteria.

ROCK TYPE

Genetic group			*Detrital sedimentary*			*Pyroclastic*	*Chemical organic*	*Metamorphic*		*Igneous*
Usual Structure			BEDDED			BEDDED		FOLIATED	MASSIVE	MASSIVE
COMPOSITION	Grain size (mm)		Grains of rock, quartz, feldspar and minerals	At least 50% of grains are of carbonate		At least 50% of grains are of fine-grained volcanic rock		Quartz, feldspars, micas, acicular dark minerals		
Very coarse grained / Coarse grained	60 / 2	RUDACEOUS	Grains are of rock, fragments Rounded grains: CONGLOMERATE Augular grains: BRECCIA	LIMESTONE (undifferentiated)	CALCI-RUDITE	Rounded grains AGGLOMERATE Angular grains VOLCANIC BRECCIA	SALINE ROCKS Halite Anhydrite Gypsum	MIGMATITE / GNEISS / Alternate layers of granular and flakey minerals	HORNFELS / MARBLE	
Medium grained	0.06	ARENACEOUS	SANDSTONE Grains are mainly mineral fragments QUARTZ SANDSTONE: 95% quartz, voids empty or cemented ARKOSE: 75% quartz, up to 25% feldspar: voids empty or cemented ARGILLACEOUS SANDSTONE: 75% quartz, 15% + fine detrital material		CALC-ARENITE	TUFF		SCHIST / PHYLLITE	GRANULITE / QUARTZITE / AMPHIBOLITE	
Fine grained / Very fine grained	0.002	ARGILLACEOUS or LUTACEOUS	MUDSTONE SHALE: fissile mudstone SILTSTONE: 50% fine-grained particles CLAYSTONE: 50% very fine-grained particles CALCAREOUS MUDSTONE		CALCI-SILTITE / CALCI-LUTITE	Fine-grained TUFF / Very fine-grained TUFF	CHERT / FLINT / COAL / OTHERS	SLATE / MYLONITE		
GLASSY										



References
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Rock Chracterrization Testing and Monitoring, ISRM Suggested Methods, E. Brown,Pergamon Press; Manual of Mineralogy, 20th Edition, C. Klein and C. Hurlbut, Wiley;
Canadian Foundation Engineering Manual, 2nd Edition, 1985, Canadian Geotechnical Society; Foundations on Rock, D. Wyllie, E & FN Spon.

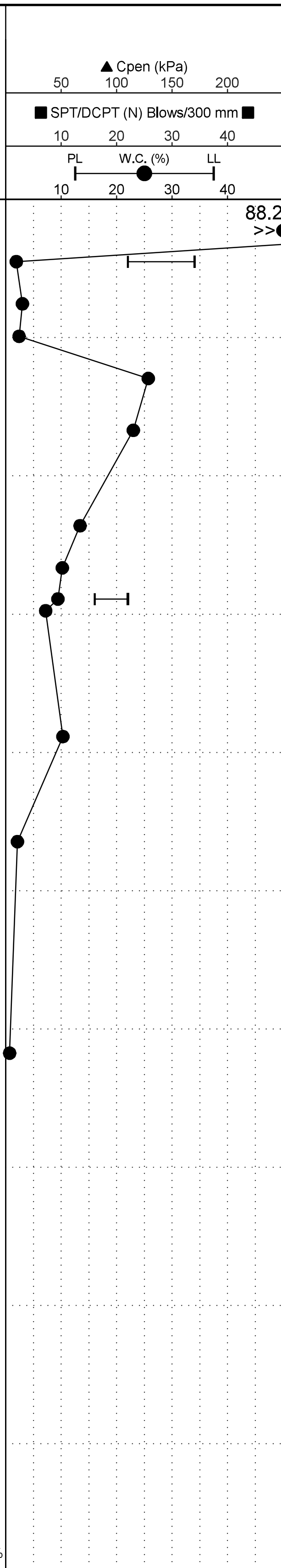
ROCK MATERIAL DESCRIPTION

THURBER ENGINEERING LTD.

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP851+931**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5611039.38 m, Easting: 682810.55 m	ELEVATION: 943.47 m (TEL-JL-BH2)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE:



DEPTH (m)	SAMPLE TYPE	SAMPLE ID	REMARKS	MUSCS / ISRM	DESCRIPTION	ELEVATION (m)
0	Grab Sample	G-1	Sonic drilling Run 1: 0.0 m to 2.1 m Recovery 85%	TPS	TOPSOIL, trace sand, trace gravel, dark brown, occasional rootlets	
				CI	CLAY, trace sand, low to medium plastic, brown, occasional oxides	943
1	Grab Sample	G-2	Gravel = 32.7%, Sand = 43.6% Silt = 20.1%, Clay = 3.6%	SM	SAND AND GRAVEL, silty, trace clay, brown, occasional oxides	
	Grab Sample	G-3	Gravel = 0.4%, Sand = 5.4% Silt = 72.7%, Clay = 21.5%			942
2	Standard Penetration Test	SPT-4 13-15/25	Run 2: 2.1 m to 3.7 m Recovery 100% SPT driven < 450 mm	ML	SILT, very dense, greenish grey to brown	941
	Grab Sample	G-5		SM	SAND, silty, gravelly, trace clay, very dense, grey	
3	Grab Sample	G-6	Gravel = 21.5%, Sand = 48.9% Silt = 27.4%, Clay = 2.2%			940
4	Standard Penetration Test	SPT-7 50/125	SPT driven < 450 mm Run 3: 3.7 m to 5.2 m Recovery 100%			939
	Grab Sample	G-8			DIORITE, strong, slightly weathered, fine to medium grained, grey to greenish grey, quartz, epidote and calcite veins noted throughout, joint angles noted at 20° to 90° to core axis (TCA)	
5	No Recovery	NR-9 50/50	SPT driven < 450 mm Run 4: 5.2 m to 6.7 m Recovery 100%			938
6	Grab Sample	G-10	Start HQ3 coring at 6.39m		-trace clay infill -broken core from 6.51 m to 6.63 m	937
7	Rock Core	RC-1 TCR = 74% SCR = 33% RQD = 16% FI = 8			-broken core from 7.00 m to 7.08 m -brecciated zones noted from 7.40 m to 9.30 m	936
8	Rock Core	RC-2 TCR = 69% SCR = 13% RQD = 19% FI = 5			-broken core from 7.80 m to 7.87 m -broken core from 8.20 m to 8.35 m	935
9	Rock Core	RC-3 TCR = 100% SCR = 79%			-strong to very strong, fresh below 8.90 m -slickensides noted on joint surfaces from 9.06 m to 10.34 m	934
10						

DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 35.3 m
RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-08-24
DRILL METHOD: Sonic/Coring	REVIEWED BY: SM	

THURBER ENGINEERING LTD.

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP851+931**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5611039.38 m, Easting: 682810.55 m	ELEVATION: 943.47 m (TEL-JL-BH2)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	Cpen (kPa) 50 100 150 200 / SPT/DCPT (N) Blows/300 mm 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
10	Rock Core	RQD = 76% FI = 7					DIORITE (continued)	
	Rock Core						-iron oxide staining noted on joint faces from 10.34 m to 11.86 m -broken core from 10.59 m to 10.66 m	933
11	Rock Core	RC-4 TCR = 100% SCR = 66% RQD = 10% FI = 7						932
12	Rock Core						-broken core from 12.03 m to 12.13 m	931
13	Rock Core	RC-5 TCR = 100% SCR = 86% RQD = 62% FI = 5					-broken core from 13.40 m to 13.56 m	930
14	Rock Core	RC-6 TCR = 99% SCR = 72% RQD = 55% FI = 7						929
15	Rock Core	RC-7 TCR = 100% SCR = 92% RQD = 74% FI = 3					-broken core from 15.69 m to 15.77 m	928
16								927
17	Rock Core	RC-8 TCR = 100% SCR = 59% RQD = 46% FI = 8						926
18								925
19	Rock Core	RC-9 TCR = 95% SCR = 59% RQD = 39% FI = 7		Drill bit stuck at 19.46 m			-broken core from 19.46 m to 20.39 m	924
20	Rock Core				IG			

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP851+931**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5611039.38 m, Easting: 682810.55 m	ELEVATION: 943.47 m (TEL-JL-BH2)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE:

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	▲ Cpen (kPa) 50 100 150 200 / ■ SPT/DCPT (N) Blows/300 mm ■ 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
20	Rock Core	RC-10 TCR = 92% SCR = 40% RQD = 25% FI = 2					DIORITE (continued)	923
21	Rock Core	RC-11 TCR = 71% SCR = 20% RQD = 9% FI = 7					-slightly weathered below 21.10 m -broken core from 21.04 m to 21.14 m -broken core from 21.83 m to 22.06 m	922
22	Rock Core	RC-12 TCR = 65% SCR = 33% RQD = 34% FI = 2					-broken core from 22.50 m to 22.60 m -fresh below 22.60 m -broken core from 22.67 m to 22.73 m -broken core from 23.18 m to 23.25 m -broken core from 23.33 m to 23.44 m	921 920
24	Rock Core	RC-13 TCR = 100% SCR = 78% RQD = 79% FI = 1						919
25	Rock Core	RC-14 TCR = 98% SCR = 66% RQD = 30% FI = 8		Packer Test completed from 25.60 m to 27.13 m			-broken core from 25.81 m to 25.88 m	918 917
27	Rock Core	RC-15 TCR = 100% SCR = 79% RQD = 41% FI = 8					-broken core from 27.06 m to 27.20 m	916 915
29–30	Rock Core	RC-16 TCR = 89% SCR = 66% RQD = 50% FI = 5					-broken core from 28.89 m to 28.94 m -broken core from 29.47 m to 29.61 m	914

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 35.3 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-08-24
	DRILL METHOD: Sonic/Coring	REVIEWED BY: SM	Page 3 of 4

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP851+931**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5611039.38 m, Easting: 682810.55 m	ELEVATION: 943.47 m (TEL-JL-BH2)

SAMPLE TYPE: Grab Sample / Standard Penetration Test / No Recovery / Rock Core

BACKFILL TYPE:

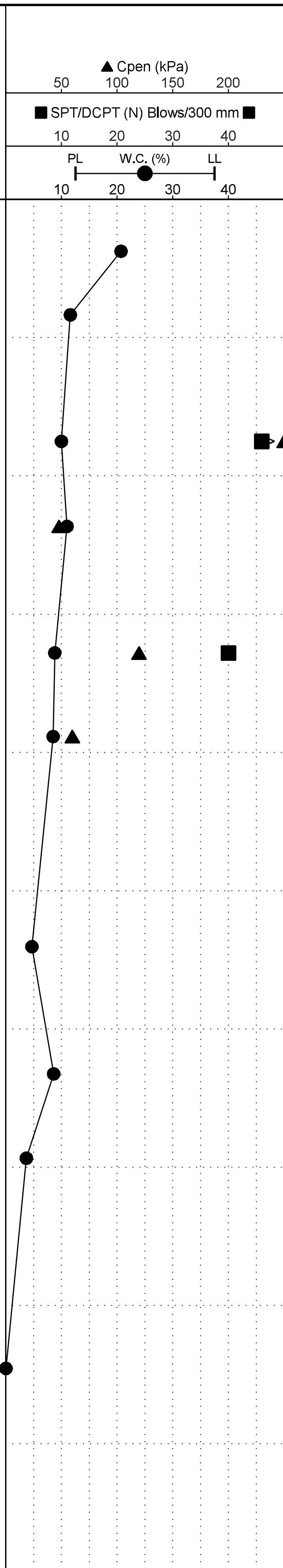
DEPTH (m)	SAMPLE TYPE	SAMPLE ID	▲ Cpen (kPa) 50 100 150 200 / ■ SPT/DCPT (N) Blows/300 mm ■ 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
30	Rock Core						DIORITE (continued) -broken core from 30.10 m to 30.42 m	913
31	Rock Core	RC-17 TCR = 100% SCR = 66% RQD = 53% FI = 7						912
32	Rock Core	RC-18 TCR = 100% SCR = 79% RQD = 43% FI = 6					-broken core from 31.73 m to 31.77 m	911
33	Rock Core	RC-19 TCR = 100% SCR = 79% RQD = 43% FI = 11						910
34								909
35	Rock Core	RC-20 TCR = 100% SCR = 97% RQD = 79% FI = 8					END OF HOLE at 35.30 m - backfilled with grout from termination depth to approx. 1.00 m below surface - backfilled with cuttings and bentonite chips from 1.00 m to surface	908
36								907
37								906
38								905
39								904
40								

