



THURBER ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT
CROCKER LAKE WEST CULVERT REPLACEMENT
HIGHWAY 17, 10.4 KM WEST OF HIGHWAY 631 (WHITE RIVER)
TOWNSHIP OF CECILE, ONTARIO
G.W.P. 6080-18-00
SITE NO. 48E-0073/C0**

GEOCRES No. 42C-49

Latitude 48.6314°, Longitude -85.3823°

Report

to

Consor

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PART 1: FACTUAL INFORMATION

1. INTRODUCTION

This section of the report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed replacement of the Crocker Lake West Culvert in the Township of Cecile, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and based on the data obtained, to provide a borehole location plan, stratigraphic profiles, records of boreholes, laboratory test results, and a written description of the subsurface conditions. A model of the subsurface conditions influencing design and construction was developed in the course of the current investigation.

Thurber was retained by Consor to carry out this foundation investigation under the Ministry of Transportation (MTO) Northwestern Region Agreement Number 6021-E-0009.

2. SITE DESCRIPTION

The site is located on Highway 17, approximately 10.4 km west of Highway 631, within the Township of Cecile, Ontario. The existing culvert conveys Crocker Lake West under Highway 17 with the culvert running in a north-south direction and Highway 17 running in a west-east direction at the site.

The provided Ontario Structure Inspection Manual (OSIM) prepared by MTO, indicates the existing structure is a 20.4 m long, 3.7 m wide by 1.75 m high concrete rigid frame structure supported on footings. Based on cross-sections included in the Existing Geometrics Review Memo, prepared by Consor, dated July 24, 2021, the culvert invert is at approximately Elev. 359.6 m and 359.5 m at the north end (inlet) and south end (outlet), respectively. The existing road grade at the culvert location is at approximately Elev. 363 m and the depth of cover over the



culvert is approximately 1.5 m. The water level in Crocker Lake was recorded at Elev. 360.16 m north of the culvert and Elev. 359.80 m south of the culvert in September 2019.

Crocker Lake West exists to the north and south of the culvert with Highway 17 embankment running through the lake and separating the northern and southern portions of the lake. There is a driveway and a boat launch located northwest of the culvert which is accessed from Highway 17. Several trees are located along the northern side of the highway embankment immediately east of the culvert and the lake itself is surrounded by numerous trees and heavy vegetation.

Photographs of the culvert and surrounding area taken at the time of the field investigation are presented in Appendix E.

3. SITE GEOLOGY

Based on published geological information, the culvert lies within an area consisting of glaciofluvial ice deposits of sand and gravel and minor till. Based on local geological maps, the bedrock in the area is identified as foliated to massive granodiorite of the Archean Era.

4. INVESTIGATION PROCEDURES

The foundation investigation was carried between August 9 and 20, 2021 at which time nine (9) boreholes were completed at the site, with four (4) boreholes drilled near the ends of the existing culvert (i.e. 21-01 and 21-04), two (2) boreholes drilled east and west of the culvert for temporary roadway protection systems (i.e. 21-05 and 21-06), and three (3) boreholes drilled in the vicinity of proposed retaining toe walls (i.e. 21-09 to 21-11). The boreholes were advanced to depths ranging from approximately 9.7 to 15.8 m (Elevation 353.4 to 347.0 m) below the existing grades. The approximate locations of the boreholes are shown on the Borehole Locations and Soil Strata Drawings provided in Appendix A. The Records of Boreholes sheets are provided in Appendix B. It is noted that two (2) pavement boreholes (i.e. 21-07 and 21-08) were also advanced at the site in conjunction with the foundation investigation. The factual results of these pavement boreholes are addressed under separate cover and not discussed in this report.

Utility clearances were obtained prior to the start of drilling. The northing and easting borehole coordinates were estimated from a hand-held GPS unit. The ground surface elevations at the boreholes were estimated from a base plan provided by Consor.

