



THURBER ENGINEERING LTD.

Preliminary Foundation Investigation Report High Fill Embankments, Deep Cuts, Swamp Crossing and Culverts

**Highway 17, Westbound Truck Climbing Lane and Realignment
Little Pic River Bridge Westerly for 4.5 km
Marathon, Ontario**

G.W.P. 6132-17-00, GEOCRES No. 42D15-001

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**PRELIMINARY FOUNDATION INVESTIGATION REPORT
HIGH FILL EMBANKMENTS, DEEP CUTS, SWAMP CROSSING, AND CULVERTS
HIGHWAY 17 WESTBOUND TRUCK CLIMBING LANE AND REALIGNMENT
LITTLE PIC RIVER BRIDGE WESTERLY FOR 4.5 KM
MARATHON, ONTARIO
G.W.P. 6132-17-00**

GEOGRES No. 42D15-001

1. INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation for the proposed Highway 17 high fill embankments, deep cuts, swamp crossing and culverts required for widening and partial realignment of Highway 17 from west of the Little Pic River Bridge for 4.5 km westerly. The project is located west of Marathon in the Township of Walsh, within the Thunder Bay District, Ontario.

The proposed works are to accommodate a new approximately 3.4 km long westbound truck climbing lane and 1.1 km of curve flattening on Highway 17. The project will include construction of high fill embankments and deep cuts for both new alignment and widened portions of Highway 17, a portion of new high fill embankment crossing a swamp, and potential installation or replacement of several non-structural culverts.

In preparation for the field investigation, a preliminary geotechnical feasibility study was conducted to provide a generalized summary of the surficial and bedrock geology, potential foundation conditions, foundation recommendations for planning purposes and route selection, and to identify requirements for the scope of future subsurface investigations. The feasibility study was completed in December 2022. The final report was dated September 28, 2023 and is presented under a separate cover.

The purpose of this investigation was to explore the subsurface conditions along the proposed alignment of the high fill embankments, deep cuts and culverts, and based on the data obtained, to provide a borehole location plan, record of borehole sheets, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions.

Thurber carried out the assignment as a sub-consultant to BTE, under the Ministry of Transportation Ontario (MTO), Assignment No. 6020-E-0003.

It is a condition of this report that Thurber's performance of its professional services is subject to the attached Statement of Limitations and Conditions.

2. SITE DESCRIPTION

2.1 Existing Highway and Proposed Alignment

The existing Highway 17 within the project limits is a two-lane rural highway that extends from just west of the Little Pic River Bridge, a 225 m long bridge built approximately 55 m above the river height, crossing the steep Little Pic River Valley, and ends just east of an at-grade intersection at Dead Horse Road. The existing highway is surrounded by heavily wooded areas and is intersected by two hydro corridors which run approximately east-west. A wetland and two waterbodies are located to the south of the existing highway.

In general, the proposed highway alignment is underlain by bedrock of the Canadian Shield. The bedrock topography on site is described as rugged, knobby, cliffy and jagged. Bedrock hills along the existing and proposed alignments are divided by steep gullies. The low-lying basins between the bedrock hills generally contain small swampy areas and small seasonal watercourses or drainage pathways that typically flow towards the south.

The proposed widened highway alignment follows portions of the existing highway at approximate Sta. 16+756 to 17+360, Sta. 18+240 to 18+980, and Sta. 20+860 to 21+473, and includes new alignment sections at approximate Sta. 17+360 to 18+240 and Sta. 18+960 to 20+860. The widened highway portions typically consist of existing bedrock cut areas or high rock fill embankments that span steep valleys. The new alignment portions typically pass through rugged terrain including steep bedrock hills, low-lying areas, and a swamp.

Typical photographs of the proposed alignment are included in Appendix F.

2.2 Geology

In general, the study area is underlain by bedrock of the Canadian Shield. The geology is characterized by rolling to rugged, bedrock-controlled topography consisting of Precambrian bedrock that is bare or covered by a discontinuous thin layer of drift. Fine-textured glaciolacustrine sediment and organic deposits can also be found in low-lying areas including bedrock depressions or where water has accumulated.

The bedrock is comprised of three geological formations. Bedrock Geology of Ontario Map 2542 indicates the bedrock ranges from mafic to intermediate metavolcanic rocks (basaltic and

andesitic flows, etc.) near the west limit of the project area, to metasedimentary rocks (wacke, arkose, argillite, etc.) through the middle of the site, to carbonatite-alkalic intrusive suite rocks (syenite, nepheline, etc.) at the east portion of the site.

3. SITE INVESTIGATION AND FIELD TESTING

Following selection of the preferred project alignment by BTE and MTO in 2022 (see Appendix A, Drawing 1), the preliminary foundation investigation commenced in 2023. The scope of the preliminary foundation investigation consisted of advancing drilled boreholes, dynamic cone penetration tests (DCPTs), hand auger holes, and shovel probes at selected intervals along the proposed highway alignment where high fill embankments (fills of 4.5 m height or greater), deep cuts (cuts of 4.5 m deep or deeper), a swamp crossing, and potential culverts are planned. The investigation program consisting of a total of 28 boreholes (drilled or hand excavated) was based on review of the proposed highway plan, profile and cross section drawings provided by BTE, as well as site reconnaissance visits conducted by Thurber staff. Where the proposed works involve deep cut sections to widen the existing highway into existing exposed rock cuts, no boreholes were included for the preliminary investigation.

The site investigation and field testing were carried out in three mobilizations. Mobilization 1 was completed between March 28 and 30, 2023. Mobilization 2 was completed on May 11, 2023. Mobilization 3 was completed between July 18 and July 24, 2023. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings in Appendix A. The records of boreholes sheets are provided in Appendix B. The centreline of the proposed new alignment areas was staked and surveyed by TBT Surveyors Inc. (TBT). The borehole locations were established in the field based on measurements (stations and offset distances) from the staked centreline alignment. The horizontal coordinates and ground surface elevations at the borehole locations were established from the TBT survey data and topographic data provided by BTE. The coordinate system MTM NAD83, Zone 14 was used. Utility clearances were obtained prior to the start of drilling. The boreholes completed during this investigation, along with the investigation locations and assigned nomenclature are summarized in Table 3.1.

Table 3.1 Summary of Boreholes

Location and Assigned Nomenclature	Station	Foundation Boreholes
High Fill Area #1 (HF1)	17+515 to 17+540	Borehole: HF1-01
Deep Cut Area #1 (DC1)	17+580 to 17+960	Shovel Probe: DC1-01, DC1-02, DC1-03
High Fill Area #2 (HF2)	17+980 to 18+020	Shovel Probe: HF2-01, HF2-03 Borehole: HF2-02
Deep Cut Area #2 (DC2)	18+660 to 18+840	*
High Fill Area #3 (HF3)	19+150 to 19+180	Borehole: HF3-01
Swamp Area #1 (SW1)	19+180 to 19+430	Borehole: SW1-01, SW1-03, SW1-04, SW1-06, SW1-07 DCPT: SW1-02, SW1-05
Deep Cut Area #3 (DC3)	19+460 to 19+630	Shovel Probe: DC3-01
High Fill Area #4 (HF4)	19+640 to 19+710	Shovel Probe: HF4-01
Deep Cut Area #4 (DC4)	19+ 720 to 19+840	Shovel Probe: DC4-01
Culvert (CULV1)	19+980	Borehole: CULV1-01
Deep Cut Area #5 (DC5)	19+980 to 20+160	Hand Auger: DC5-01 Shovel Probe: DC5-02
High Fill Area #5 (HF5)	20+180 to 20+230	Hand Auger: HF5-01
Deep Cut Area #6 (DC6)	20+300 to 20+440	Shovel Probe: DC6-01, DC6-02
Deep Cut Area #7 (DC7)	20+550 to 20+720	Shovel Probe: DC7-01 Hand Auger: DC7-02
High Fill Area #6 (HF6)	20+760 to 20+860	Hand Auger: HF6-01 Borehole: HF6-02
Deep Cut Area #8 (DC8)	20+920 to 21+100	*
Deep Cut Area #9 (DC9)	21+260 to 21+360	*
Deep Cut Area #10 (DC10)	21+440 to 21+460	*

* Indicates no boreholes were completed in this section (for widening into existing rock cuts)

The drilled boreholes and DCPTs were advanced using truck and track-mounted drill rigs with hollow stem augers and NW casing, supplied and operated by Eastern Ontario Diamond Drilling of Hawkesbury, Ontario. The hand auger boreholes and shovel probes were conducted by Thurber's technical staff. Standard Penetration Testing (SPT) was carried out in the drilled boreholes in accordance with ASTM D1586 at selected depth intervals and to obtain soil samples. NQ coring methods were used to advance boreholes HF1-01, HF2-02, CULV-1 and HF6-02 through embankment rock fill and to collect core samples of the bedrock when encountered.

The field investigation was supervised on a full-time basis by members of Thurber's technical staff who directed the drilling, sampling and in-situ testing operations, conducted the hand auger boreholes and shovel probes, logged the boreholes, and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

The rock cores were logged, and the Total Core Recovery (TCR), Solid Core Recovery (SCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions were observed in the open boreholes throughout the drilling operation. A standpipe piezometer was installed in a selected borehole in the swamp area for additional measurement of the groundwater level at the site. The piezometer was decommissioned in general accordance with Ontario Regulation 903 as amended at the completion of the field investigation carried out during Mobilization 1. All other boreholes were decommissioned in general accordance with Ontario Regulation 903 as amended upon completion of drilling.

4. LABORATORY TESTING

The recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer), and Atterberg Limits testing where appropriate. Rock core samples were subject to Unconfined Compression Tests (UCS) and Point Load Testing. The laboratory test results are summarized on the Record of Borehole sheets included in Appendix B and the figures included in Appendices C and D.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the potential culverts, selected samples of the fill and native soil from four boreholes were collected for analytical testing. The samples were submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing are summarized in Section 5.5 and are presented in Appendix E.

5. DESCRIPTION OF SUBSURFACE CONDITIONS

Details of the subsurface conditions encountered during the foundation investigation are presented in the Record of Borehole sheets and the Borehole Locations and Soil Strata Drawings included in Appendices A and B.

A general description of the soil stratigraphy is given below. However, the factual data presented on the Record of Borehole sheets takes precedence over this general description and must be

used for interpretation of the site conditions. It should be recognized and expected that soil conditions may vary between and beyond borehole locations.

In general, the deep cut areas of the site consist of a typically very thin layer of topsoil overlying Precambrian Bedrock. The boreholes drilled on Highway 17 at the high fill embankment and culvert areas contain embankment rock fill overlying peat, native deposits of sand or clayey silt to silty clay, and/or bedrock. The boreholes in the swamp crossing area contained a thick layer of peat overlying sand and possible bedrock.

5.1 Swamp Area (SW1)

Five (5) boreholes (SW1-01, SW1-03, SW1-04, SW1-06, and SW1-07) and two (2) DCPTs (SW1-02 and SW1-05) were advanced to depths ranging from 0.5 to 8.5 m (Elev. 288.2 to 270.7 m) along the proposed highway alignment between Sta. 19+180 to Sta 19+430, which contains a low-lying area characterized as a swamp. Although not observed during the borehole investigation, which was drilled during snow cover conditions, the swamp area appears to receive surface water flow from the northeast, which subsequently flows to a waterbody to the southwest. Existing topographic mapping indicates that a watercourse may cross below the existing Highway 17 to the northeast of the swamp; however, the presence of a watercourse or existing culvert was not readily apparent during the investigation. The boreholes and visual observations indicated that the portion of the swamp area within the proposed right-of-way is approximately 80 m long (extending from approximate Sta. 19+340 to 19+420), and that the swamp appears to be longer to the southwest of the proposed alignment. Boreholes SW1-01 to SW1-03 were drilled at higher ground elevations (Elev. 288.9 to 283.8 m) to the north of the low-lying swamp area. Boreholes SW1-04 to SW1-07 were drilled within the swamp at ground elevations ranging from Elev. 279.5 to 279.2 m.

The soil conditions encountered generally consist of a variable thickness of peat, overlying sand to silty sand and possible bedrock.

5.1.1 Peat

Peat was encountered at the ground surface in each of Boreholes SW1-01 to SW1-07. The peat thickness ranged from 0.2 to 0.3 m in Boreholes SW1-01 and SW1-03 (base Elev. from 288.5 to 283.6 m), and from 2.2 to 4.6 m in Boreholes SW1-04 to SW1-07 (base Elev. 277.0 to 274.7 m). The peat thickness may vary between and beyond the boreholes. The peat is described as fibrous, with some roots.

SPT 'N' values recorded within the peat ranged from 0 (weight of hammer) to 5 blows per 0.3 m penetration, indicating that the peat is very loose to loose. Natural moisture contents of samples of the peat ranged from 114 to 1473%.

5.1.2 Sand to Silty Sand

A native deposit ranging in composition from sand to silty sand was encountered below the peat. The sand to silty sand deposit generally contained trace silt to silty, trace clay, and trace to some gravel and became gravelly near the underlying anticipated bedrock surface. In Boreholes SW1-01 and SW1-03, the sand to silty sand deposit was 0.3 to 4.5 m thick and extended to depths from 0.6 to 4.7 m (Elev. 288.2 to 279.1 m). The DCPT at SW1-02 was terminated at a depth of 0.5 m (Elev. 284.6 m) upon refusal on inferred bedrock. In Boreholes SW1-04, SW1-06, and SW1-07, the sand to silty sand deposit was 0.4 to 3.9 m thick and extended to depths from 3.3 m to 8.5 m (Elev. 275.9 to 270.7 m). The DCPTs at SW1-05 and the base of SW1-07 were terminated at depths of 4.3 to 8.5 m (Elev. 275.1 to 207.7 m) upon refusal on inferred bedrock. All boreholes were terminated within the sand to silty sand deposit upon auger refusal on inferred bedrock, except for Borehole SW1-06, where the sand unit was penetrated at a depth of 3.3 m (Elev. 276.2 m), overlying a gravel layer.

SPT 'N' values recorded within the sand to silty sand deposit typically ranged from 16 to greater than 50 blows per 0.3 m penetration, indicating that the density ranges from compact to very dense. Lower SPT 'N' values from 0 (weight of hammer) to 5 blows per 0.3 m of penetration were recorded in Borehole SW1-07, where sand blowback inside the augers was noted, and may have contributed to the very loose to loose density of the sand to silty sand at this borehole. The SPT 'N' values of greater than 50 blows per 0.3 m of penetration at the base of Boreholes SW1-03 and SW1-04 were due to split spoon refusal on possible bedrock.

The natural moisture content of samples of the sand to silty sand ranged from 5 to 28%.

The results of grain size analyses conducted on samples of the sand to silty sand are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C3 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Silty Sand	Sand
Gravel	11 to 15	5
Sand	53 to 65	92
Silt	24	-
Clay	8	-
Silt and Clay	24	3

5.1.3 Gravel

A 0.2 m thick layer of gravel with some sand and some silt was encountered underlying the silty sand in Borehole SW1-06 at a depth of 3.3 m (Elev. 276.2 m). The base of the gravel was encountered at a depth of 3.5 m (Elev. 276.0 m) where auger refusal on possible bedrock was encountered. An SPT 'N' value of 50 blows per 0.1 m penetration was recorded in the gravel due

to split spoon refusal on possible bedrock. The measured natural moisture content of the gravel was 12%.

The results of a grain size analysis conducted on a sample of the gravel are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C5 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
	Gravel
Gravel	76
Sand	11
Silt and Clay	13

5.1.4 Inferred Bedrock

All boreholes were terminated by reaching auger or DCPT refusal at depths ranging from 0.5 to 8.5 m (Elev. 288.2 to 270.7 m) upon encountering the possible bedrock surface.

5.2 High Fill and Culvert Areas

Ten (10) boreholes (HF1-01, HF2-01 to 03, HF3-01, HF4-01, HF5-01, HF6-01 to 02, and CULV-01) were advanced along six (6) high fill embankment sections and near one existing CSP culvert along the proposed alignment. Four (4) boreholes, HF1-01, HF2-02, HF6-02 and CULV-01 were drilled through the existing Highway 17 embankment to depths ranging from 8.9 to 19.6 m (Elev. 280.1 to 250.2 m). The remaining six (6) boreholes were advanced along new alignment high fill (off-road) areas by hollow stem augers, hand augers or shovel probes to depths ranging from 0.1 to 2.1 m (Elev. 293.1 to 264.1 m).