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 35.3 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-08-24
	DRILL METHOD: Sonic/Coring	REVIEWED BY: SM	Page 4 of 4

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP852+390**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5610672.83 m, Easting: 682538.13 m	ELEVATION: 935.96 m (TEL-JL-BH14)

SAMPLE TYPE: Grab Sample; Standard Penetration Test; No Recovery; Rock Core

BACKFILL TYPE: GROUT



DEPTH (m)	SAMPLE ID	REMARKS	MUSCS / ISRM	DESCRIPTION	ELEVATION (m)
0		Auger Drilling from surface	FILL	CLAY (FILL), sandy, black, occasional rootlets	
	G-1				
	G-2		CI	CLAY, trace fine sand, trace gravel, brown, hard, occasional oxides	
1					935
	SPT-3 11-18-28 (46)	Cpen > 215kPa			934
2	G-4			-some fine sand below 2.4 m	
3	SPT-5 5-19-21 (40)				933
4	G-6				932
	NR-7 38-50/150	Seepage noted at 4.57 m			
5					931
	G-8	Auger refusal at 5.33 m, start ODEX Drilling		-diorite fragments noted at 5.33 m	
6	SPT-9 50/125			-very hard below 6.10 m	930
7	G-10				929
8				DIORITE, strong, fresh, greenish grey, massive, epidote noted throughout, trace calcite and quartz veins noted throughout, iron oxide staining and clay infill noted on joint surfaces, joint angles noted at 15° to 90° to core axis (TCA)	928
	G-11				
9		Start HQ3 coring at 8.98 m			927
	RC-1 TCR = 95% SCR = 48% RQD = 39%			-medium strong, slightly weathered from 9.33 to 9.76 m -broken core from 9.35 m to 9.37 m	
10					

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 55.4 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-12-05
	DRILL METHOD: Auger/ODEX/Coring	REVIEWED BY: SM	Page 1 of 6

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP852+390**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5610672.83 m, Easting: 682538.13 m	ELEVATION: 935.96 m (TEL-JL-BH14)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE: GROUT

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	▲ Cpen (kPa) 50 100 150 200 / ■ SPT/DCPT (N) Blows/300 mm ■ 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	VIBRATING WIRE	VIBRATING WIRE	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
10									DIORITE (continued)	
	Rock Core	RC-2 TCR = 100% SCR = 64% RQD = 47%							-broken core from 10.39 m to 10.44 m	
11										925
	Rock Core			Packer Test completed from 11.23 m to 14.36 m					-broken core from 11.17 m to 11.20 m	
12		RC-3 TCR = 100% SCR = 75% RQD = 64%								924
13	Rock Core	RC-4 TCR = 100% SCR = 42% RQD = 22%								923
14									-broken core from 13.92 m to 13.97 m	922
	Rock Core								-broken core from 14.56 m to 14.61 m	
15		RC-5 TCR = 96% SCR = 34% RQD = 15%							-broken core from 15.11 m to 15.13 m	921
16	Rock Core								-grey, epidote and hornblende noted at 15.88 m	920
		RC-6 TCR = 100% SCR = 41% RQD = 38%								
17										919
18	Rock Core	RC-7 TCR = 100% SCR = 69% RQD = 48%								918
19	Rock Core								-broken core from 19.06 m to 19.19 m	917
20		RC-8 TCR = 100%								

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 55.4 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-12-05
	DRILL METHOD: Auger/ODEX/Coring	REVIEWED BY: SM	

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP852+390**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5610672.83 m, Easting: 682538.13 m	ELEVATION: 935.96 m (TEL-JL-BH14)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE: GROUT

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	▲ Cpen (kPa) 50 100 150 200 / ■ SPT/DCPT (N) Blows/300 mm ■ 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	VIBRATING WIRE	VIBRATING WIRE	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
20	Rock Core	SCR = 63% RQD = 57%							DIORITE (continued)	
									-broken core from 20.44 m to 20.57 m	
21	Rock Core	RC-9 TCR = 99% SCR = 42% RQD = 33%								915
22	Rock Core	RC-10 TCR = 100% SCR = 89% RQD = 82%								914
23										913
24	Rock Core	RC-11 TCR = 100% SCR = 89% RQD = 84%								912
25	Rock Core	RC-12 TCR = 100% SCR = 66% RQD = 49%								911
26										910
27	Rock Core	RC-13 TCR = 98% SCR = 76% RQD = 69%							-broken core from 27.26 m to 27.35 m	909
28									-brecciated hornblende noted at 28.04 m	908
29	Rock Core	RC-14 TCR = 100% SCR = 66% RQD = 49%		Packer Test completed from 29.00 m to 34.12 m						907
30										