All of the boreholes were drilled using a rubber tracked CME 55 drill rig with the exception of Borehole 21-02, which was drilled using a tripod, due to access constraints. The CME 55 drill rig and the tripod were supplied and operated by RPM Drilling of Thunder Bay and OGS Inc of



Almonte, respectively. The boreholes were advanced through the overburden using hollow stem augers and NW casing. Soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). Dynamic Cone Penetration Tests (DCPT) were completed from the bottom of sampled boreholes 21-01, 21-05, 21-09 and 21-11.

NQ coring methods were used to advance borehole 21-04 a distance of 3.1 m into bedrock. The obtained 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. Three (3) Unconfined Compression Strength (UCS) tests were performed on selected rock core samples to measure the unconfined compressive strength of the bedrock.

The drilling and sampling operations were supervised on a full-time basis by a member of Thurber's technical staff. The supervisor logged the boreholes and processed the recovered soil and rock samples for transport to Thurber's laboratory for further examination and testing.

A standpipe piezometer was installed in Borehole 21-03 to permit measurement of the groundwater level. The piezometer was decommissioned at the end of the field investigation in general accordance with Ontario Regulation 903 as amended.

Completion details of the boreholes are summarized in Table 4.1.

Table 4.1 – Borehole Completion Details from 2021 Field Investigation

Borehole	Borehole Depth / Base Elevation (m)	Piezometer Tip Depth / Elevation (m)	Completion Details
21-01 (culvert inlet)	9.7 / 351.1	-	Backfilled with sand and bentonite from 9.7 m to surface.
21-02 (culvert inlet)	10.4 / 351.0	-	Backfilled with sand and bentonite from 10.4 m to surface.
21-03 (culvert outlet)	12.8 / 349.8	12.8 / 349.8	Backfilled with sand from 12.8 to 9.1 m, bentonite to 0.3 m, then asphalt to surface.
21-04 (culvert outlet)	15.8 / 347.0	-	Backfilled with bentonite from 15.8 m to 0.3 m, then asphalt to surface.
21-05 (TPS)	12.2 / 350.8	-	Backfilled with sand and bentonite from 12.2 to 0.3 m, then asphalt to surface.
21-06 (TPS)	13.5 / 349.5	-	Backfilled with sand and bentonite from 13.5 to 0.3 m, then asphalt to surface.
21-09 (Retaining Wall)	12.2 / 351.5		Backfilled with sand and bentonite from 10.4 to 0.3 m, then asphalt to surface.
21-10 (Retaining Wall)	9.8 / 353.1		Backfilled with sand and bentonite from 9.8 to 0.3 m, then asphalt to surface.
21-11 (Retaining Wall)	11.4 / 352.2		Backfilled with sand and bentonite from 10.4 to 0.3 m, then gravel to surface.

5. LABORATORY TESTING

All recovered soil samples were subjected to visual identification and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (hydrometer and/or sieve), where appropriate. Point load tests and Unconfined Compression Strength (UCS) tests were conducted on the selected rock cores. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix B and on the figures included in Appendix C.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with any buried steel element of the structure, samples of the native soil from the boreholes near the proposed foundation elements were collected, as well as



a surface water sample from the upstream side of the culvert. The samples were submitted to SGS, 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 6.7 and are presented in Appendix D.

6. DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix B and the encountered soil stratigraphy is presented on the Borehole Locations and Soil Strata Drawings included in Appendix A. A general description of the stratigraphy, based on the conditions encountered in the boreholes, is given in the following paragraphs. 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 must be recognized and expected that soil and groundwater conditions will vary between and beyond the borehole locations.

In general, the subsurface conditions encountered at the borehole locations consisted of asphalt underlain by cohesionless fill. The fill materials are underlain by a native deposit of sand and gravel to sand with silty sand encountered at the inlet of the culvert. The overburden soils are underlain by granite bedrock. Descriptions of the individual strata are presented below from the current borehole investigation for the proposed culvert replacement, retaining walls, and embankment assessment.

6.1 Asphalt

A 125 to 200 mm thick layer of asphalt was encountered at the ground surface in Boreholes 21-03 to 21-06, 21-09 and 21-10.