The soil conditions encountered along the new alignment areas generally consist of a thin layer of topsoil or peat directly overlying bedrock or a thin sand layer. The boreholes drilled on the highway were advanced through asphalt and granular fill, overlying the embankment rock fill material. Below the fill materials, peat and native deposits of sand, silt and clay were encountered overlying the Precambrian bedrock.

5.2.1 Pavement Structure

A 100 to 150 mm thick layer of asphalt was encountered at the ground surface at all road boreholes (HF1-01, HF2-02, CULV-01, and HF6-02). The asphalt was underlain by gravelly sand to sand and gravel granular fill in all boreholes.

The gravelly sand to sand and gravel fill was encountered directly below the asphalt and ranged in thickness from 0.6 to 1.4 m. The base of the granular fill was encountered at depths ranging

from 0.8 to 1.5 m (Elev. 287.8 to 268.9 m). The granular material was brown and contained trace silt to silty and occasional cobbles.

SPT 'N' values recorded within the granular fill ranged 39 to 88 blows per 0.3 m penetration, indicating that the fill ranges from dense to very dense. Natural moisture contents ranged from 3 to 9%.

The results of grain size analyses conducted on samples of the granular fill are provided on the Record of Borehole sheets in Appendix B, and illustrated in Figure C1 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Gravelly Sand	Sand and Gravel
Gravel	34	37 to 46
Sand	57	37 to 54
Silt and Clay	9	9 to 17

Locally, a layer of silty sand fill with trace gravel was observed below the granular material in Borehole CULV-01 from a depth of 1.4 to 2.0 m (Elev. 283.8 to 283.2 m). The SPT "N" value recorded in the dense silty sand fill was 33 blows per 0.3 m of penetration. The natural moisture content was measured as 7%.

5.2.2 Rock Fill

The granular fill was underlain by rock fill, which composed the embankment. The rock fill generally contained cobbles, boulders, some gravelly sand, and trace silt to silty. Typically, the boreholes were advanced by rock coring through this layer, but SPTs were taken between the cobbles and boulders. Boulders in the rock fill ranged in diameter from 200 to 300 mm.

The thickness of the rock fill encountered in the boreholes ranged from 3.2 to 12.1 m and extended to depths from 5.2 to 13.0 m (Elev. 280.1 to 256.8 m) below the road surface. Borehole HF2-02 was terminated at the base of the rock fill upon encountering the top of a previously unidentified wooden culvert at a depth of 9.1 m (Elev. 280.1 m).

SPT 'N' values recorded in the rock fill typically ranged from 12 to 78 blows per 0.3 m penetration. Additional SPT 'N' values of 50 blows per 0.15 m penetration were recorded throughout the rock fill, where the SPT reached refusal on possible boulders or cobbles. The results of the SPT testing generally indicated that the rock fill ranged from compact to very dense. One SPT 'N' value in Borehole HF6-02 was recorded as 7 blows per 0.3 m of penetration, indicating that occasional loose zones may exist in the rock fill between the boulders and cobbles.

Natural moisture contents typically ranged from 1 to 21% in the rock fill, and up to 37% where silty zones were encountered.

The results of grain size analyses conducted on samples of the rock fill are provided on the Record of Borehole sheets in Appendix B and illustrated in Figure C2 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	15 to 72
Sand	16 to 65
Silt and Clay	7 to 31

5.2.3 Topsoil

Topsoil was encountered at the ground surface in the off-road boreholes (HF2-01, HF4-01, HF5-01, and HF6-01). The topsoil thickness ranged from 25 mm to 150 mm at the borehole locations. The moisture content in the topsoil was measured as 146% in a sample from Borehole HF6-01. The topsoil thickness may vary between and beyond the boreholes.

5.2.4 Peat

Native peat was encountered below the embankment rock fill at depths of 5.2 and 13.0 m (Elev. 280.0 and 256.8 m) below the road surface in Boreholes CULV-01 and HF6-02, respectively. The peat was 0.7 m thick in both boreholes, and the base was encountered at depths of 5.9 and 13.7 m below the road surface (Elev. 279.3 and 256.1 m). The peat was described as fibrous, with occasional sand seams present in Borehole HF6-02.

Peat was also observed at the ground surface in Boreholes HF2-03 and HF3-01. The peat layer extended to depths of 0.3 and 0.9 m (Elev. 293.1 and 279.2 m).

The measured natural moisture content of the peat ranged from 110 to 410%, typically higher in the surficial deposits. Two SPT 'N' values were recorded in the peat, 7 blows per 0.3 m of penetration (loose) and 10 blows per 0.1 m of penetration, which was terminated due to refusal on possible bedrock in Borehole HF3-01.

5.2.5 Sand

A sand layer was encountered below the peat in Boreholes HF2-03 and CULV-01. The composition of the sand layer ranged from sand with some silt, trace clay and trace gravel to gravelly sand with some silt to silty and trace clay. The thickness of the sand layer ranged from 0.7 to 1.2 m, with the base encountered at depths of 2.1 and 6.6 m below the ground surface (Elev. 278.0 and 278.6 m), where it overlies possible bedrock in Borehole HF2-03 and confirmed bedrock in Borehole CULV-01.

An SPT 'N' value recorded in the gravelly sand layer in Borehole CULV-01 was 23 blows per 0.3 m penetration, indicating a compact density. The natural moisture content of the sand ranged from 10 to 54%.

The results of grain size analyses conducted on samples of the sand and gravelly sand are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C3 and C4 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	1 to 32
Sand	43 to 86
Silt and Clay	25
Silt	10
Clay	3

5.2.6 Clayey Silt to Silty Clay

A deposit of clayey silt to silty clay with trace sand was encountered underlying the peat deposit in Borehole HF6-02 at a depth of 13.7 m (Elev 256.1 m). The deposit was approximately 5.9 m thick, based on DCPT refusal on possible bedrock at a depth of 19.6 m (Elev. 250.2 m) below the roadway, where the borehole was terminated.

SPT 'N' values recorded in the clayey silt to silty clay ranged from 14 to 21 blows per 0.3 m penetration, indicating a stiff to very stiff consistency. The natural moisture content ranged from 21 to 29%.

The results of grain size analyses conducted on samples of the clayey silt to silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C6 and C7 of Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Clayey Silt	Silty Clay
Gravel	0	0
Sand	3	3
Silt	81	57
Clay	16	40

The results of the Atterberg Limits tests conducted on samples of the clayey silt to silty clay are provided on the Record of Borehole sheets in Appendix B and illustrated in Figures C8 and C9 of Appendix C. The results are summarized as follows:



Index Property	Percentage (%)	
	Clayey Silt	Silty Clay
Liquid Limit	21	31
Plastic Limit	18	18
Plasticity Index	3	13

The results of the Atterberg Limits testing indicate the clayey silt and silty clay have low plasticity, with group symbols of ML and CL respectively.

5.2.7 Bedrock and Inferred Bedrock

Proven and inferred bedrock was encountered underlying the overburden soils in all boreholes (except for Borehole HF2-02) in the high fill embankment areas, which was either confirmed by rock coring or inferred by drill refusal or DCPT refusal. The bedrock depth ranged from 0.03 to 2.1 m (Elev. 293.1 to 264.1 m) in the off-road boreholes and from 5.7 to 19.6 m (Elev. 278.6 to 250.2 m) in the on-road boreholes.

Bedrock was confirmed by coring 3.2 and 3.6 m in Boreholes HF1-01 and CULV-01, which were terminated at depths of 8.9 and 10.2 m (Elev. 263.3 and 275.0 m), respectively.

The bedrock encountered in Borehole HF1-01 was described as a grey meta-volcanic (mafic to intermediate in composition), which was slightly weathered. The bedrock encountered at Borehole CULV-01 was described as a grey syenite, which was fresh.

The Fracture index (FI), measured as the total number of fractures per 0.3 m of rock core length, was typically between 0 and 2 for the syenite and between 0 and 8 for the metavolcanic, with >greater than 10 in localized zones in both rock types. Total Core Recovery (TCR) values measured on recovered bedrock samples ranged from 78 to 100%, with the majority of the TCR values between 98 to 100%. Solid Core Recovery (SCR) values ranged from 56 to 100% (average of 82%). Rock Quality Designation (RQD) values varied from 0 to 95% with most values exceeding 50% indicating typically fair to excellent quality (average of 65%).

Two Uniaxial Compressive Strength (UCS) tests were completed on the rock core samples from each borehole. The results of the testing indicate that the metavolcanic UCS ranges from 106 to 112 MPa, and the Syenite UCS ranges from 109 to 172 MPa. Additional estimated rock strength values were interpreted from point load tests conducted on the rock cores. The average UCS values per core run from the point load tests ranged from 189 to greater than 245 MPa for the metavolcanic rock, and from 226 to 241 MPa for the syenite. The UCS and point load test results indicate that the bedrock is very strong. The results of the UCS tests and photographs of the rock core samples are presented in Appendix D.

5.3 Deep Cut Areas

Eleven (11) boreholes (DC1-01 to 03, DC3-01, DC4-01, DC5-01 to 02, DC6-01 to 02, and DC7-01 to 02) were advanced along six (6) deep cut sections along the proposed alignment of Highway 17. The soil conditions encountered typically consist of a layer of topsoil overlying shallow bedrock. The boreholes were all located off-road and advanced by shovel probe or hand auger.

No boreholes were advanced at deep cut sections DC2, DC8, DC9 or DC10, where visual observation confirmed the presence of exposed bedrock where Highway 17 is proposed to be widened into existing rock cut areas.

5.3.1 Topsoil

Topsoil was encountered at the ground surface in all deep cut boreholes except for Boreholes DC1-02 and DC1-03 where bedrock was exposed. Where encountered, the topsoil thickness ranged from 25 to 325 mm at the borehole locations. The topsoil was underlain by possible bedrock at all locations. The natural moisture content of two samples of the topsoil ranged from 17 to 43%. The topsoil thickness may vary between and beyond the boreholes.

5.3.2 Bedrock

All boreholes were terminated by reaching hand auger or shovel probe refusal upon possible bedrock at depths ranging from 0 m (exposed bedrock at ground surface) to 0.3 m (Elev. 303.8 to 272.0 m).

5.4 Groundwater Conditions

A standpipe piezometer was installed in Borehole SW1-04 to measure the groundwater level in the swamp area. Groundwater conditions were also observed in the open boreholes throughout the drilling operation. The measured groundwater levels are summarized in Table 5.1 below.

Table 5.1 Groundwater Measurements

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
SW1-04	March 29, 2023	3.0	276.2	Standpipe Piezometer
	March 29, 2023	1.3	277.9	
	March 30, 2023	- 0.6	279.8	
SW1-07	March 30, 2023	0.5	278.7	Open Borehole

Slight artesian pressure was noted in Borehole SW1-04, resulting in a standpipe piezometer water level measurement that was slightly above the ground surface.

Additional unstabilized water level readings ranging from 1.4 to 3.2 m below the ground surface were measured in Boreholes SW1-03 and SW1-06 following completion of drilling. Due to the short-term nature of the water level measurements, they may not reflect the stabilized water level in the swamp area, which was generally observed to be near the ground surface or near the top of the peat.

Representative groundwater readings could not be practically recorded at the drilled boreholes through the Highway 17 embankment due to the introduction of water for advancing the drilling by wash boring and rock coring techniques. The groundwater level is anticipated to lie near the base of the highway embankment or near the top of the peat where encountered in the high fill and culvert areas. No groundwater was observed where thin topsoil overlying shallow bedrock was encountered at the hand auger or shovel probe boreholes in high fill and deep cut areas.

The groundwater levels above are short-term readings and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation after periods of significant or prolonged precipitation.

5.5 Corrosivity and Sulphate Test Results

Two (2) samples of the native soils and two (2) samples of the granular fill soils were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are summarized in Table 5.2 below and the laboratory certificates of analysis are presented in Appendix E.

Table 5.2 Corrosivity Test Results

Parameter	Units	HF6-02 SS15 (55'-57')	HF2-02 SS1 (4"-2'4")	CULV-01 SS1 (6"-2'6")	SW1-07A SS7A (20'-21'8")
		Native Silty Clay, 16.8 – 17.4 m	Gravelly Sand Fill, 0.1 – 0.7 m	Gravelly Sand Fill, 0.2 – 0.8 m	Native Sand, 6.1 – 6.6 m
Redox Potential	mV	147	195	282	220
Resistivity	Ohms.cm	3150	1930	1690	3560
Chloride	µg/g	94	130	140	21
Sulphate	µg/g	42	21	35	64
Sulphide	%	< 0.04	< 0.04	< 0.04	< 0.04
Conductivity	µS/cm	317	519	591	281
pH	-	8.60	9.31	9.17	8.46



THURBER ENGINEERING LTD.

6. CLOSURE

The field investigation was supervised on a full-time basis by Mr. Ian Ross, E.I.T., Mr. Jakob Flood, and Ms. Rachel Bourassa, E.I.T. of Thurber. Overall supervision of the field program was provided by Ms. Rachel Bourassa, E.I.T.

Geotechnical laboratory testing was carried out at Thurber's geotechnical laboratory. Analytical testing was carried out by SGS Canada Inc.

Interpretation of the field data and report preparation was carried out by Ms. Rachel Bourassa, E.I.T., and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.

Rachel Bourassa, E.I.T.
Geotechnical Engineering Intern



Mark Farrant, P.Eng.
Associate, Senior Geotechnical Engineer



Date: December 6, 2023
File: 29771

P.K. Chatterji, P.Eng.
Principal, Designated MTO Contact

STATEMENT OF LIMITATIONS AND CONDITIONS

1. STANDARD OF CARE

This Report has been prepared in accordance with generally accepted engineering or environmental consulting practices in the applicable jurisdiction. No other warranty, expressed or implied, is intended or made.

2. COMPLETE REPORT

All documents, records, data and files, whether electronic or otherwise, generated as part of this assignment are a part of the Report, which is of a summary nature and is not intended to stand alone without reference to the instructions given to Thurber by the Client, communications between Thurber and the Client, and any other reports, proposals or documents prepared by Thurber for the Client relative to the specific site described herein, all of which together constitute the Report.

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The Report has been prepared for the specific site, development, design objectives and purposes that were described to Thurber by the Client. The applicability and reliability of any of the findings, recommendations, suggestions, or opinions expressed in the Report, subject to the limitations provided herein, are only valid to the extent that the Report expressly addresses proposed development, design objectives and purposes, and then only to the extent that there has been no material alteration to or variation from any of the said descriptions provided to Thurber, unless Thurber is specifically requested by the Client to review and revise the Report in light of such alteration or variation.

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5. INTERPRETATION OF THE REPORT

- a) Nature and Exactness of Soil and Contaminant Description: Classification and identification of soils, rocks, geological units, contaminant materials and quantities have been based on investigations performed in accordance with the standards set out in Paragraph 1. Classification and identification of these factors are judgmental in nature. Comprehensive sampling and testing programs implemented with the appropriate equipment by experienced personnel may fail to locate some conditions. All investigations utilizing the standards of Paragraph 1 will involve an inherent risk that some conditions will not be detected and all documents or records summarizing such investigations will be based on assumptions of what exists between the actual points sampled. Actual conditions may vary significantly between the points investigated and the Client and all other persons making use of such documents or records with our express written consent should be aware of this risk and the Report is delivered subject to the express condition that such risk is accepted by the Client and such other persons. Some conditions are subject to change over time and those making use of the Report should be aware of this possibility and understand that the Report only presents the conditions at the sampled points at the time of sampling. If special concerns exist, or the Client has special considerations or requirements, the Client should disclose them so that additional or special investigations may be undertaken which would not otherwise be within the scope of investigations made for the purposes of the Report.
- b) Reliance on Provided Information: The evaluation and conclusions contained in the Report have been prepared on the basis of conditions in evidence at the time of site inspections and on the basis of information provided to Thurber. Thurber has relied in good faith upon representations, information and instructions provided by the Client and others concerning the site. Accordingly, Thurber does not accept responsibility for any deficiency, misstatement or inaccuracy contained in the Report as a result of misstatements, omissions, misrepresentations, or fraudulent acts of the Client or other persons providing information relied on by Thurber. Thurber is entitled to rely on such representations, information and instructions and is not required to carry out investigations to determine the truth or accuracy of such representations, information and instructions.
- c) Design Services: The Report may form part of design and construction documents for information purposes even though it may have been issued prior to final design being completed. Thurber should be retained to review final design, project plans and related documents prior to construction to confirm that they are consistent with the intent of the Report. Any differences that may exist between the Report's recommendations and the final design detailed in the contract documents should be reported to Thurber immediately so that Thurber can address potential conflicts.
- d) Construction Services: During construction Thurber should be retained to provide field reviews. Field reviews consist of performing sufficient and timely observations of encountered conditions in order to confirm and document that the site conditions do not materially differ from those interpreted conditions considered in the preparation of the report. Adequate field reviews are necessary for Thurber to provide letters of assurance, in accordance with the requirements of many regulatory authorities.