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 55.4 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-12-05
	DRILL METHOD: Auger/ODEX/Coring	REVIEWED BY: SM	Page 3 of 6

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP852+390**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5610672.83 m, Easting: 682538.13 m	ELEVATION: 935.96 m (TEL-JL-BH14)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE: GROUT

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	▲ Cpen (kPa) 50 100 150 200 / ■ SPT/DCPT (N) Blows/300 mm ■ 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	VIBRATING WIRE	VIBRATING WIRE	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
30	Rock Core	RC-15 TCR = 100% SCR = 83% RQD = 83%					IG		DIORITE (continued)	
31										905
32	Rock Core	RC-16 TCR = 100% SCR = 68% RQD = 53%								904
33	Rock Core	RC-17 TCR = 100% SCR = 84% RQD = 81%							-strong to very strong below 32.60 m	903
34										902
35	Rock Core	RC-18 TCR = 100% SCR = 80% RQD = 72%							-broken core from 35.64 m to 35.74 m	901
36	Rock Core	RC-19 TCR = 100% SCR = 59% RQD = 49%								900
37									-becomes brecciated below 36.91 m	899
38	Rock Core	RC-20 TCR = 100% SCR = 67% RQD = 54%							-broken core from 38.41 m to 38.51 m	898
39	Rock Core	RC-21 TCR = 100% SCR = 78% RQD = 68%								897
40										

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 55.4 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-12-05
	DRILL METHOD: Auger/ODEX/Coring	REVIEWED BY: SM	Page 4 of 6

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP852+390**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5610672.83 m, Easting: 682538.13 m	ELEVATION: 935.96 m (TEL-JL-BH14)

SAMPLE TYPE: Grab Sample | Standard Penetration Test | No Recovery | Rock Core

BACKFILL TYPE: GROUT

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	▲ Cpen (kPa) 50 100 150 200 / ■ SPT/DCPT (N) Blows/300 mm ■ 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	VIBRATING WIRE	VIBRATING WIRE	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
40									DIORITE (continued) -medium strong to strong below 40.20 m	
41	Rock Core	RC-22 TCR = 92% SCR = 51% RQD = 39%							-broken core from 41.22 m to 41.27 m -olivine noted at 41.72 m	895
42	Rock Core	RC-23 TCR = 100% SCR = 59% RQD = 38%								894
43										893
44	Rock Core	RC-24 TCR = 100% SCR = 91% RQD = 89%		Packer Test completed from 44.32 m to 49.32 m						892
45	Rock Core	RC-25 TCR = 100% SCR = 68% RQD = 53%								891
46										890
47	Rock Core	RC-26 TCR = 100% SCR = 58% RQD = 53%								889
48	Rock Core	RC-27 TCR = 100% SCR = 64% RQD = 63%							-pyrite noted below 47.80 m	888
49										887
50										

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 55.4 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-12-05
	DRILL METHOD: Auger/ODEX/Coring	REVIEWED BY: SM	

CLIENT: Trans Mountain Pipeline L.P.	PROJECT: Jacko Lake	TEST HOLE NO: **SH21-5A-19-TEL-JL-KP852+390**
PROJECT NO: 23560	UTM 10 NAD 83, Northing: 5610672.83 m, Easting: 682538.13 m	ELEVATION: 935.96 m (TEL-JL-BH14)