6.2 Cohesionless Fill

Cohesionless fill was encountered in eight (8) boreholes (Borehole 21-01, 21-03 to 21-06 and 21-09 to 21-11) and varied in composition from sand and gravel to sand with some silty inclusions. Boulders were noted within the fill in Borehole 21-06. The cohesionless fill extended to underside depths ranging from 0.8 to 4.5 m (Elev. 360.8 to 358.5 m).

The cohesionless fill typically ranged from loose to very dense, with SPT N-values typically ranging from 7 to over 100 blows. In general, the upper 2 m of the fill was dense to very dense and the lower portion of the fill was loose to compact. The measured moisture content in the cohesionless fill ranged from 3 to 15%.

The results of grain size analyses conducted on five (5) samples of the cohesionless fill are summarized on the Record of Boreholes in Appendix B and illustrated on Figure C1 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)	
	Gravelly Silty Sand	Silty Sand to Sand
Gravel	20 to 23	8 to 23
Sand	46 to 73	53 to 71
Silt & Clay	4 to 34	6 to 34

6.3 Silty Sand

A deposit of silty sand was encountered at ground surface in Borehole 21-02, advanced near the culvert inlet, and was found to be 2.2 m thick with an underside depth of 2.2 m (Elev. 359.1 m). Cobbles were also noted in the silty sand.

The SPT N-values recorded in the silty sand deposit ranged from 5 to over 100 blows indicating that the deposit was very loose to very dense. The measured moisture contents ranged from 2 to 4%.

6.4 Sand and Gravel to Sand

A deposit of sand and gravel to sand was encountered below the fill in Boreholes 21-01, 21-03 to 21-06 and 21-09 to 21-11 and below the silty sand in Borehole 21-02. The sand and gravel to sand was found to extend to bedrock or probable bedrock/refusal at depths ranging from 9.7 to 13.5 m (Elev. 353.4 to 349.5 m). Cobbles and/or boulders were noted within the native sand and gravel to sand in Boreholes 21-01, 21-03 to 21-06, 21-09 and 21-11.

The SPT N-values recorded in the silt deposit ranged from 3 to over 100 blows indicating that the deposit was very loose to very dense (typically loose to compact). The measured moisture content ranged from 3 to 22%.

The results of grain size analyses conducted on sixteen (16) samples of the sand and gravel to sand are summarized on the Record of Boreholes in Appendix B and illustrated on Figures C2 and C3 in Appendix C. The results are summarized as follows:

Soil Particle	Percentage (%)
Gravel	0 to 50
Sand	31 to 93
Silt & Clay	2 to 39
Silt	9 to 36
Clay	1 to 3

6.5 Bedrock/Refusal

Granite bedrock was proven by coring techniques in Borehole 21-04. Probable bedrock/refusal was encountered in Boreholes 21-01, 21-05, 21-06, 21-09 and 21-11 at depths of 9.7 m to 13.5 m (Elev. 352.2 to 349.5 m). The bedrock was generally grey in colour and is generally described as slightly weathered to fresh. In Borehole 21-04, bedrock was encountered at a depth of 12.7 m below existing grade level at an Elevation of 350.1.

Total Core Recovery (TCR) in the bedrock was 100%, and Solid Core Recovery (SCR) ranged between 98 and 100%. The Rock Quality Designation (RQD) determined from the recovered cores ranged between 97 and 100%. The Fracture Index (FI) of the rock, expressed as fractures per 0.3 m of core, ranged from 0 to 2.

The Unconfined compressive strength (UCS) of the rock cores measured in UCS tests ranged between 48 and 60 MPa, indicating the rock is medium strong to strong. The UCS estimated from Point Load Tests ranged from 148 to 204 MPa indicating very strong rock. A summary of the UCS and Point Load test results and photographs of the rock cores are presented in Appendix C.

6.6 Groundwater Level

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the monitoring piezometer installed in Borehole 21-03. It should be noted that water was introduced into the boreholes during coring activities and may not be representative of the water level. A summary of the water level measurements from the field investigation is provided in Table 6.1 below.