6. RELEASE OF POLLUTANTS OR HAZARDOUS SUBSTANCES

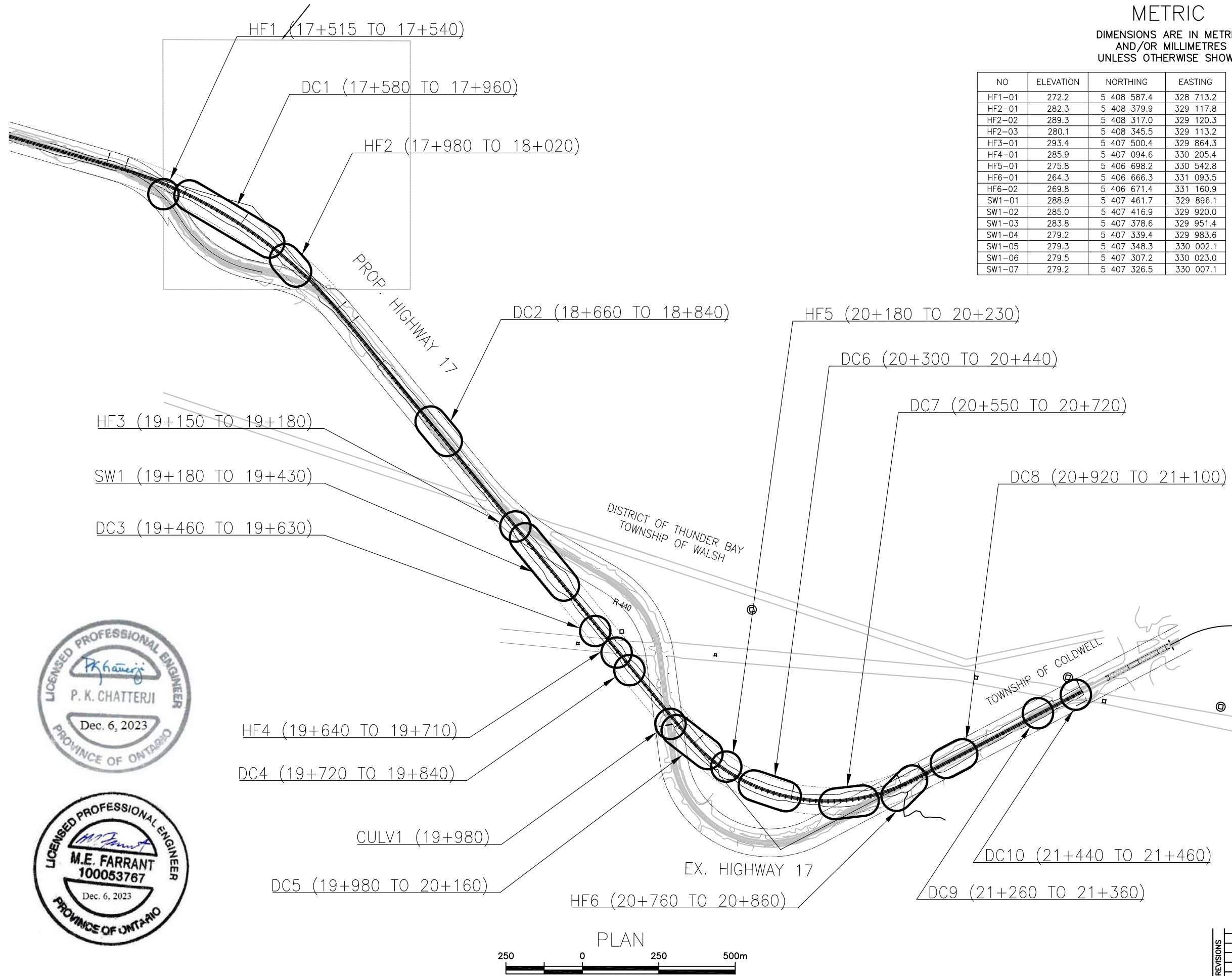
Geotechnical engineering and environmental consulting projects often have the potential to encounter pollutants or hazardous substances and the potential to cause the escape, release or dispersal of those substances. Thurber shall have no liability to the Client under any circumstances, for the escape, release or dispersal of pollutants or hazardous substances, unless such pollutants or hazardous substances have been specifically and accurately identified to Thurber by the Client prior to the commencement of Thurber's professional services.

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APPENDIX A

Borehole Locations and Soil Strata Drawings



METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

NO	ELEVATION	NORTHING	EASTING
HF1-01	272.2	5 408 587.4	328 713.2
HF2-01	282.3	5 408 379.9	329 117.8
HF2-02	289.3	5 408 317.0	329 120.3
HF2-03	280.1	5 408 345.5	329 113.2
HF3-01	293.4	5 407 500.4	329 864.3
HF4-01	285.9	5 407 094.6	330 205.4
HF5-01	275.8	5 406 698.2	330 542.8
HF6-01	264.3	5 406 666.3	331 093.5
HF6-02	269.8	5 406 671.4	331 160.9
SW1-01	288.9	5 407 461.7	329 896.1
SW1-02	285.0	5 407 416.9	329 920.0
SW1-03	283.8	5 407 378.6	329 951.4
SW1-04	279.2	5 407 339.4	329 983.6
SW1-05	279.3	5 407 348.3	330 002.1
SW1-06	279.5	5 407 307.2	330 023.0
SW1-07	279.2	5 407 326.5	330 007.1

CONT No
GWP No.6132-17-00

HIGHWAY 17
WESTBOUND TRUCK CLIMBING
LANE AND REALIGNMENT
SITE PLAN



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CULV-01	285.2	5 406 854.8	330 371.7
DC1-01	272.3	5 408 583.1	328 798.3
DC1-02	303.8	5 408 519.2	328 944.4
DC1-03	301.2	5 408 419.1	329 051.8
DC3-01	296.9	5 407 177.6	330 148.8
DC4-01	293.9	5 407 043.1	330 252.9
DC5-01	298.2	5 406 853.1	330 415.5
DC5-02	301.7	5 406 748.8	330 485.9
DC6-01	295.0	5 406 653.4	330 644.6
DC6-02	293.0	5 406 618.5	330 748.7
DC7-01	293.8	5 406 612.9	330 907.1
DC7-02	291.5	5 406 623.6	330 999.8

-NOTES-







- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D15-001

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RB	CHK	RB
DRAWN	MC	CHK	MEF
CODE		SITE	
LOAD		STRUCT	
DATE	DEC	DWG	1



LEGEND

	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
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DC1-02	303.8	5 408 519.2	328 944.4
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HF2-01	282.3	5 408 379.9	329 117.8
HF2-02	289.3	5 408 317.0	329 120.3
HF2-03	280.1	5 408 345.5	329 113.2

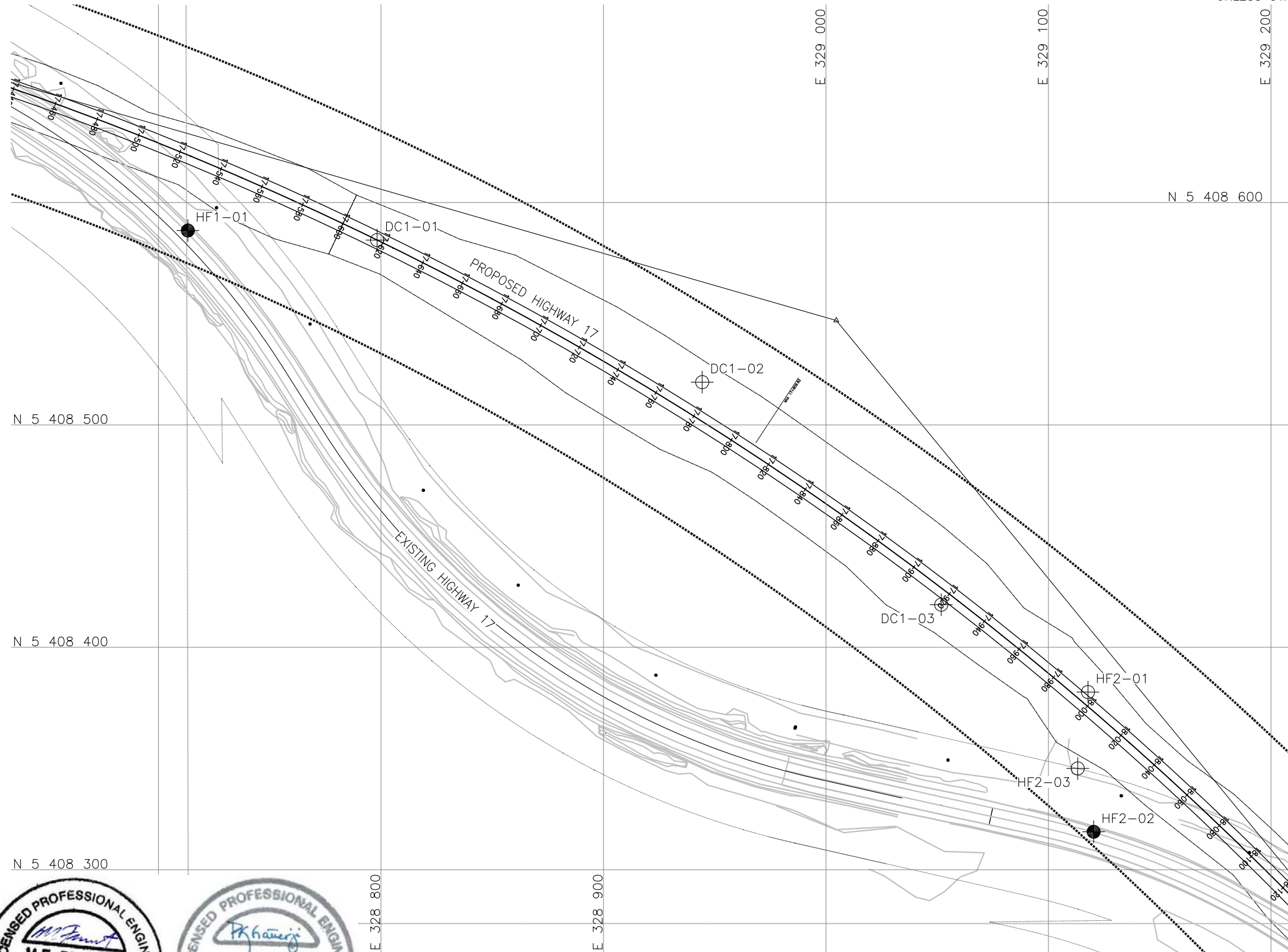
-NOTES-

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GEOCRES No. 42D15-001

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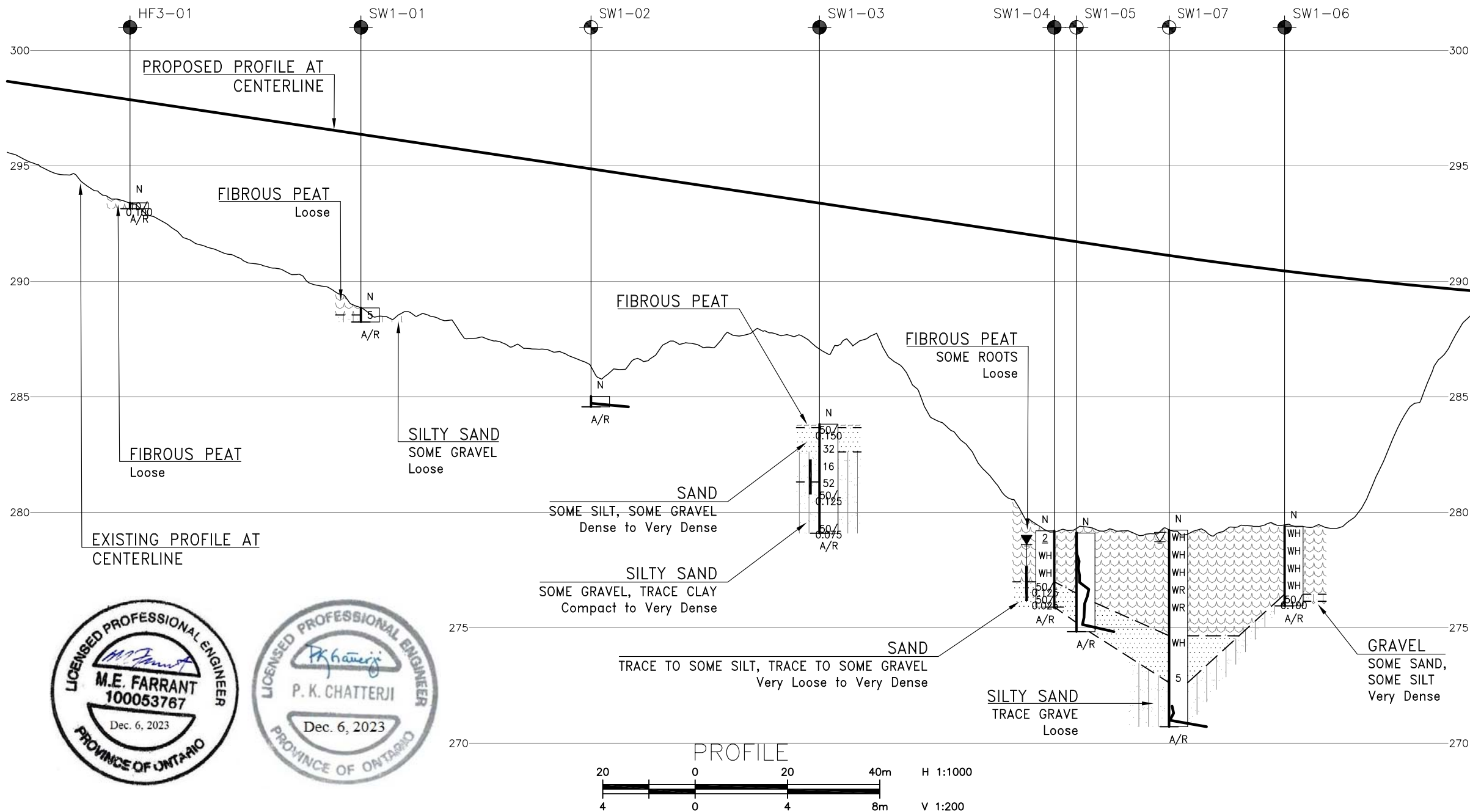
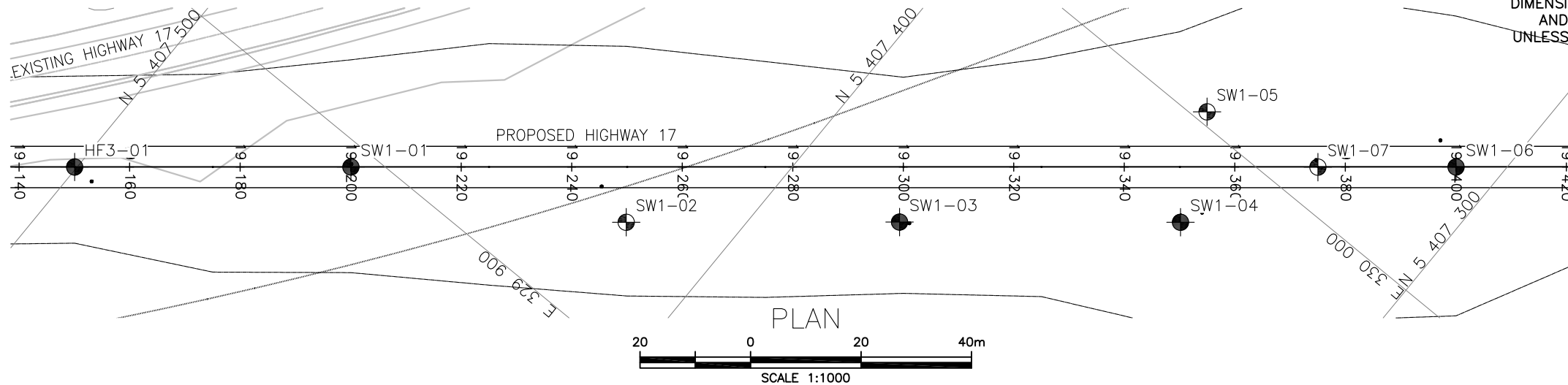
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CONT No
GWP No.6132-17-00