SAMPLE TYPE: Grab Sample; Standard Penetration Test; No Recovery; Rock Core

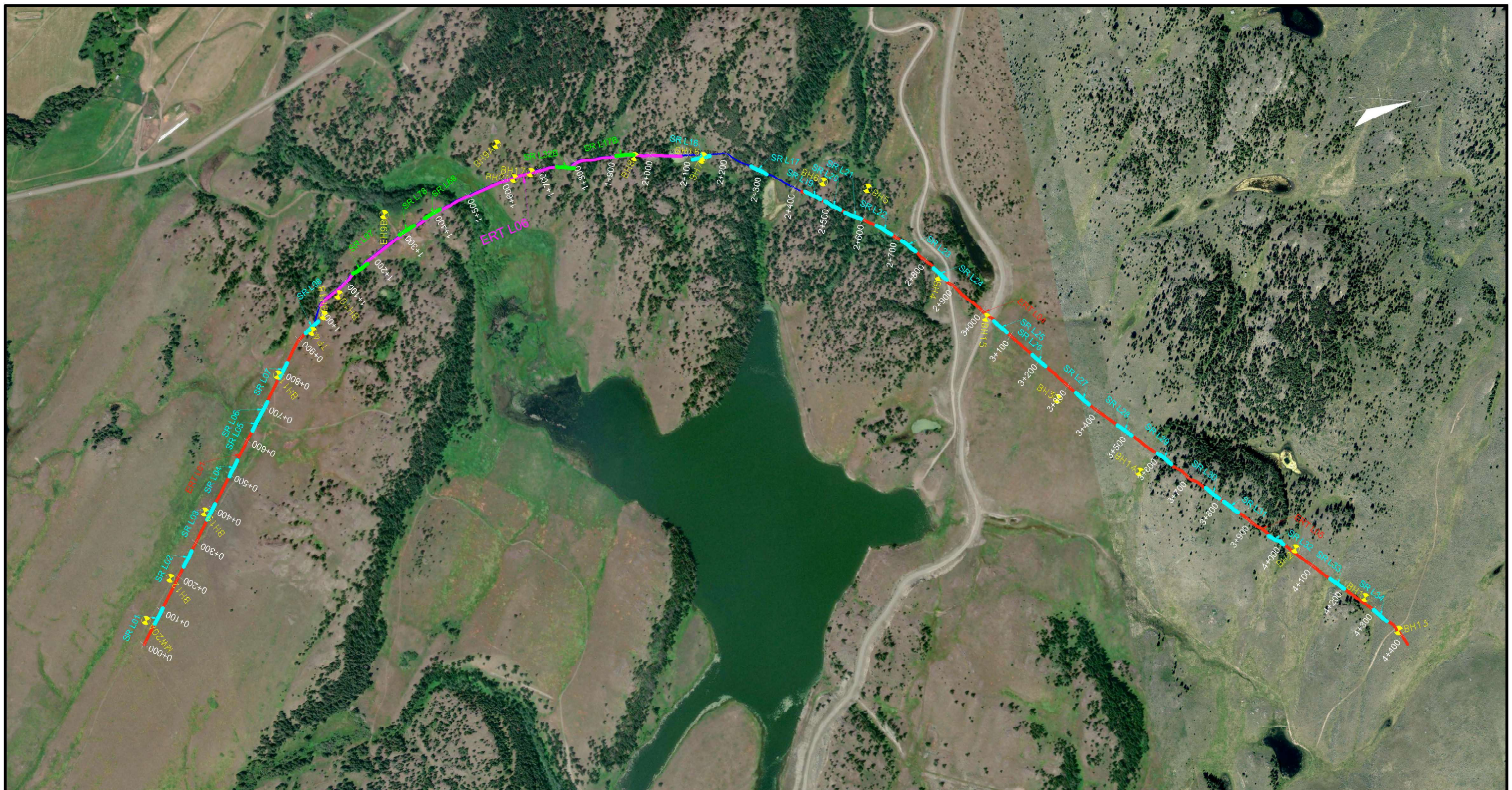
BACKFILL TYPE: GROUT

DEPTH (m)	SAMPLE TYPE	SAMPLE ID	Cpen (kPa) 50 100 150 200 / SPT/DCPT (N) Blows/300 mm 10 20 30 40 / PL W.C. (%) LL 10 20 30 40	REMARKS	VIBRATING WIRE	VIBRATING WIRE	MUSCS / ISRM	Soil Symbol	DESCRIPTION	ELEVATION (m)
50	Rock Core	RC-28 TCR = 100% SCR = 61% RQD = 59%							DIORITE (continued)	
51	Rock Core	RC-29 TCR = 100% SCR = 68% RQD = 56%								885
52										884
53	Rock Core	RC-30 TCR = 100% SCR = 40% RQD = 22%								883
54	Rock Core	RC-31 TCR = 100% SCR = 39% RQD = 28%							-broken core from 54.37 m to 54.43 m -clay infill along joint surfaces from 54.68 m to 54.78 m	882
55										881
56									END OF HOLE at 55.40 m UPON COMPLETION: - Two vibrating wire piezometers installed (S/N 138411 at 7.50 m and S/N 132067 at 50.00 m) - backfilled with grout from termination depth to surface WATER LEVEL BELOW GROUND SURFACE: S/N 138411: -December 9, 2021 = 2.4 m -December 11, 2021 = 2.6 m -December 13, 2021 = 2.6 m -January 29, 2022 = 2.6 m -March 26, 2022 = 1.8 m -April 7, 2022 = 1.8 m -May 17, 2022 = 2.0 m -May 30, 2022 = 2.1 m S/N 132067: -December 9, 2021 = 50.0 m -December 11, 2021 = 50.5 m -December 13, 2021 = 50.0 m -January 29, 2022 = 50.0 m -March 26, 2022 = 50.0 m -April 7, 2022 = 50.0 m -May 17, 2022 = 50.0 m -May 30, 2022 = 50.0 m	880
57										879
58										878
59										877
60										

THURBER ENGINEERING LTD.	DRILLING CO.: Mud Bay Drilling	FIELD LOGGED BY: GS	COMPLETION DEPTH: 55.4 m
	RIG TYPE: Track	PREPARED BY: NFR	COMPLETION DATE: 2021-12-05
	DRILL METHOD: Auger/ODEX/Coring	REVIEWED BY: SM	Page 6 of 6

Appendix D

Surface Search Geophysics Figures



GENERAL DRAWING NOTES:

1. The geologic profile descriptions shown on this drawing are derived from geophysical data analysis and interpretations made by Surface Search Inc. of the Electrical Resistivity Tomography (ERT) and Seismic Refraction (SR) inversion model results obtained at the TMEP Jacko Lake re-route investigation site.

2. The geophysics data used to create the stratigraphy model as shown in this drawing were acquired from June 15 - 24 and December 02 - 03, 2021.

3. Users of this information should be aware that actual ground conditions may differ from those depicted on this drawing due to limitations associated with interpreting the geophysical results. These limitations include: 1) measurement equivalence of geophysical response where differing geologic materials exhibit similar or near identical data measurement values e.g. similar electrical resistivity values and/or seismic velocity values); 2) 3-Dimensional, or out-of-plane data distortions associated with complex lateral changes in geologic conditions at depth; and 3) Data resolution limitations where thin layer sequences may not have been detected at depth in the geophysical results.

4. Ground surface profile elevations as shown are taken from 1m LiDAR data provided by Thurber.

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PROJECT NO: 21318	SURVEY: 2021 GEOPHYSICS PROGRAM
DRAWING NO: 21318BX-01	DRAWING SET: 1 of 6
ROUTE VERSION:	PLAN PROJECTION: UTM NAD 83 ZONE 10 U
DRAWN BY: JC/PT	DATE: JUNE 16, 2022

CLIENT: THURBER ENGINEERING LTD.