Table 6.1 – Groundwater Measurements

Location	Borehole	Date	Water Level (m)		Remark
			Depth	Elevation	
Culvert Inlet	21-01	August 14, 2021	0.6	360.2	Open borehole
	21-02	August 20, 2021	1.8	359.5	Open Borehole
Culvert Outlet	21-03	August 10, 2021	2.9	359.7	Piezometer
TPS	21-05	August 13, 2021	2.7	360.3	Open borehole
	21-06	August 12, 2021	3.2	359.8	Open borehole
Retaining Wall	21-10	August 10, 2021	2.2	360.6	Open borehole
	21-11	August 12, 2021	3.9	359.7	Open borehole

The groundwater level should be anticipated to be controlled by the lake water level. The water level in the lake was recorded at Elev. 360.16 m north of the culvert and Elev. 359.80 m south of the culvert in September 2019. The culvert invert is indicated on the Alignment & Profile to be at an elevation of approximately 359.5 m. Groundwater levels are short-term observations and seasonal fluctuations of the groundwater levels are to be expected. In particular, the groundwater levels may be at a higher elevation during spring and after periods of significant or prolonged precipitation.

6.7 Analytical Testing

Two (2) samples of the native soil, and a sample of the lake water from Crocker Lake West were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.2. The laboratory certificates of analysis are presented in Appendix D.

Table 6.2 – Analytical Testing Results

Parameter	Units (soil)	Units (water)	Test Results		
			21-04 SS4, 2.3 to 2.9 m (Culvert / Retaining Wall)	21-11 SS5, 3.1 to 3.7 m (Retaining Wall)	Crocker Lake West
			Native Sand and Gravel	Native Sand and Gravel	Lake Water
Sulphide	%	µg /L	<0.04	<0.04	<6
Chloride	µg/g	mg/L	360	150	13
Sulphate	µg/g	mg/L	18	11	1.8
pH	no unit	no unit	9.26	8.77	8.37
Conductivity	uS/cm	uS/cm	862	510	275
Resistivity (calculated)	ohms.cm	ohms.cm	1160	1960	-
Redox Potential	mV	mV	263	222	289

7. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. Borehole locations were selected relative to existing site features and the anticipated foundation locations. The northing and easting borehole coordinates were estimated from a hand-held GPS unit. The ground surface elevations at the borehole locations were estimated from a base plan provided by Consor.

All of the boreholes were drilled using a rubber tracked CME 55 drill rig with the exception of Borehole 21-02, which was drilled using a tripod. The CME 55 drill rig and the tripod were supplied and operated by RPM Drilling of Thunder Bay and OGS Inc of Almonte, respectively. The field investigation was supervised on a full-time basis by Mr. Amir Fereidouni of Thurber. The overall supervision of the field program was conducted by Mr. Joshua Alexander, EIT and Mr. Geoff Lay, P.Eng. of Thurber.

Routine geotechnical laboratory testing was carried out by Thurber's geotechnical laboratory in Oakville, Ontario. Analytical testing was carried out by SGS Canada Inc. in Lakefield, Ontario. Interpretation of the field data and preparation of this report was carried out by Mr. Joshua Alexander, EIT and Mr. Geoff Lay, P.Eng. The report was reviewed by Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, Ph.D., P.Eng., a Designated Principal Contact for MTO Foundations Projects.



Thurber Engineering Ltd.
Report Prepared By:

Joshua Alexander, E.I.T.
Geotechnical Engineer Intern



Mr. Jason Lee, M.Sc.(Eng), P.Eng.
Principal / Senior Geotechnical Engineer



Geoff Lay, P.Eng.
Geotechnical Engineer



Dr. P.K. Chatterji P.Eng.
Review Principal / MTO Foundation
Designated Contact



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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8. GENERAL

This report provides an interpretation of the geotechnical data in the factual report and presents foundation design recommendations for the design of the proposed replacement of the Crocker Lake West Culvert in the Township of Cecile, Ontario.