HIGH FILL AREA 3
SWAMP AREA 1



SHEET

BOREHOLE LOCATIONS AND SOIL STRATA



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
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GEOCRES No. 42D15-001







REVISIONS	DATE	BY	DESCRIPTION
DESIGN	RB	CHK RB	CODE
DRAWN	MC	CHK MEF	SITE
LOAD		STRUCT	
DATE	DEC 2023	DWG	3





KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
DC3-01	296.9	5 407 177.6	330 148.8
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GEOCRES No. 42D15-001

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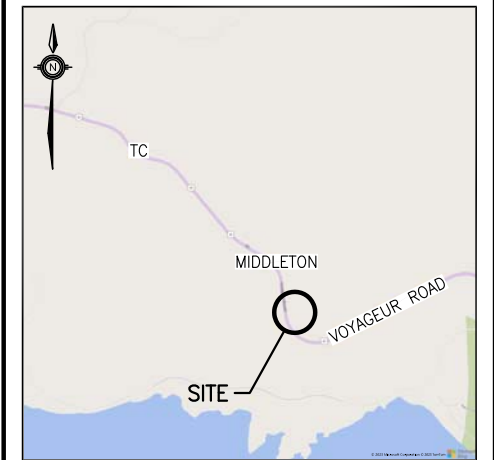
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AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No.6132-17-00



CULVERT 1
DEEP CUT AREA 5
HIGH FILL AREA 5
BOREHOLE LOCATIONS

SHEET



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CULV-01	285.2	5 406 854.8	330 371.7
DC5-01	298.2	5 406 853.1	330 415.5
DC5-02	301.7	5 406 748.8	330 485.9
HF5-01	275.8	5 406 698.2	330 542.8

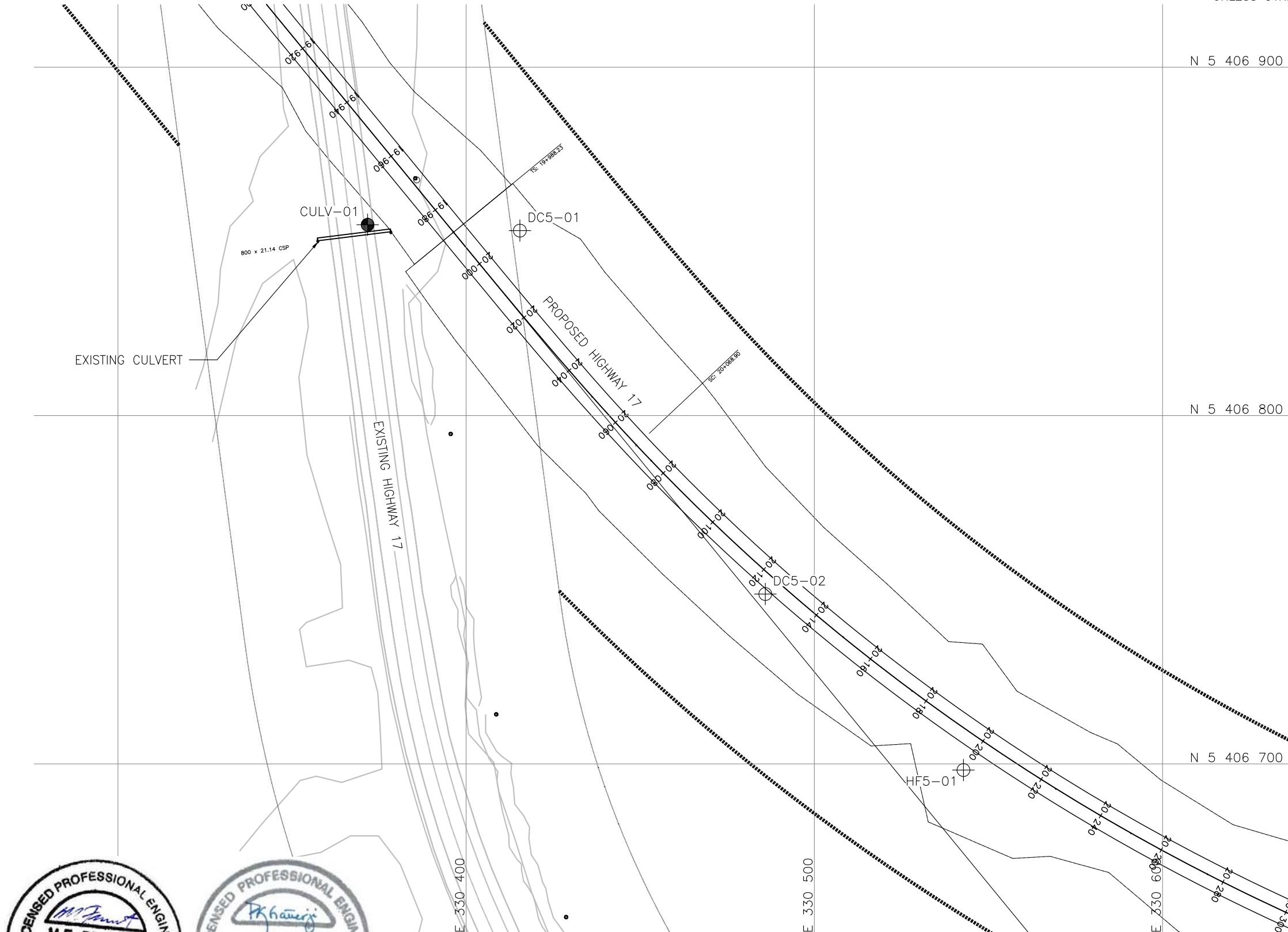
-NOTES-

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- Coordinate system is MTM NAD 83 Zone 14.

GEOCRES No. 42D15-001

REVISIONS					
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PLAN





KEYPLAN

LEGEND

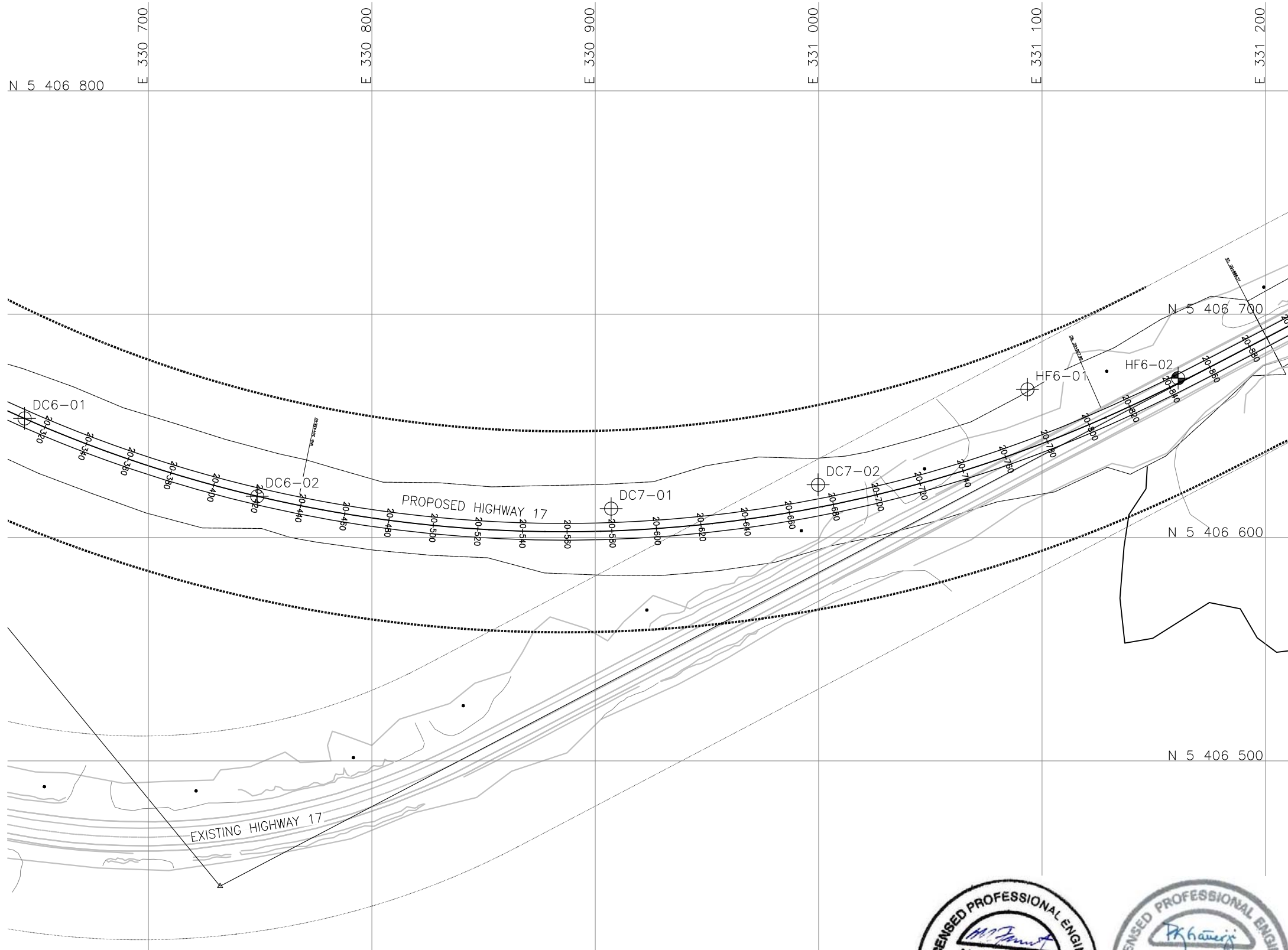
	Borehole
	Borehole and Cone
	Hand Auger / Shovel Probe
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
	Water Level Upon Completion of Drilling
	Water Level in Monitoring Well/Piezometer
	Monitoring Well/Piezometer Screen
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
DC6-01	295.0	5 406 653.4	330 644.6
DC6-02	293.0	5 406 618.5	330 748.7
DC7-01	293.8	5 406 612.9	330 907.1
DC7-02	291.5	5 406 623.6	330 999.8
HF6-01	264.3	5 406 666.3	331 093.5
HF6-02	269.8	5 406 671.4	331 160.9

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GEOCRES No. 42D15-001



PLAN

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APPENDIX B

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$


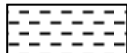



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

<u>ROCK WEATHERING CLASSIFICATION</u>		<u>SYMBOLS</u>	
Fresh (FR)	No visible signs of weathering.		
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		CLAYSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SILTSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		SANDSTONE
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		COAL
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		Bedrock (general)

<u>DISCONTINUITY SPACING</u>		<u>STRENGTH CLASSIFICATION</u>			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

<u>TERMS</u>	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No CULV-01

1 OF 2

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+970 O/S 18R N 5 406 854.8 E 330 371.7 ORIGINATED BY JF
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2023.07.18 - 2023.07.18 LATITUDE 48.799559 LONGITUDE -86.651885 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
285.2	GROUND SURFACE												
0.0	ASPHALT:(150mm)												
0.2	Gravelly SAND , trace silt, occasional cobbles Very Dense to Dense Brown Moist (FILL)		1	SS	68								
			2	SS	39								
283.8													
1.4	Silty SAND , trace gravel Dense Brown Moist (FILL)		3	SS	33								
283.2													
2.0	ROCKFILL , with cobbles and boulders (approx. 200 to 300mm diameter), some gravelly sand, trace silt to silty Dense to Compact Brown Moist to Wet (FILL)		4	SS	31								
	Cored through blasted rockfill from 2.0m to 2.6m		5	SS	27								
	Cored through blasted rockfill from 4.0m to 4.6m												
280.0			6	SS	29								
5.2	PEAT , fibrous Loose Dark Brown Wet		7	SS	7								
279.3													
5.9	Gravelly SAND , some silt to silty, trace clay Compact Grey Moist		8	SS	23								
278.6													
6.6	BEDROCK (SYENITE) , grey, fresh, very strong		1	RUN									
	Rubble zone from 7.5 to 7.6m and 8.5 to 8.6m		2	RUN									
	Sub-vertical fractures from 7.6 to 7.8m and 8.4 to 8.5m												
			3	RUN									

Continued Next Page

+³, ×³: Numbers refer to Sensitivity
15 20 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No CULV-01

2 OF 2

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+970 O/S 18R N 5 406 854.8 E 330 371.7 ORIGINATED BY JF
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2023.07.18 - 2023.07.18 LATITUDE 48.799559 LONGITUDE -86.651885 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
275.0							275										
10.2	END OF BOREHOLE AT 10.2m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.2m, GRAVEL TO 0.1m, THEN COLD PATCH TO SURFACE.																

RECORD OF BOREHOLE No DC1-01

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 17+617 CL N 5 408 583.1 E 328 798.3 ORIGINATED BY RB
DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN
DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.815165 LONGITUDE -86.673202 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
272.3	GROUND SURFACE																
0.0	TOPSOIL: (300mm)																
272.0																	
0.3	SHOVEL PROBE TERMINATED ON POTENTIAL BEDROCK AT 0.3m.																

METRIC

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RECORD OF BOREHOLE No DC4-01

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+750 O/S 10L N 5 407 043.1 E 330 252.9 ORIGINATED BY RB
DIST Thunder Bay HWY 17 BOREHOLE TYPE Shovel Probe COMPILED BY AN
DATUM Geodetic DATE 2023.05.11 - 2023.05.11 LATITUDE 48.801258 LONGITUDE -86.653490 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
293.9	GROUND SURFACE																
0.0	TOPSOIL: (325mm)																
293.6																	
0.3	SHOVEL PROBE TERMINATED AT 0.3m UPON REFUSAL ON POSSIBLE BEDROCK.																

RECORD OF BOREHOLE No DC5-01

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 20+000 O/S 15L N 5 406 853.1 E 330 415.5 ORIGINATED BY JF
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN
DATUM Geodetic DATE 2023.07.20 - 2023.07.20 LATITUDE 48.799542 LONGITUDE -86.651289 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)					
298.2	GROUND SURFACE													
0.0	TOPSOIL: (75mm)													
0.1	HAND AUGER TERMINATED AT 0.1m UPON REFUSAL ON POSSIBLE BEDROCK.													

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SOIL PROFILE						SAMPLES			<div>DYNAMIC CONE PENETRATION RESISTANCE PLOT SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE WATER CONTENT (%) </div>	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE				
295.0	GROUND SURFACE										
0.0	TOPSOIL: (50mm) SHOVEL PROBE TERMINATED AT 0.0m UPON REFUSAL ON POSSIBLE BEDROCK.										