OWNER CLIENT: TRANSMOUNTAIN

DRAWING PREPARED BY:

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PROJECT:

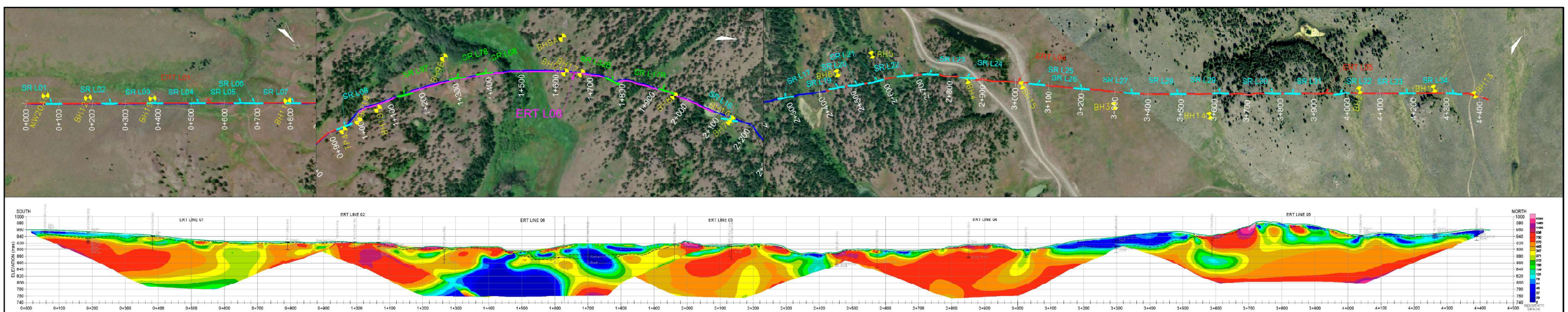
TRANS MOUNTAIN EXPANSION PROJECT

LOCATION: Jacko Lake, British Columbia

DRAWING TITLE:

PLAN MAP SHOWING THE LOCATIONS OF THE ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) AND SEISMIC REFRACTION (SR) LINES RELATIVE TO GEOTECHNICAL BOREHOLE LOCATIONS AT THE TMEP JACKO LAKE RE-ROUTE INVESTIGATION SITE.

ADDITIONAL LINES ACQUIRED IN DECEMBER 2021: ERT LINE 06 (SHOWN AS PURPLE LINE) AND SR LINES 17B, 32B, 68, 78 AND 97 (SHOWN AS GREEN LINES). CHAINAGE SHOWN FOLLOWING NEW ALIGNMENT (THROUGH SR LINE 06). ORIGINAL ALIGNMENT SHOWN IN BEIGE.



GENERAL DRAWING NOTES:

1. The geologic profile descriptions shown on this drawing are derived from geophysical data analysis and interpretations made by Surface Search Inc. of the Electrical Resistivity Tomography (ERT) and Seismic Refraction (SR) inversion model results obtained at the TMEP Jacko Lake ... investigation site.

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PROJECT NO.: 21318	SURVEY: 2021 GEOPHYSICS PROGRAM	PROJECT:	**TRANS MOUNTAIN EXPANSION PROJECT**
DRAWING NO.: 21318BX-02	DRAWING SET: 2 of 6		
ROUTE VERSION:	PLAN PROJECTION: UTM NAD 83 ZONE 10 U	LOCATION:	Jacko Lake, British Columbia
DRAWN BY: JC/PT	DATE: JUNE 16, 2022		

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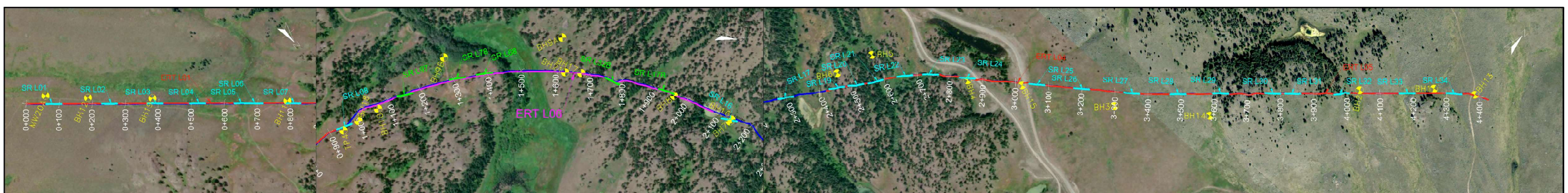
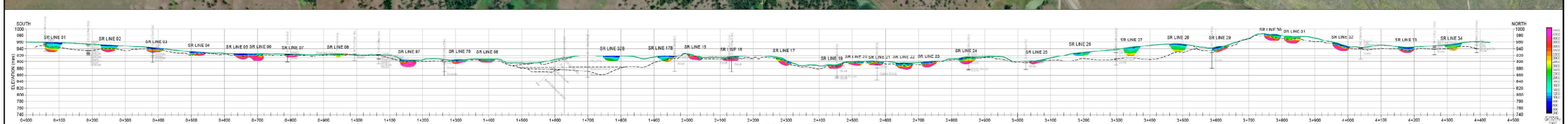
DRAWING TITLE:

PLAN MAPS SHOWING SECTIONS OF THE ERT/SR SURVEY LAYOUT (TOP PANELS) AND ELECTRICAL RESISTIVITY TOMOGRAPHY (ERT) INVERSION MODEL RESULTS BENEATH ERT LINES 01 THROUGH 06 (BOTTOM PANEL). CHAINAGE AND GROUND TOPOGRAPHY ARE EDITED TO REFLECT NEW ALIGNMENT FOLLOWING ERT LINE 06.





GENERAL DRAWING NOTES:

1. The geologic profile descriptions shown on this drawing are derived from geophysical data analysis and interpretations made by Surface Search Inc. of the Electrical Resistivity Tomography (ERT) and Seismic Refraction (SR) inversion model results acquired at the TMEP Jacko Lake reroute investigation site.

2. The geophysics data used to create the stratigraphy model as shown in this drawing were acquired from June 15 - 24 and December 02 - 03, 2021.