This foundation investigation and design report with the interpretation and recommendations are intended for the use of the Ministry of Transportation, and shall not be used or relied upon for any other purposes or by any other parties including the construction or design-build contractor. The contractors must make their own interpretation based on the factual data in Part 1 of the report. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project. Contractors must make their own interpretation of the factual information provided as it may affect equipment selection, proposed construction methods and scheduling.

Information on the existing culvert site was obtained from the MTO Terms of Reference and the Ontario Structure Inspection Manual prepared by MTO on August 6, 2020. The existing culvert is a 20.4 m long, 3.7 m wide by 1.75 m high concrete rigid frame structure supported on footings. Based on cross-sections included in the Existing Geometrics Review Memo, prepared by Consor, dated July 24, 2021, the existing culvert invert is founded at approximately Elev. 359.6 m and 359.5 m at the north end (inlet) and south end (outlet), respectively. The existing road grade at the culvert location is at approximately Elev. 363 m and the depth of cover over the culvert is approximately 1.5 m. The water level in Crocker Lake in September 2019 was recorded at Elev. 360.16 m north of the culvert and Elev. 359.80 m south of the culvert. The side slopes of the existing embankment range from approximately 2H:1V to 1.5H:1V inclination.

Based on discussions with Consor, it is understood that three alternatives were initially considered for the culvert replacement as follows:



- Alternative 2A: Cast-in-Place Reinforced Concrete Box Culvert (7.0m Wide x 2.0m Rise);
- Alternative 2B: Three 2.4 m Round SPCSP Culverts; and
- Alternative 2C: Twin Precast Reinforced Concrete Box Culverts (3.6m Wide x 1.8m Rise)

A General Arrangement (GA) drawing provided by Consor is included in Appendix J. Based on the GA drawing, the current design includes installation of a precast concrete box culvert along the same alignment as the existing culvert. The precast concrete box culvert will be comprised of 12 box culvert units and the overall box culvert will have a span of 7.0 m and a length of 20.4 m. The base of the culvert will be founded at approximately Elev. 358.8 m. There will be gabion walls installed at each corner of the replacement culvert.

Based on alignment and profile drawings provided by Consor, the grade above the culvert will be raised approximately 1 m and three (3) retaining walls have been proposed along the north and south sides of the embankment to the west and east of the culvert. It is understood that one lane of traffic will need to be maintained at all times during construction; therefore, installation of a temporary protection system and construction staging will be required.

9. CULVERT DESIGN

9.1 Summary of Subsurface Conditions

In general, the subsurface conditions encountered at the borehole locations consisted of asphalt underlain by cohesionless fill. The fill materials are underlain by a deposit of sand and gravel to sand with native silty sand encountered at the inlet of the culvert. The overburden soils are underlain by granite bedrock. Pieces of cobbles were noted in the sand and gravel to gravel deposit. Boulders were noted in the cohesionless fill in Borehole 21-06 and in the sand and gravel to gravel deposit in Boreholes 21-03, 21-04 and 21-06.

Water levels in the piezometers and open boreholes ranged between Elev. 360.6 m and 359.5 m.

The water level in Crocker Lake was recorded at Elev. 360.16 m north of the culvert and Elev. 359.80 m south of the culvert in September 2019.

9.2 Culvert Alternatives

This section presents discussions on available types of replacement culverts and foundation alternatives and provides recommendations on preferred culvert type and foundation options.

As stated above, three different culvert replacement alternatives were initially considered at this site.



A comparison of the culvert types and foundation alternatives based on their respective advantages and disadvantages is included in Appendix G.

There are two primary geotechnical concerns at this site:

1. The excavations for the culvert replacement will extend below the water level in the lake through cohesionless fill and into the sand and gravel to gravel deposit. Dewatering in these deposits is expected to be difficult given the proximity of the culvert to the lake.
2. Driving of sheet piles or H-piles for cofferdams or roadway protection may encounter cobbles and boulders within the cohesionless fill and underlying native sand and gravel to gravel deposit.