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RECORD OF BOREHOLE No HF1-01

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 17+540 O/S 31R N 5 408 587.4 E 328 713.2 ORIGINATED BY JF
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring COMPILED BY AN
DATUM Geodetic DATE 2023.07.21 - 2023.07.22 LATITUDE 48.815207 LONGITUDE -86.674361 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
272.2	GROUND SURFACE							20 40 60 80 100					
0.0	ASPHALT: (150mm)						272						
0.2	SAND and GRAVEL, trace silt Very Dense Brown Moist (FILL)		1	SS	88								37 54 9 (SI+CL)
271.4													
0.8	ROCKFILL, with cobbles and boulders (approx. 200 to 300mm diameter), trace sand Very Dense Brown Moist (FILL)		2	SS	51		271						
	Coring from 0.8m to 5.7m No recovery												
			3	SS	50/ 0.150		270						
	No recovery						269						
			4	SS	50/ 0.150		268						
	No recovery						267						
			5	SS	50/ 0.150								
266.5													
5.7	BEDROCK (METAVOLCANIC), slightly weathered, grey, very strong		1	RUN			266						RUN #1 TCR=100% SCR=91% RQD=69% UCS=201MPa (Point Load) UCS=112.2MPa
	Sub-vertical to vertical fractures from 6.0 to 6.2m, 6.4 to 6.5m, 6.6 to 6.7m, 6.8 to 6.9m, 7.0 to 7.1m, 8.7 to 8.8m and 8.9 to 9.0m		2	RUN									RUN #2 TCR=78% SCR=56% RQD=0% UCS=188MPa
	Highly fractured at 6.5m		3	RUN									RUN #3 TCR=100% SCR=73% RQD=73% UCS=189MPa
							265						
			4	RUN									RUN #4 TCR=100% SCR=92% RQD=47% UCS>=245MPa (Point Load) UCS=105.6MPa
							264						RUN #5 TCR=88% SCR=88% RQD=88%
263.3			5	RUN									UCS=182MPa
8.9	END OF BOREHOLE AT 8.9m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.2m, GRAVEL TO 0.1m, THEN COLD PATCH TO SURFACE.												

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(%) STRAIN AT FAILURE

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SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					GR	SA	SI	CL
289.3	GROUND SURFACE																			
0.0	ASPHALT: (100mm)																			
0.1	Gravelly SAND, trace silt Very Dense Light Brown		1	SS	82															
288.5	Moist (FILL)																			
0.8	SAND and GRAVEL, trace silt, some cobbles Dense Black to Reddish Brown		2	SS	50															
287.8	Moist (FILL)																			
1.5	ROCKFILL, with cobbles and boulders (approx. 200 to 300mm diameter), trace to some sand, trace silt Very Dense to Dense Brown and Grey Moist (FILL) No recovery Coring from 2.9m to 3.8m		3	SS	57															
			4	SS	-															
			5	SS	53															
			6	SS	78															
	Coring from 4.2m to 4.8m																			
			7	SS	43															
			8	SS	50															
	No recovery		9	SS	50															
	No recovery		10	SS	50															
	End of borehole at 9.1m upon encountering top of wooden culvert at 8.5m. Borehole continued by hand auger at toe of embankment beside culvert (refer to HF2-03)																			
280.1																				
9.2	END OF BOREHOLE AT 9.2m. BOREHOLE BACKFILLED WITH BENTONITE TO 0.2m, GRAVEL TO 0.1m, THEN COLD PATCH TO SURFACE.																			

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+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No HF2-03

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 18+015 O/S 24R N 5 408 345.5 E 329 113.2 ORIGINATED BY JF
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY AN
DATUM Geodetic DATE 2023.07.20 - 2023.07.20 LATITUDE 48.813016 LONGITUDE -86.668929 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
280.1	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT Dark Brown Wet		1	GS			280									410 110	
279.2																	
0.9	SAND, some silt, trace clay, trace gravel, some organics Brown Wet		2	GS			279										
	Hand auger terminated at 2.1 m on possible bedrock or boulders.		3	GS													1 86 10 3
278.0																	
2.1	END OF BOREHOLE AT 2.1m.																

RECORD OF BOREHOLE No HF3-01

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+150 CL N 5 407 500.4 E 329 864.3 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN
DATUM Geodetic DATE 2023.03.28 - 2023.03.28 LATITUDE 48.805386 LONGITUDE -86.658753 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
							20	40	60	80	100						
							20	40	60	80	100						
293.4	GROUND SURFACE																
0.0	PEAT, fibrous		1	SS	10/												
293.1	Loose																
0.3	Black				0.100												
	Wet																
	Auger refusal at 0.25m																
	END OF BOREHOLE AT 0.3m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																

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RECORD OF BOREHOLE No HF6-02

1 OF 3

METRIC

GWP# 6132-17-00 LOCATION Sta. 20+845 O/S 2L N 5 406 671.4 E 331 160.9 ORIGINATED BY JF
DIST Thunder Bay HWY 17 BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test (DCPT) COMPILED BY AN
DATUM Geodetic DATE 2023.07.22 - 2023.07.24 LATITUDE 48.797877 LONGITUDE -86.641153 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
269.8	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT: (125mm)																			
0.1	SAND and GRAVEL, silty to some silt, occasional cobbles Very Dense Brown Moist (FILL)		1	SS	51															
268.9			2	SS	86															
0.9	ROCKFILL, with cobbles and boulders (approx. 200 to 300mm diameter), some sand, trace silt, occasional pockets of sand and gravel Compact to Very Dense Brown and Grey Moist (FILL) Cored from 2.0m to 3.1m		3	SS	32															
			4	SS	12															
	Cored from 3.2m to 4.6m		5	SS	50/ 0.150															
			6	SS	50/ 0.150															
	Cored from 6.1 to 7.0m																			
			7	SS	23															
	Cored from 8.2m to 9.5m																			
			8	SS	26															
			9	SS	50/ 0.0															
			10	SS	14															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

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(%) STRAIN AT FAILURE

METRIC

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

METRIC

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RECORD OF BOREHOLE No SW1-01

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+200 CL N 5 407 461.7 E 329 896.1 ORIGINATED BY IR
 DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN
 DATUM Geodetic DATE 2023.03.28 - 2023.03.28 LATITUDE 48.805037 LONGITUDE -86.658322 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
288.9	GROUND SURFACE							20	40	60	80	100					
0.0	PEAT, fibrous																
288.5	Loose		1	SS	5												
0.3	Black																
288.2	Wet																
0.6	Silty SAND, some gravel																
	Loose																
	Grey																
	Wet																
	END OF BOREHOLE AT 0.61m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																

RECORD OF BOREHOLE No SW1-02

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+250 O/S 10R N 5 407 416.9 E 329 920.0 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT) COMPILED BY AN
DATUM Geodetic DATE 2023.03.28 - 2023.03.28 LATITUDE 48.804633 LONGITUDE -86.657999 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
285.0	GROUND SURFACE																
0.0	DCPT from surface																
284.6	DCPT REFUSAL AT 0.5m UPON POSSIBLE BEDROCK.																
0.5																	

RECORD OF BOREHOLE No SW1-03

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+300 O/S 10R N 5 407 378.6 E 329 951.4 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN
DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.804287 LONGITUDE -86.657574 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT 7 kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)											
283.8	GROUND SURFACE							20	40	60	80	100		W _p	W	W _L	GR	SA	SI	CL			
0.0	PEAT, fibrous (150mm)		1	SS	50/ 0.150																		
0.2																							
	SAND, some silt, some gravel Dense to Very Dense Reddish Brown Moist		2	SS	32		283																
282.6																							
	Silty SAND, some gravel, trace clay Compact to Very Dense Reddish Brown Moist																						
1.2																							
					3	SS	16		282														
					4	SS	52		281														
	Becoming gravelly, with occasional cobbles from 3.1 to 4.6,		5	SS	50/ 0.125		280																
279.1	Auger refusal at 4.7m		6	SS	50/ 0.075																		
4.7	END OF BOREHOLE AT 4.7m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																						

+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No SW1-04

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+350 O/S 10R N 5 407 339.4 E 329 983.6 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN
DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.803933 LONGITUDE -86.657138 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
279.2	GROUND SURFACE							20 40 60 80 100						
0.0	PEAT , fibrous, some roots Very Loose Dark Brown Wet		1	SS	2		279						548	
			2	SS	WH		278						861	
			3	SS	WH								468	
277.0							277							
2.2	SAND , some gravel to gravelly, some silt Very Dense Grey Wet		4	SS	50/ 0.125									
			5	SS	50/ 0.025									
275.9	Auger refusal at 3.3m						276							
3.3	END OF BOREHOLE AT 3.3m ON AUGER REFUSAL ON POSSIBLE BEDROCK. Well installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2023.03.29 3.0 276.2 2023.03.29 1.3 277.9 2023.03.30 -0.6 279.8													

RECORD OF BOREHOLE No SW1-05

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+355 O/S 10L N 5 407 348.3 E 330 002.1 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Dynamic Cone Penetration Test (DCPT) COMPILED BY AN
DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.804013 LONGITUDE -86.656886 CHECKED BY RB

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%) PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w _p w w _L				
279.3	GROUND SURFACE												
0.0	DCPT from surface												

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RECORD OF BOREHOLE No SW1-06

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+400 CL N 5 407 307.2 E 330 023.0 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY AN
DATUM Geodetic DATE 2023.03.29 - 2023.03.29 LATITUDE 48.803642 LONGITUDE -86.656604 CHECKED BY RB

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa												
279.5	GROUND SURFACE							20	40	60	80	100								
0.0	PEAT , fibrous Very Loose Black Wet		1	SS	WH		279													
			2	SS	WH														784	
			3	SS	WH														603	
			4	SS	WH		277											302		
276.5																				
2.9	Silty SAND , trace gravel Loose Dark Grey Wet																			
276.2																				
276.0			5	SS	50/ 0.100															
276.0	GRAVEL , some sand, some silt Very Dense Grey Wet Auger refusal at 3.5m END OF BOREHOLE AT 3.5m UPON AUGER REFUSAL ON POSSIBLE BEDROCK. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																			
3.5																				

ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-29771.GPJ 10-5-23

RECORD OF BOREHOLE No SW1-07

1 OF 1

METRIC

GWP# 6132-17-00 LOCATION Sta. 19+375 CL N 5 407 326.5 E 330 007.1 ORIGINATED BY IR
DIST Thunder Bay HWY 17 BOREHOLE TYPE Hollow Stem Auger/Dynamic Cone Penetration Test (DCPT) COMPILED BY AN
DATUM Geodetic DATE 2023.03.30 - 2023.03.30 LATITUDE 48.803816 LONGITUDE -86.656819 CHECKED BY RB

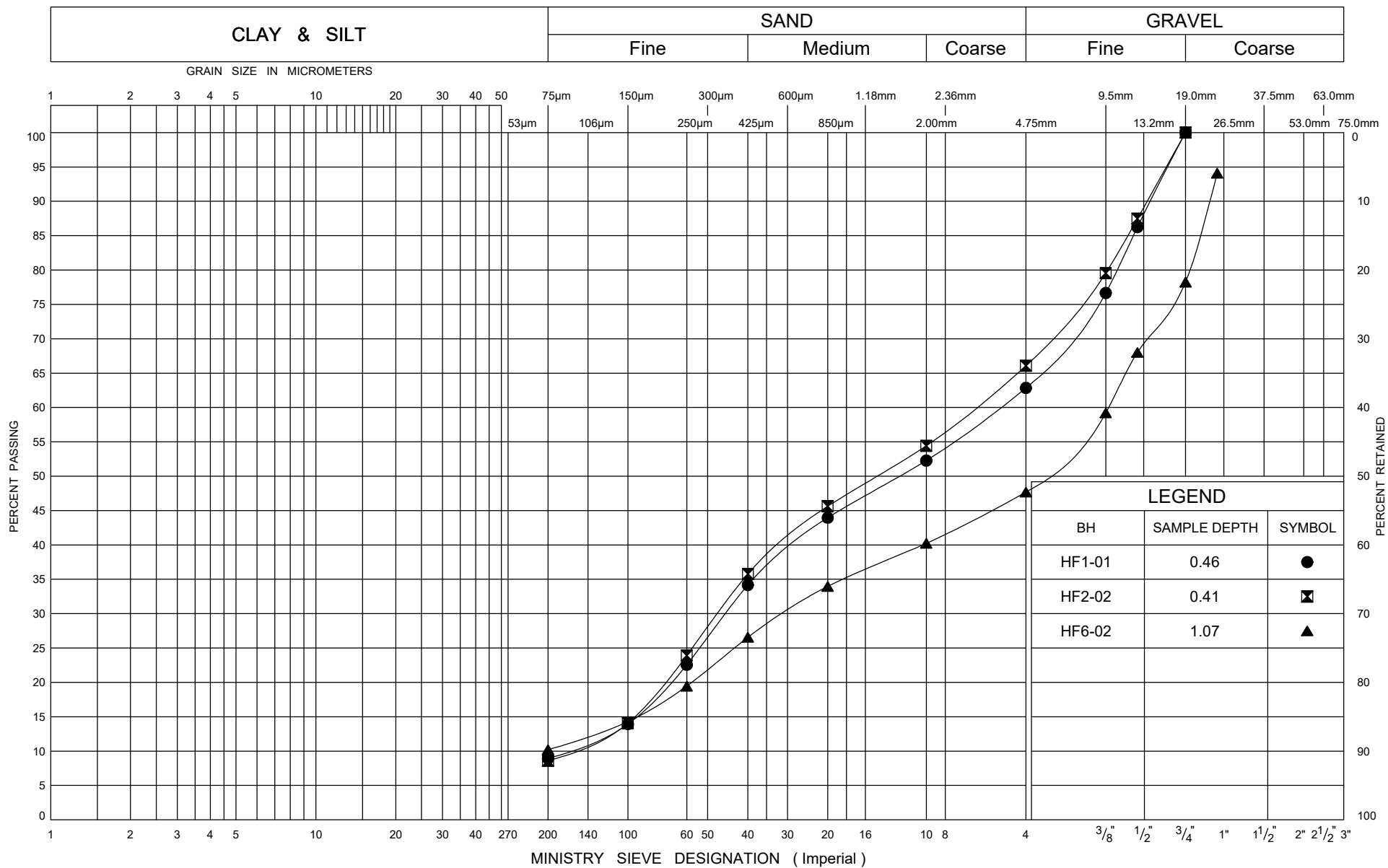
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)	
279.2	GROUND SURFACE						20 40 60 80 100	○ UNCONFINED	+ FIELD VANE								
0.0	PEAT , fibrous Very Loose Black Wet		1	SS	WH		279							1475			
																648	
																	622
																	512
																	351
			2	SS	WH		278										
			3	SS	WH		277										
			4	SS	WR		276										
			5	SS	WR		275										
274.7																	
4.6	SAND , trace gravel, trace silt Very Loose to Loose Grey Wet		6	SS	WH		274								5 92 3 (SI+CL)		
			7	SS	5		273										
272.6																	
6.6	Silty SAND , trace gravel Loose Grey Wet						272										
	End of augering at 7.6m due to sand blowback inside augers. DCPT advanced from 7.6m						271										
270.7																	
8.5	END OF BOREHOLE AT 8.5m UPON DCPT REFUSAL ON POSSIBLE BEDROCK. WATER LEVEL AT OPEN BOREHOLE AT 0.5m. BOREHOLE BACKFILLED WITH HOLEPLUG TO SURFACE.																