3. Users of this information should be aware that actual ground conditions may differ from those depicted on this drawing due to limitations associated with interpreting the geophysical results. These limitations include: 1) measurement equivalence of geophysical response where differing geologic materials exhibit similar or near identical data measurement values, e.g. similar electrical resistivity values and/or seismic velocity values; 2) 3-Dimensional, or out-of-plane data distortions associated with complex lateral changes in geologic conditions at depth; and 3) Data resolution limitations where thin layer sequences may not have been detected at depth in the geophysical results.

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PROJECT NO.: 21318	SURVEY: 2021 GEOPHYSICS PROGRAM	PROJECT: **TRANS MOUNTAIN EXPANSION PROJECT**
DRAWING NO.: 21318BX-03	DRAWING SET: 3 of 6	
ROUTE VERSION:	PLAN PROJECTION: UTM NAD 83 ZONE 10 U	LOCATION: Jacko Lake, British Columbia
DRAWN BY: JC/PT	DATE: JUNE 16, 2022	

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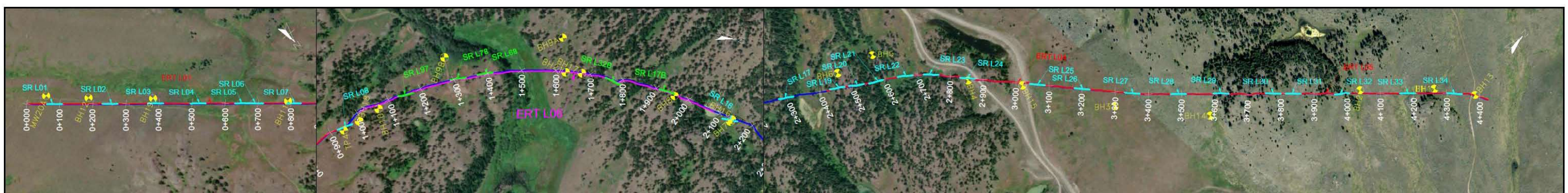
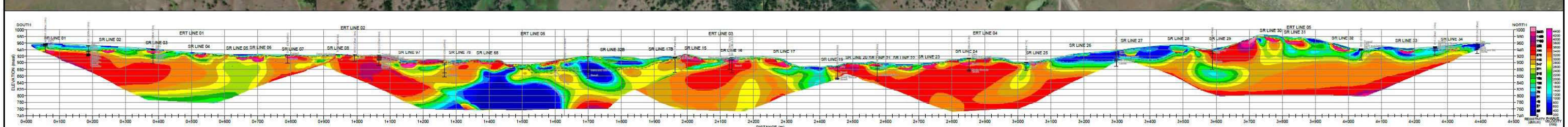
DRAWING TITLE:

PLAN MAPS (TOP PANELS) SHOWING SECTIONS OF THE ERT/SR SURVEY LAYOUT AND SEISMIC REFRACTION (SR) INVERSION MODEL RESULTS (BOTTOM PANEL) BENEATH SR LINES 01 THROUGH 34 AND NEWLY ACQUIRED SR LINES 17B, 32B, 68, 78 AND 92. NEWLY ACQUIRED SR LINES ARE SHOWN AS GREEN LINES ON THE PLAN MAP.





GENERAL DRAWING NOTES:

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2. The geophysics data used to create the stratigraphy model as shown in this drawing were acquired from June 15 - 24 and December 02 - 03, 2021.

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PROJECT NO.: 21318	SURVEY: 2021 GEOPHYSICS PROGRAM
DRAWING NO.: 21318BX-04	DRAWING SET: 4 of 6
ROUTE VERSION:	PLAN PROJECTION: UTM NAD 83 ZONE 10 U
DRAWN BY: JC/PT	DATE: JUNE 16, 2022

PROJECT: TRANS MOUNTAIN EXPANSION PROJECT

LOCATION: Jacko Lake, British Columbia

CLIENT: THURBER ENGINEERING LTD.

OWNER CLIENT: TRANSMOUNTAIN

DRAWING PREPARED BY:

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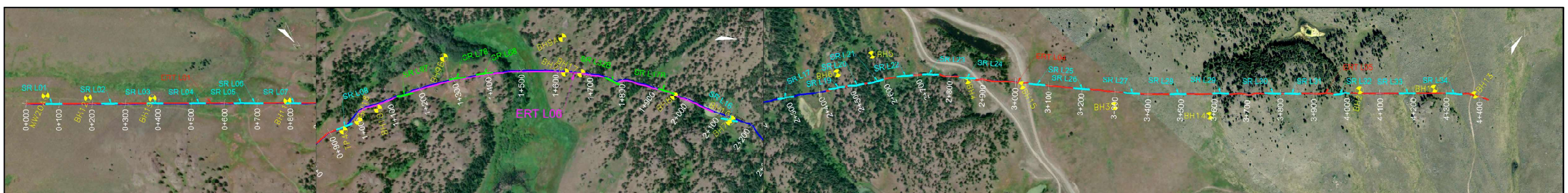
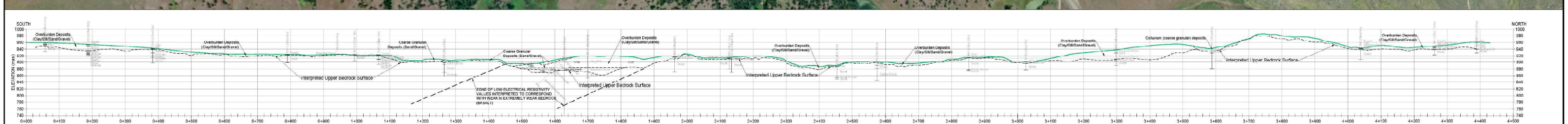
DRAWING TITLE:

PLAN MAPS SHOWING SECTIONS OF THE ERT/SR SURVEY LAYOUT (TOP PANELS) AND SR INVERSION MODEL RESULTS OVERLAID ON ERT INVERSION MODEL RESULTS (BOTTOM PANEL).





GENERAL DRAWING NOTES:

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PROJECT NO.: 21318	SURVEY: 2021 GEOPHYSICS PROGRAM
DRAWING NO.: 21318BX-05	DRAWING SET: 5 of 6
ROUTE VERSION:	PLAN PROJECTION: UTM NAD 83 ZONE 10 U
DRAWN BY: JC/PT	DATE: JUNE 16, 2022

PROJECT: **TRANS MOUNTAIN EXPANSION PROJECT**

LOCATION: Jacko Lake, British Columbia

CLIENT: THURBER ENGINEERING LTD.

OWNER/CLIENT: TRANSMOUNTAIN

DRAWING PREPARED BY:

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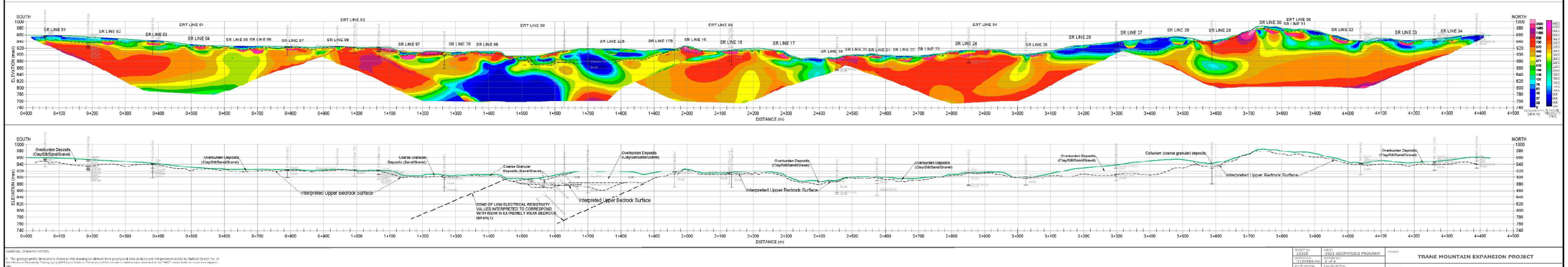
DRAWING TITLE:

PLAN MAPS SHOWING SECTIONS OF THE ERT/SR SURVEY LAYOUT (TOP PANELS) AND OUR INTERPRETATION OF SUBSURFACE FEATURES ALONG THE SURVEYED PROFILE (NEW ALIGNMENT FOLLOWING ERT LINE 06) (BOTTOM PANEL).



GENERAL DRAWING NOTES:

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PROJECT NO.: 21318	SURVEY: 2021 GEOPHYSICS PROGRAM
DRAWING NO.: 21318BX-06	DRAWING SET: 6 of 6
ROUTE VERSION:	PLAN PROJECTION: UTM NAD 83 ZONE 10 U
DRAWN BY: JC/PT	DATE: JUNE 16, 2022

PROJECT: **TRANS MOUNTAIN EXPANSION PROJECT**

LOCATION: Jacko Lake, British Columbia

THURBER ENGINEERING LTD.

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DRAWING PREPARED BY:

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DRAWING TITLE:

ERT AND SR INVERSION MODEL RESULTS (TOP PANEL) AND OUR INTERPRETATION OF SUBSURFACE FEATURES ALONG THE SURVEYED PROFILE (BOTTOM PANEL).

THURBER

Appendix E

Sonic Soil Recovery (SH21-5A-19-TEL-JL-KP851+931) and Rock Core Photos

THURBER

PHOTO 1 TEL-JL-BH2 RUN 1 to 3 (6.39 to 10.34 m)

PHOTO 2 TEL-JL-BH2 RUN 4 to 6 (10.34 to 14.9 m)

PHOTO 3 TEL-JL-BH2 RUN 7 to 9 (14.9 to 19.46 m)

PHOTO 4 TEL-JL-BH2 RUN 10 to 12 (19.46 to 24.02 m)

PHOTO 5 TEL-JL-BH2 RUN 13 to 15 (24.02 to 28.58 m)

PHOTO 6 TEL-JL-BH2 RUN 16 to 18 (28.58 to 33.14 m)

PHOTO 7 TEL-JL-BH14 RUN 1-3 (8.98 to 12.84 m)

PHOTO 8 TEL-JL-BH14 RUN 4-6 (12.84 to 17.40 m)

PHOTO 9 TEL-JL-BH14 RUN 7-9 (17.40 to 21.96 m)

THURBER

PHOTO 10 TEL-JL-BH14 RUN 10-12 (21.96 to 26.52 m)

PHOTO 11 TEL-JL-BH14 RUN 13-15 (26.52 to 31.08 m)

PHOTO 12 TEL-JL-BH14 RUN 16-18 (31.08 to 35.64 m)

PHOTO 13 TEL-JL-BH14 RUN 19-21 (35.64 to 40.20 m)

PHOTO 14 TEL-JL-BH14 RUN 22-24 (40.20 to 44.72 m)

PHOTO 15 TEL-JL-BH14 RUN 25-27 (44.72 to 49.30 m)

PHOTO 16 TEL-JL-BH14 RUN 28-30 (49.30 to 53.88 m)

PHOTO 17 TEL-JL-BH14 RUN 31 (53.88 to 55.40 m)

PHOTO 1 TEL-JL-BH2 RUN 1 (0 to 2.13 m)

PHOTO 2 TEL-JL-BH2 RUN 2 to 3 (2.13 to 5.18 m)

PHOTO 3 TEL-JL-BH2 RUN 4 (5.18 to 6.17 m)