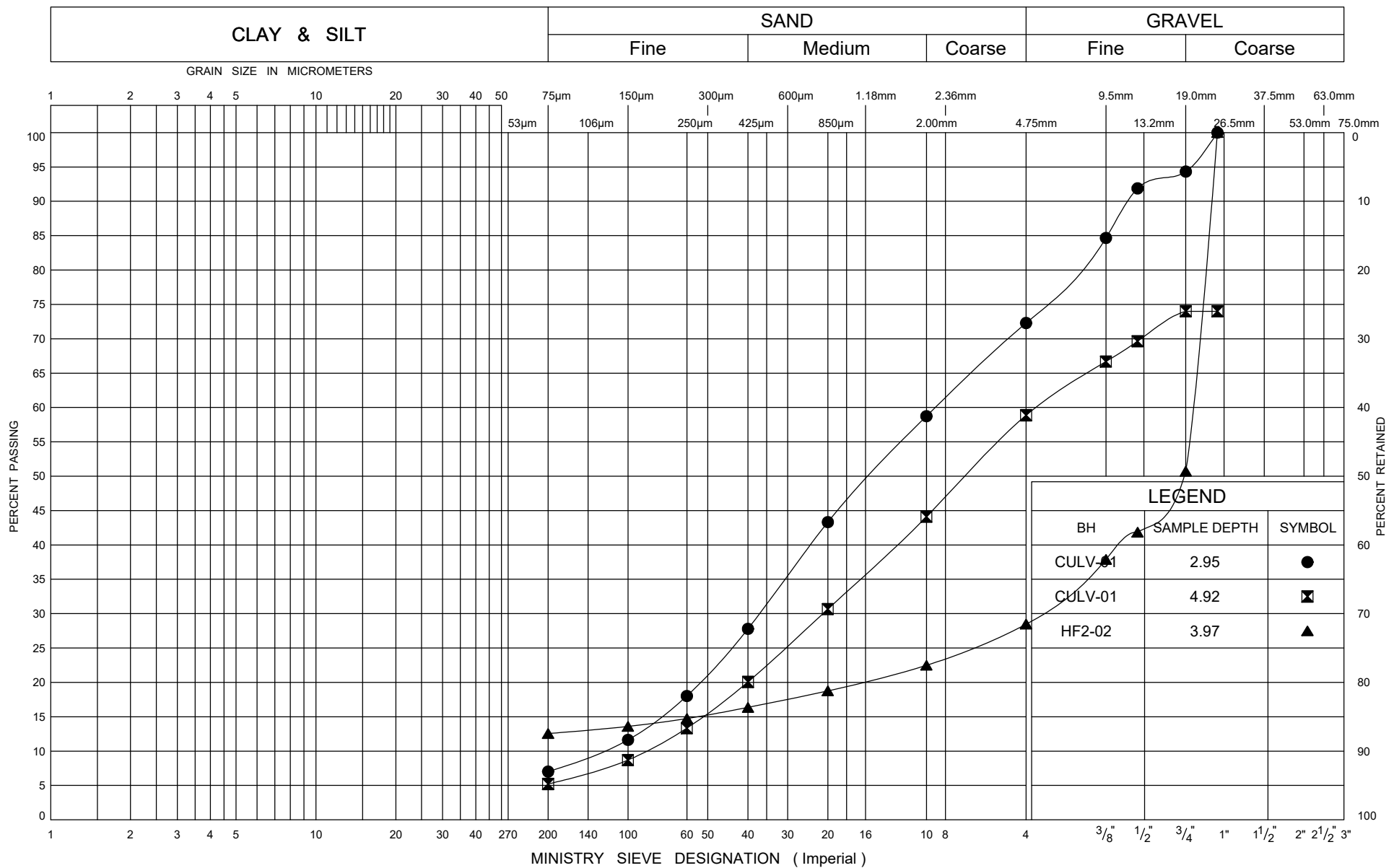
ONTMT452 2020LIBRARY(MTO) - COPY.GLB MTO-29771.GPJ 10-5-23

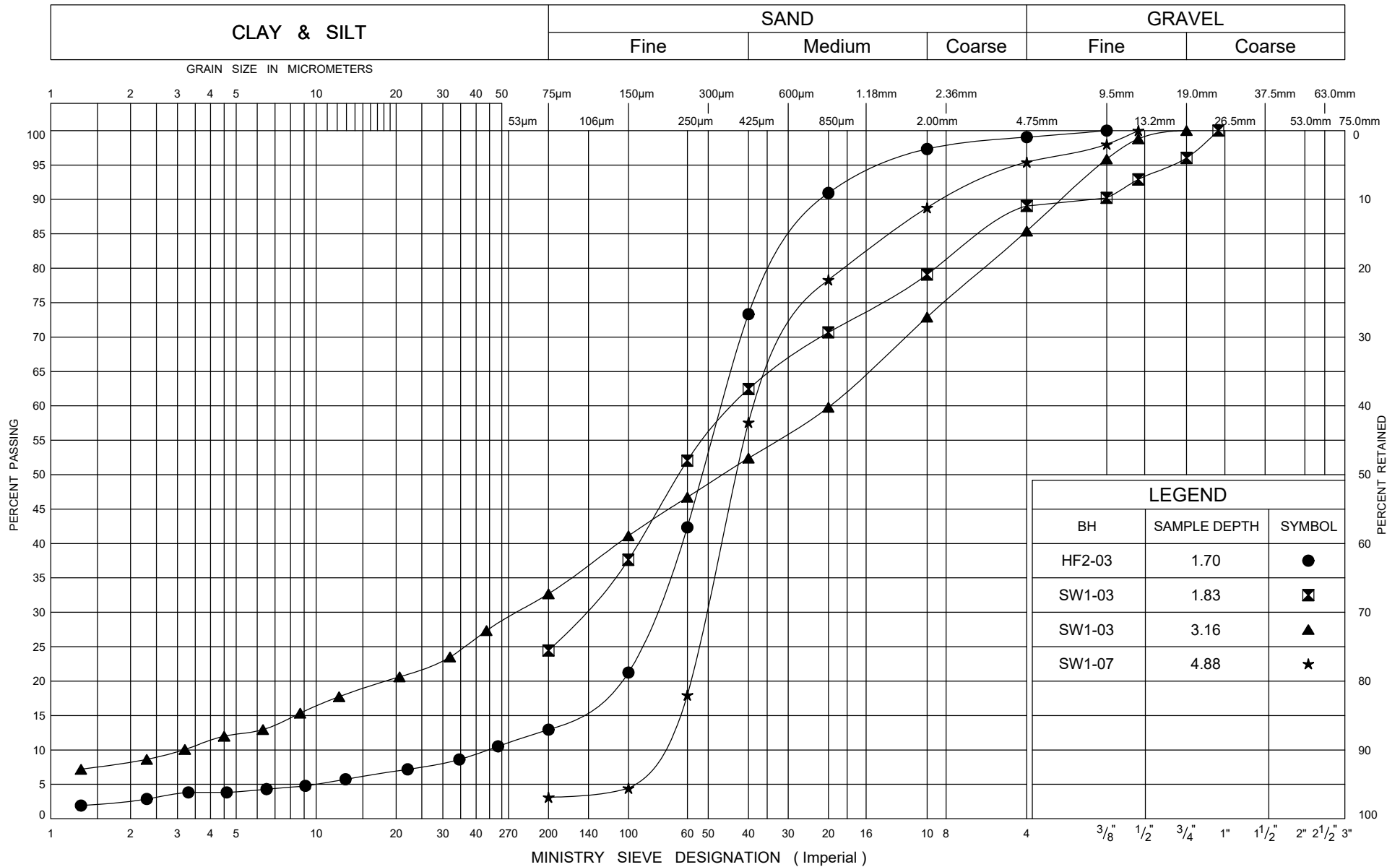
+³, ×³: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

APPENDIX C

Soil Laboratory Test Results





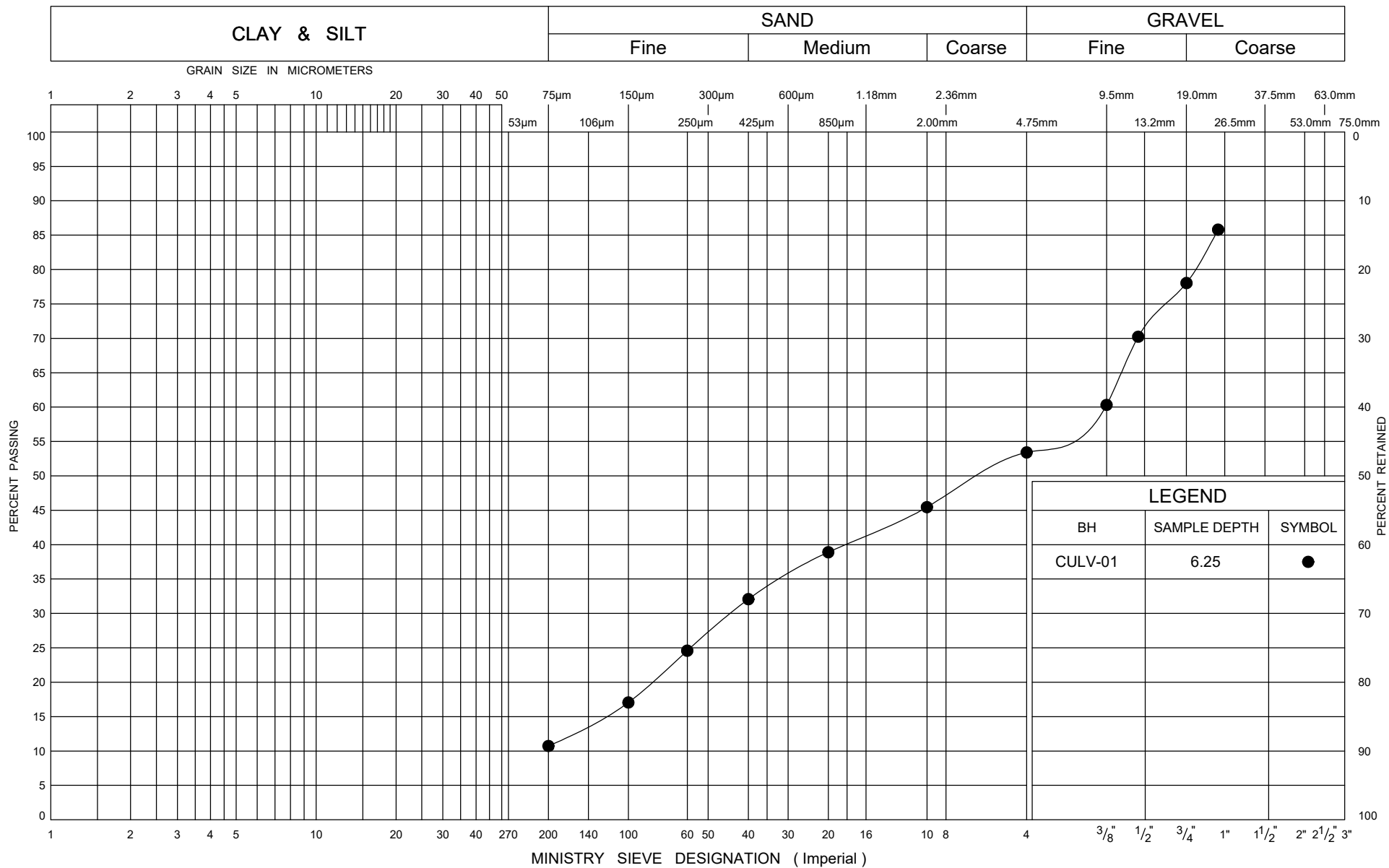


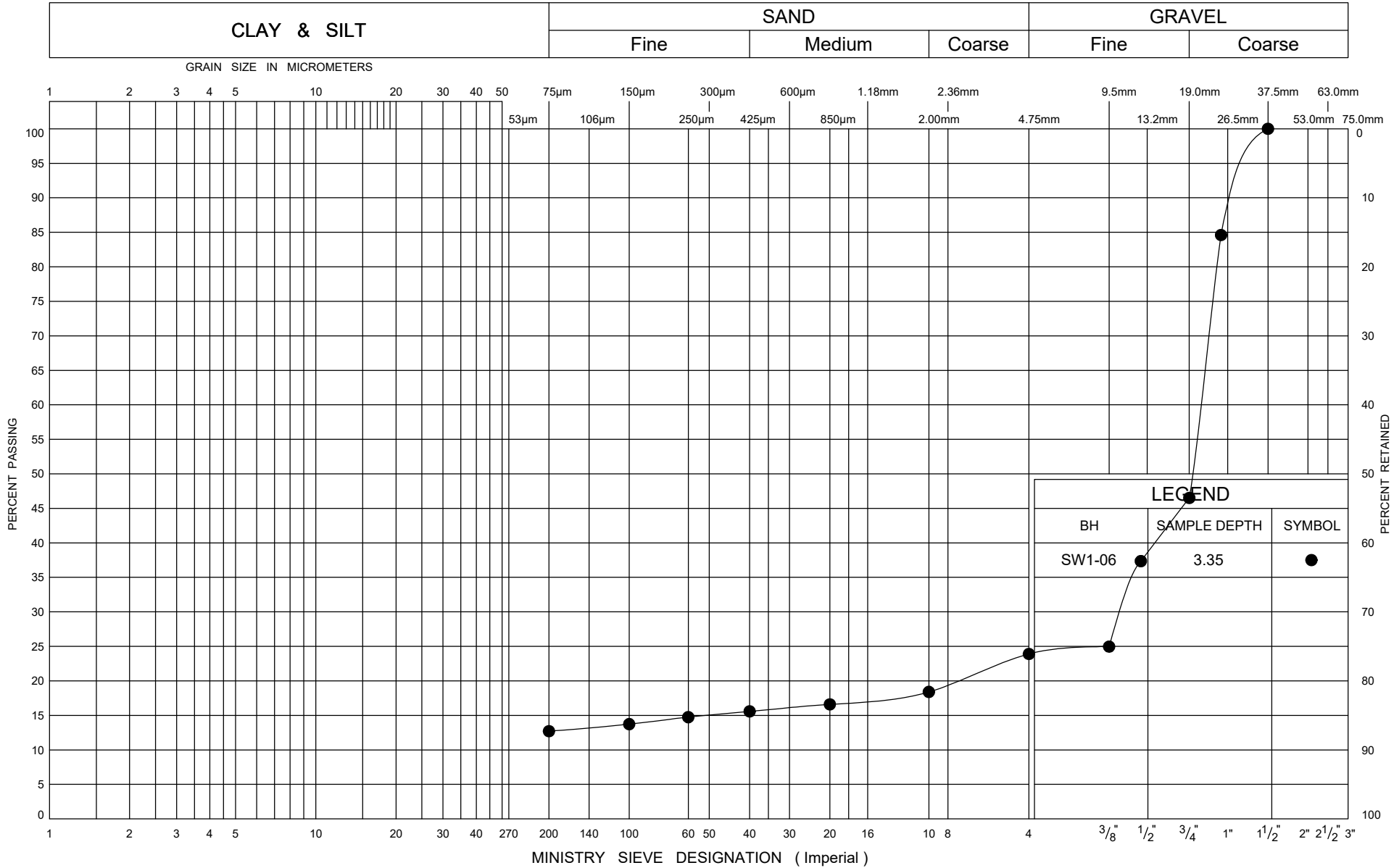
Ministry of
Transportation

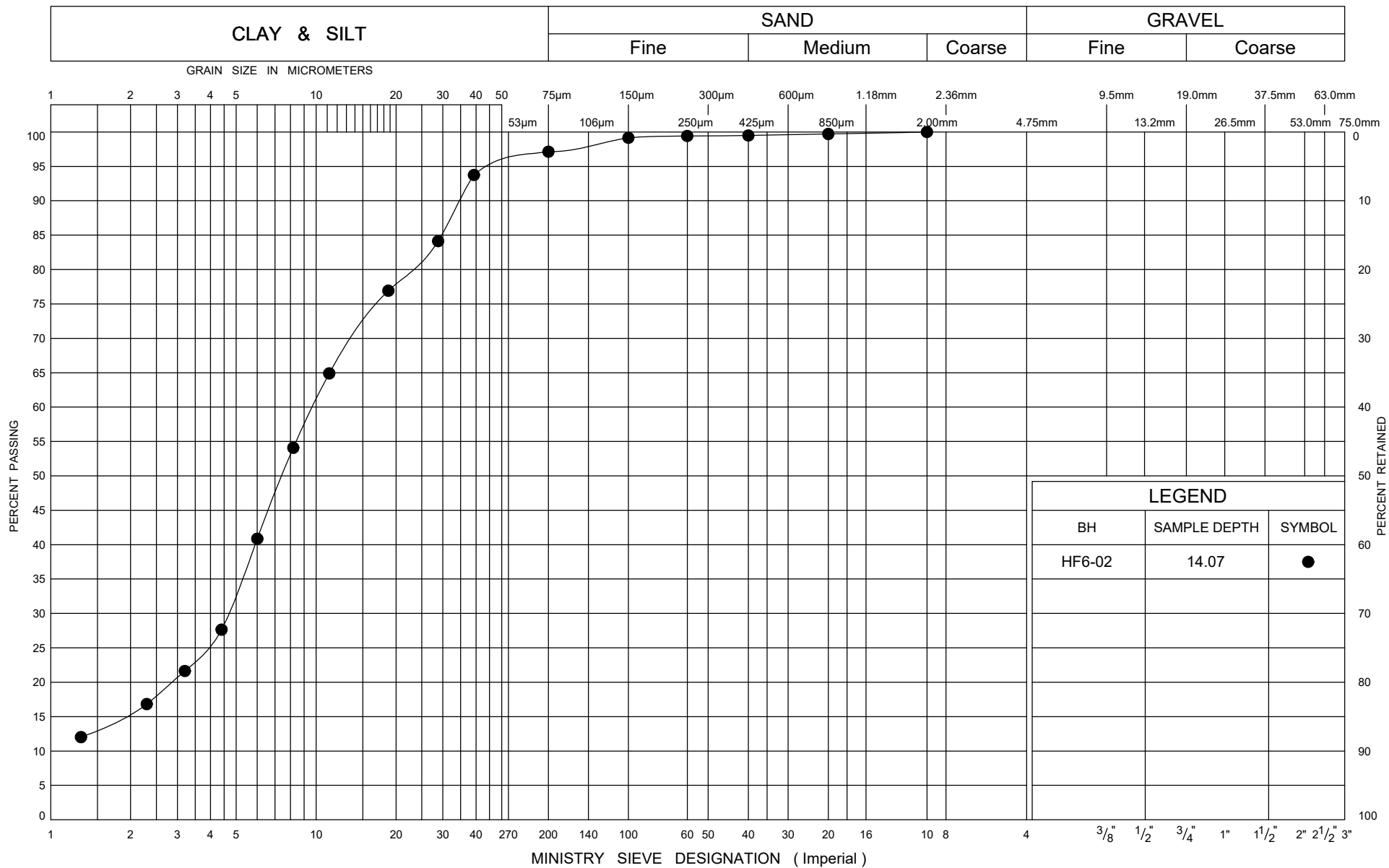
GRAIN SIZE DISTRIBUTION SAND to Silty SAND

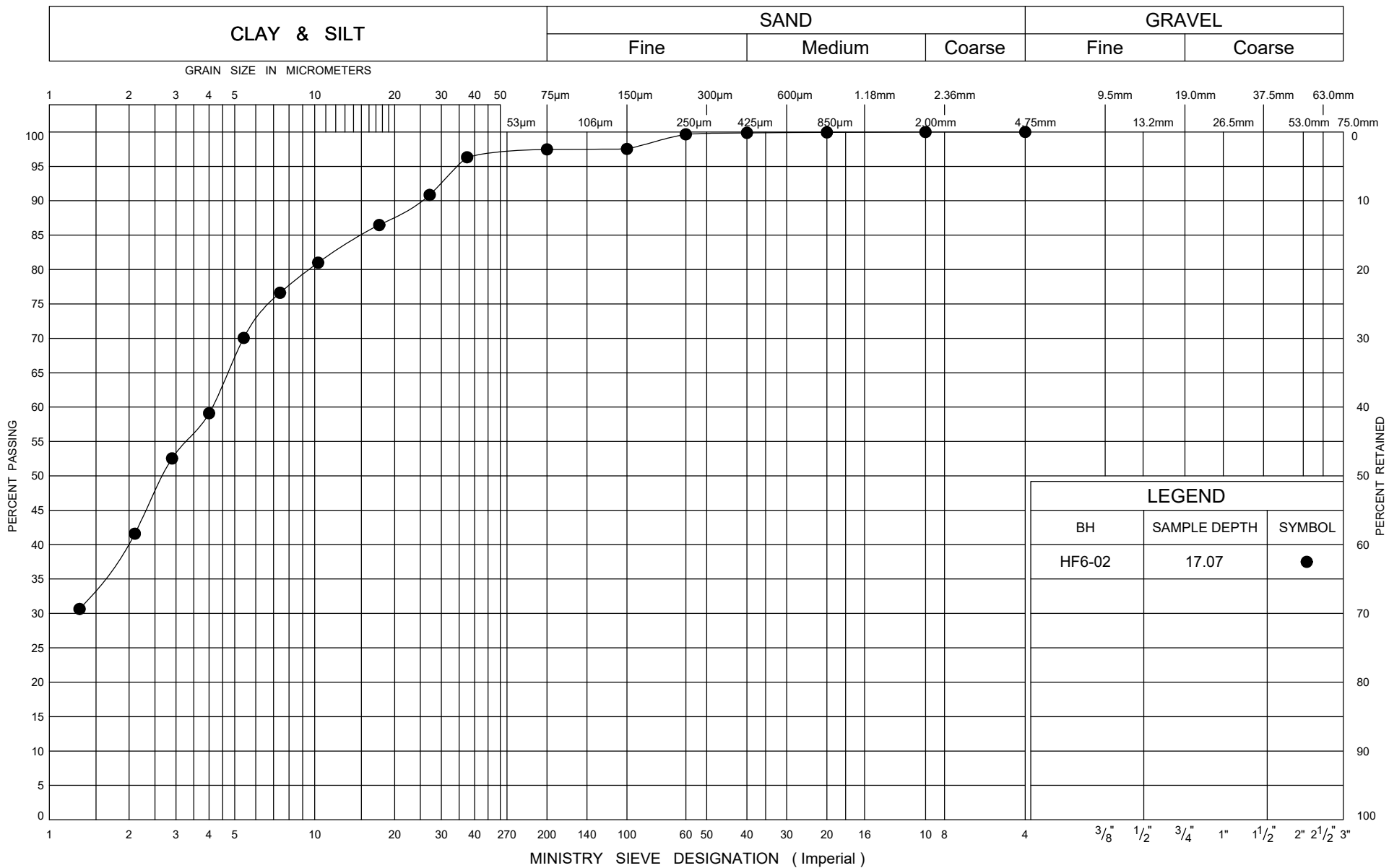
FIG No C3

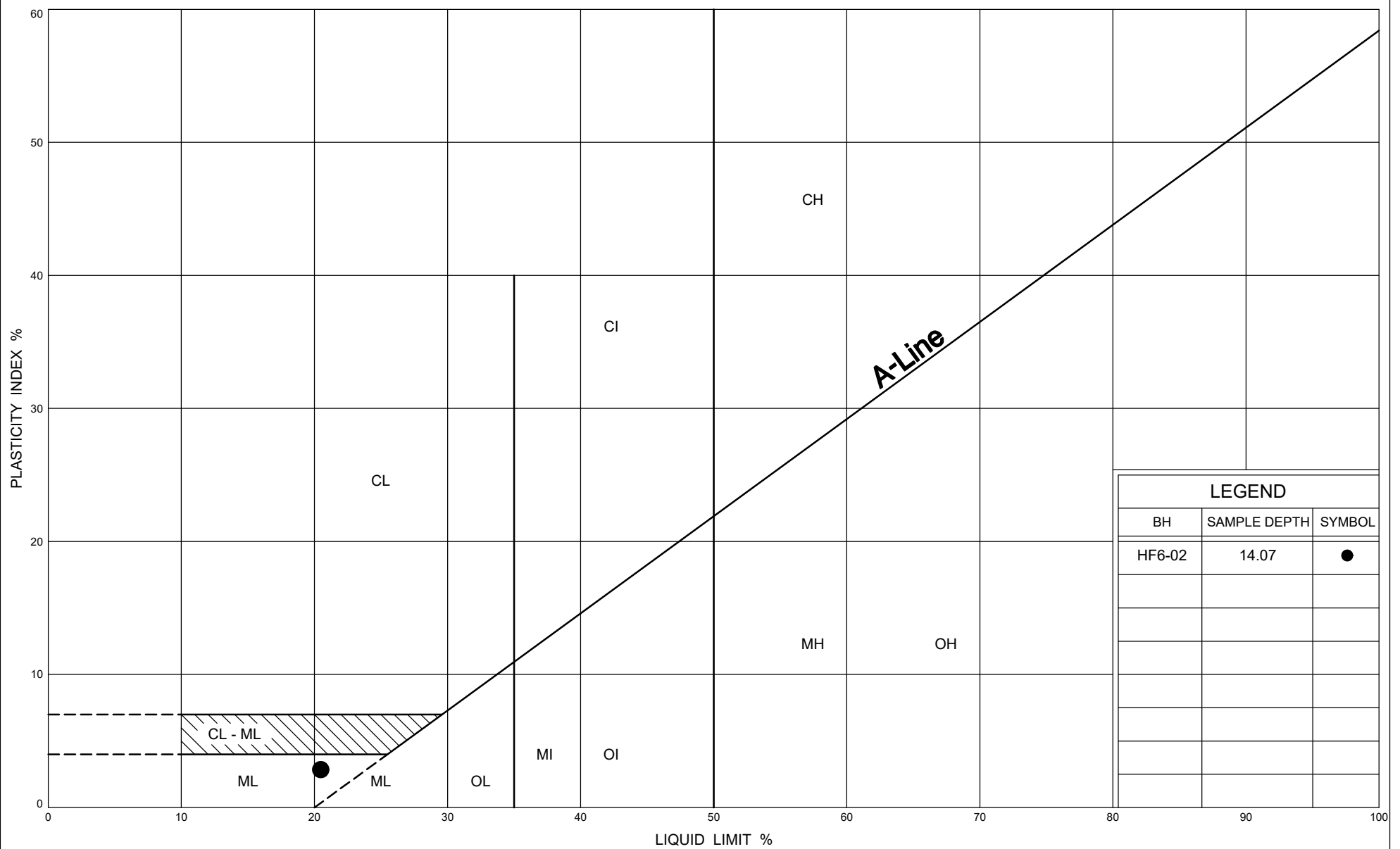
GWP# 6132-17-00











LEGEND		
BH	SAMPLE DEPTH	SYMBOL
HF6-02	14.07	●



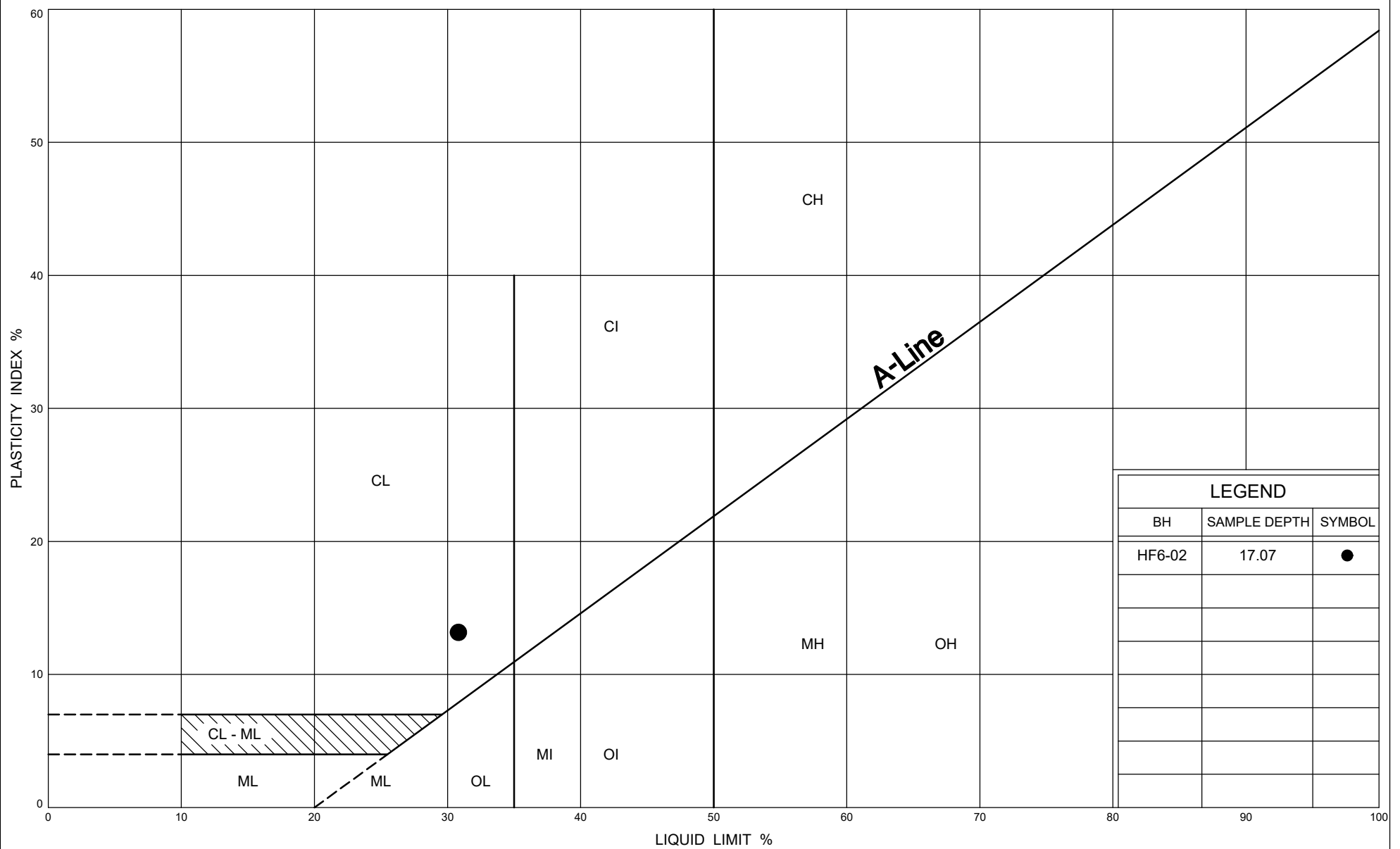
Ministry of
Transportation

PLASTICITY CHART

Clayey SILT

FIG No C1

GWP# 6132-17-00



Ministry of
Transportation

PLASTICITY CHART

Silty CLAY

FIG No CJ

GWP# 6132-17-00

APPENDIX D

Bedrock Laboratory Test Results and Rock Core Photographs

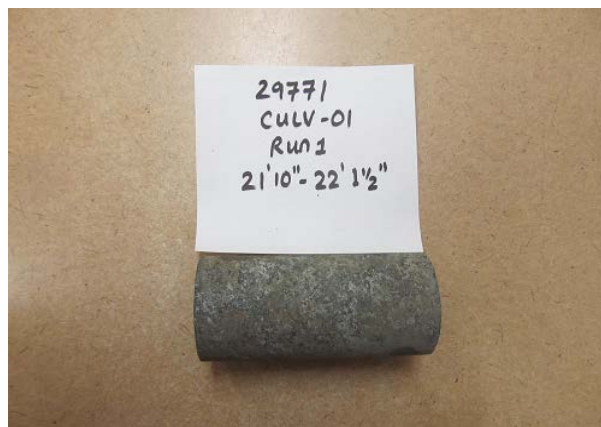
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

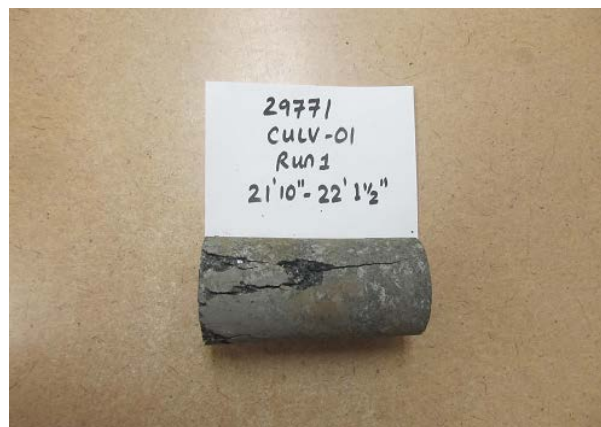
CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	CULV-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	6.65-6.74 m		
DESCRIPTION:	Syenite		

Avg. Height (cm):	9.8	Weight (g):	557.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	3,208
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m ³):	2,550
Cross Sectional Area (cm ²):	17.72	Moisture Content (%):	N/A
Sample Volume (cm ³):	173.66		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	193.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	109.4 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

CULV-01 Run 1

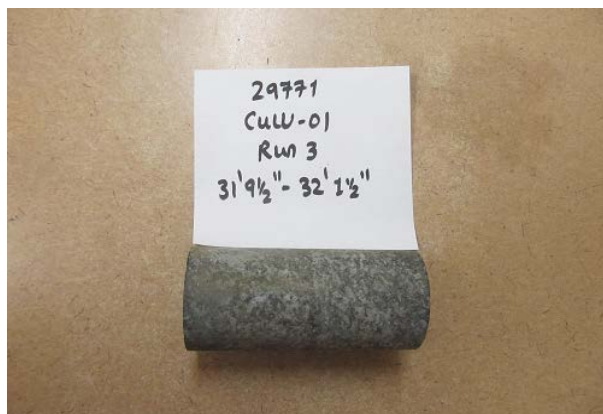
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

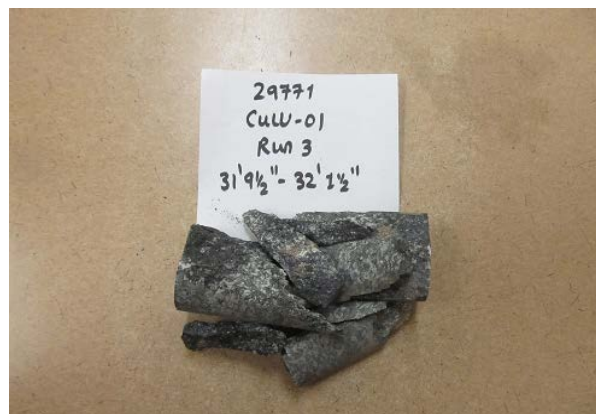
CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	CULV-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 3		
SAMPLE DEPTH:	9.69-9.79 m		
DESCRIPTION:	Syenite		

Avg. Height (cm):	9.8	Weight (g):	548.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	3,156
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m ³):	2,550
Cross Sectional Area (cm ²):	17.72	Moisture Content (%):	N/A
Sample Volume (cm ³):	173.66		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	304.7 kN
UNCONFINED COMPRESSIVE STRENGTH:	171.9 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

CULV-01 Run 3

UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	HF1-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 1		
SAMPLE DEPTH:	5.79-5.89 m		
DESCRIPTION:	Metavolcanic		

Avg. Height (cm):	9.8	Weight (g):	477.9
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,749
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m ³):	2,550
Cross Sectional Area (cm ²):	17.80	Moisture Content (%):	N/A
Sample Volume (cm ³):	173.86		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	199.6 kN
UNCONFINED COMPRESSIVE STRENGTH:	112.2 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

HF1-01 Run 1

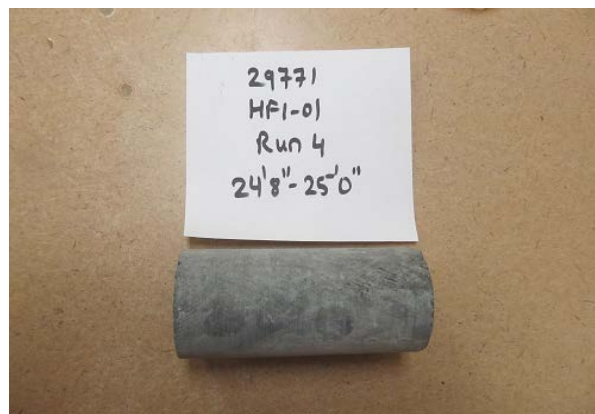
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

CLIENT:	BTE	FILE NUMBER:	29771
PROJECT NAME:	Little Pic River	REPORT DATE:	5-Oct-23
BOREHOLE No.:	HF1-01	TEST DATE:	28-Sep-23
SAMPLE No.:	RUN 4		
SAMPLE DEPTH:	7.52-7.62 m		
DESCRIPTION:	Metavolcanic		

Avg. Height (cm):	10.0	Weight (g):	482.6
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,720
H. to Dia. Ratio*:	2.1:1	Dry Density (kg/m ³):	2,550
Cross Sectional Area (cm ²):	17.80	Moisture Content (%):	N/A
Sample Volume (cm ³):	177.42		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	1.5% / min
MAXIMUM COMPRESSIVE LOAD:	187.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	105.6 MPa

Note:

* Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: BS
REVIEWED BY: WM

HF1-01 Run 4

POINT LOAD TEST SHEET

ASTM D5731-08

Job No:	29771
Client:	BTE
Project Name:	Highway 17, Little Pic River Westerly
Core Size:	NQ BH No : CULV - 01

Date Drilled:	18-Jul-23
Date Tested:	20-Sep-23
Tester:	AK
Reviewed by:	MEF

[illegible]



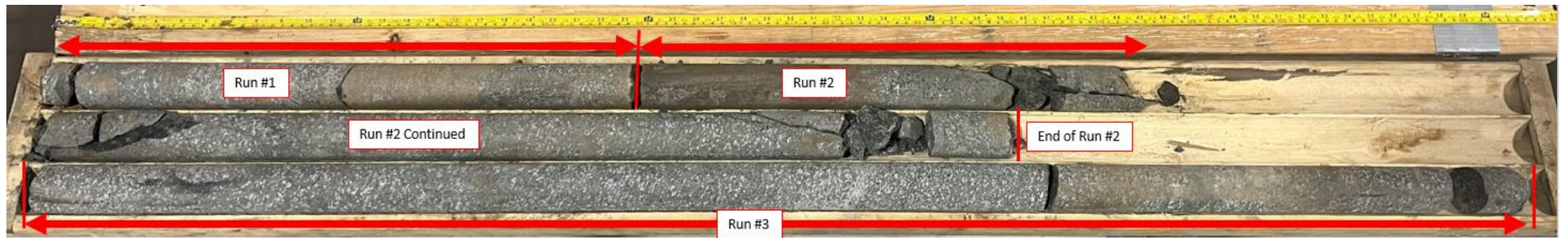
ASTM D5731-08

Date Drilled:	22-Jul-23
Date Tested:	20-Sep-23
Tester:	AK
Reviewed by:	MEF

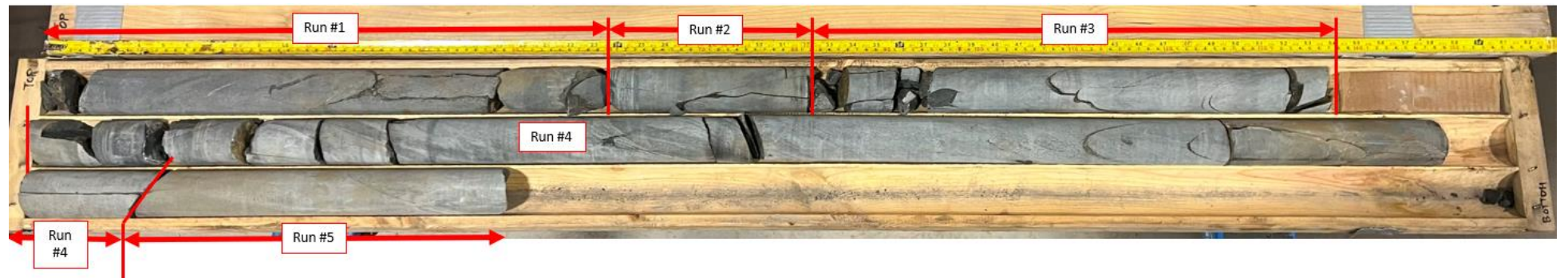
[illegible]

Photographs of Rock Core

Borehole CULV-01– Runs 1, 2, and 3 – 6.6 to 10.2 m (Elev. 275.0 to 278.6 m)



Borehole HF1-01 – Runs 1, 2, and 3 – 5.7 to 8.9 m (Elev. 263.3 to 266.5 m)



APPENDIX E

Analytical Laboratory Test Results



FINAL REPORT

CA40254-AUG23 R1

29771, Little Pic River

Prepared for

Thurber Engineering Ltd.

First Page

CLIENT DETAILS

Client Thurber Engineering Ltd.

Address 103, 2010 Winston Park Drive
Oakville, ON
L6H 5R7, Canada

Contact Rachel Bourassa

Telephone 905-829-8666 x 263

Facsimile

Email rbourassa@thurber.ca

Project 29771, Little Pic River

Order Number

Samples Soil (4)

LABORATORY DETAILS

Project Specialist Maarit Wolfe, Hon.B.Sc

Laboratory SGS Canada Inc.

Address 185 Concession St., Lakefield ON, K0L 2H0

Telephone 705-652-2000

Facsimile 705-652-6365

Email Maarit.Wolfe@sgs.com

SGS Reference CA40254-AUG23

Received 08/24/2023

Approved 08/31/2023

Report Number CA40254-AUG23 R1

Date Reported 08/31/2023

COMMENTS

Temperature of Sample upon Receipt: 8 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: n/a

Corrosivity Index is based on the American Water Works Corrosivity Scale according to AWWA C-105. An index greater than 10 indicates the soil matrix may be corrosive to cast iron alloys.

SIGNATORIES

Maarit Wolfe, Hon.B.Sc






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Legend..... 6

Annexes..... 7



FINAL REPORT

CA40254-AUG23 R1

Client: Thurber Engineering Ltd.

Project: 29771, Little Pic River

Project Manager: Rachel Bourassa

Samplers: NA

MATRIX: SOIL

Sample Number	5	6	7	8
Sample Name	HF6-02 SS15 (55'-57')	HF2-02 SS1 (4"-2'4")	CUIV-01 SS1 (6"-2'6")	SW1-07 SS7A (20'-21'8")
Sample Matrix	Soil	Soil	Soil	Soil
Sample Date	19/07/2023	24/07/2023	18/07/2023	30/03/2023

Parameter	Units	RL		Result	Result	Result	Result
Corrosivity Index							
Corrosivity Index	none	1		4	9	12	1
Soil Redox Potential	mV	no		147	195	282	220
Sulphide (Na ₂ CO ₃)	%	0.04		< 0.04	< 0.04	< 0.04	< 0.04
pH	pH Units	0.05		8.60	9.31	9.17	8.46
Resistivity (calculated)	ohms.cm	-9999		3150	1930	1690	3560
General Chemistry							
Conductivity	uS/cm	2		317	519	591	281
Metals and Inorganics							
Moisture Content	%	0.1		20.2	3.4	7.8	18.7
Sulphate	µg/g	0.4		42	21	35	64
Other (ORP)							
Chloride	µg/g	0.4		94	130	140	21



FINAL REPORT

CA40254-AUG23 R1

QC SUMMARY

Anions by IC
Method: EPA300/MA300-Ions1.3 | Internal ref.: ME-CA-IENVIIC-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Chloride	DIO0656-AUG23	µg/g	0.4	<0.4	2	35	102	80	120	104	75	125
Sulphate	DIO0656-AUG23	µg/g	0.4	<0.4	5	35	97	80	120	97	75	125

Carbon/Sulphur
Method: ASTM E1915-07A | Internal ref.: ME-CA-IENVIARD-LAK-AN-020

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide (Na2CO3)	ECS0111-AUG23	%	0.04	< 0.04	ND	20	83	80	120			

Conductivity
Method: SM 2510 | Internal ref.: ME-CA-IENVIEWL-LAK-AN-006

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Conductivity	EWL0547-AUG23	uS/cm	2	3	1	20	100	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-|ENVIEWL-LAK-AN-001

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
pH	EWL0520-AUG23	pH Units	0.05	NA	0		100			NA		

Method Blank: a blank matrix that is carried through the entire analytical procedure. Used to assess laboratory contamination.

Duplicate: Paired analysis of a separate portion of the same sample that is carried through the entire analytical procedure. Used to evaluate measurement precision.

LCS/Spike Blank: Laboratory control sample or spike blank refer to a blank matrix to which a known amount of analyte has been added. Used to evaluate analyte recovery and laboratory accuracy without sample matrix effects.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate laboratory accuracy with sample matrix effects.

Reference Material: a material or substance matrix matched to the samples that contains a known amount of the analyte of interest. A reference material may be used in place of a matrix spike.

RL: Reporting limit

RPD: Relative percent difference

AC: Acceptance criteria

Multielement Scan Qualifier: as the number of analytes in a scan increases, so does the chance of a limit exceedance by random chance as opposed to a real method problem. Thus, in multielement scans, for the LCS and matrix spike, up to 10% of the analytes may exceed the quoted limits by up to 10% absolute and the spike is considered acceptable.

Duplicate Qualifier: for duplicates as the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Matrix Spike Qualifier: for matrix spikes, as the concentration of the native analyte increases, the uncertainty of the matrix spike recovery increases. Thus, the matrix spike acceptance limits apply only when the concentration of the matrix spike is greater than or equal to the concentration of the native analyte.

LEGEND

FOOTNOTES

NSS Insufficient sample for analysis.

RL Reporting Limit.

↑ Reporting limit raised.

↓ Reporting limit lowered.

NA The sample was not analysed for this analyte

ND Non Detect

Results relate only to the sample tested.

Data reported represent the sample as submitted to SGS. Solid samples expressed on a dry weight basis.

"Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

Analysis conducted on samples submitted pursuant to or as part of Reg. 153/04, are in accordance to the "Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act and Excess Soil Quality" published by the Ministry and dated March 9, 2004 as amended.

SGS provides criteria information (such as regulatory or guideline limits and summary of limit exceedances) as a service. Every attempt is made to ensure the criteria information in this report is accurate and current, however, it is not guaranteed. Comparison to the most current criteria is the responsibility of the client and SGS assumes no responsibility for the accuracy of the criteria levels indicated.

SGS Canada Inc. statement of conformity decision rule does not consider uncertainty when analytical results are compared to a specified standard or regulation.

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This report supersedes all previous versions.

-- End of Analytical Report --

APPENDIX F

Site Photographs



**Photo 1: West end of proposed highway alignment looking southeast towards HF1,
Photo Taken May 11, 2023**



**Photo 2: HF1 Section, looking south at existing highway embankment,
Photo Taken May 11, 2023**



**Photo 3: Rock outcropping in DC1 Section looking east at Station 17+725,
Photo taken May 11, 2023**



**Photo 4: Rock Cliff leading from DC1 to HF2 Section. Photo of centerline looking southwest,
Photo taken May 11, 2023**



Photo 5: HF2 Section. Photo of centerline looking southwest, Photo taken May 11, 2023



Photo 6: Near DC2 Section looking northwest towards HF2, Photo taken September 29, 2023



Photo 7: DC2 Section. Photo of existing highway alignment looking southwest, Photo taken November 10, 2023



Photo 8: Looking northwest at Swamp area SW1, Photo taken September 29, 2023



Photo 9: Approaching DC3 Rock slope in the Hydro Corridor looking northwest down alignment centerline, Photo taken May 11, 2023



Photo 10: Approaching DC4 Rock slope from the north, looking southwest towards alignment, Photo taken May 11, 2023



**Photo 11: Approaching CULV-01 from the north. Looking south towards alignment,
Photo taken September 29, 2023**

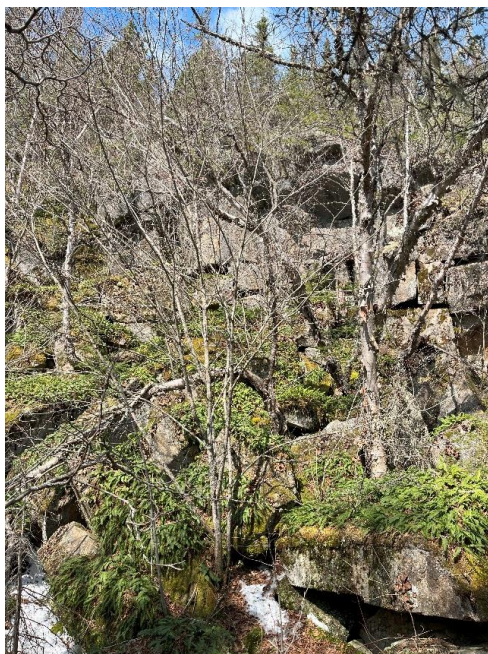


Photo 12: HF5 Section looking west at cliff boundary of the section along alignment,

Photo taken May 11, 2023



Photo 13: DC5 Section looking southeast along alignment, Photo taken May 11, 2023



Photo 14: DC6 Section looking east along alignment, Photo taken May 11, 2023



Photo 15: Looking at DC7 from the east side along alignment, Photo taken May 11, 2023



Photo 16: Looking at HF6 from the west side along alignment, Photo taken May 11, 2023



Photo 17: Image of DC8, taken from the south side along existing highway, looking east towards Little Pic River. Photo taken November 12, 2020



Photo 18: Looking north at DC10 from the south side of the existing highway, Photo taken November 12, 2020