In light of the anticipated dewatering challenges, the use of precast box or pipe culverts is recommended at this site. Precast culverts offer several advantages over cast-in-place culverts such as the following:

- Precast box and pipe culverts can often be installed more expeditiously than cast-in-place culverts, resulting in shorter durations for dewatering and construction;
- Precast box and pipe culverts can be installed in wet conditions if necessary, however compacting bedding material under water will not be possible.

The use of cast-in-place culverts is not recommended at this site given the anticipated dewatering challenges and difficulty maintaining a dry excavation. Consequently, this option has not been developed further.

SPCSP culverts are considered feasible however there may be difficulties shaping the bedding beneath the culvert in wet conditions. Consequently, from a foundations perspective, precast box culverts are generally preferred to precast SPCSP culverts for construction in the wet.

Recommendations for the design and installation of precast box and pipe culverts for construction in the wet are presented below.

9.3 Foundation Design for Culverts

Three alternatives were initially considered for the culvert replacement as follows:

- Alternative 2A: Cast-in-Place Reinforced Concrete Box Culvert (7.0m Wide x 2.0m Rise);
- Alternative 2B: Three 2.4 m Round SPCSP Culverts; and



- Alternative 2C: Twin Precast Reinforced Concrete Box Culverts (3.6m Wide x 1.8m Rise)

Based on the General Arrangement (GA) drawing provided by Consor (Appendix J), the current design includes installation of a precast concrete box culvert along the same alignment as the existing culvert. The precast concrete box culvert will be comprised of 12 box culvert units and the overall box culvert will have a span of 7.0 m and a length of 20.4 m. The base of the culvert will be founded at approximately Elev. 358.8 m. There will be gabion walls installed at each corner of the replacement culvert.

The founding soils encountered in the boreholes at this elevation generally consist of compact sand and gravel fill and loose to compact sand and gravel to gravel.

9.3.1 Structural Plate Corrugated Steel Pipe (SPCSP) Culverts

Replacement of the existing culvert with round SPCSP culverts along the same alignment may be considered for this site. If this alternative is selected, the pipes would have to be placed on a minimum thickness of 300 mm bedding layer of clear stone constructed in the wet as described in Section 9.3.3. The bedding layer should be placed on the compact cohesionless fill or loose to compact native sand and gravel to sand deposit.

Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

9.3.2 Precast Reinforced Concrete Box Culverts

Replacement of the existing culvert with precast reinforced box culverts on a similar alignment is considered a viable alternative for this site.

Similar to the SPCSP option, the precast box culvert will have to be placed in the wet on a minimum 300 mm thick bedding layer of coarse 53 mm clear stone as described in Section 9.3.3. The bedding layer should be placed on the compact cohesionless fill or loose to compact native sand and gravel to sand deposit. Construction equipment should not be allowed to travel on the bedding or the prepared subgrade, which should be protected from disturbance during construction.

The following geotechnical resistances as indicated in Table 9.1 are recommended for the preliminary design of a 7.8 wide precast box culvert founded at or below Elevation 358.8 m on a 300 mm thick clear stone bedding layer placed over compact cohesionless fill or loose to compact native sand and gravel to sand deposit.

Table 9.1 – Recommended Geotechnical Resistances

Geotechnical Resistance	7.8 wide Twin Culvert
Factored Geotechnical Resistance at ULS	250 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	150 kPa

A consequence factor of 1.0 was utilized in this design adopting the typical consequence level. The geotechnical resistance factor of 0.5 for bearing and 0.8 for settlement, both adopted for typical degree of understanding, were used to obtain the above values, as per Canadian Highway Bridge Design Code (CHBDC) 2019, Section 6.9.

The factored ultimate resistance and settlement are dependent on the footing/culvert size, configuration and applied loads; the geotechnical resistances should, therefore, be reviewed if the culvert width or founding/invert elevation differs significantly from that given above.

The geotechnical bearing resistances provided above are based on an estimated settlement not exceeding 25 mm and are for concentric, vertical loading. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC 2019, Clause 6.10.3 and Clause 6.10.4.

Resistance to sliding between the precast concrete box culvert and the underlying clear stone bedding material should be calculated assuming an ultimate coefficient of friction of 0.55.

The culvert should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of embankment fill, traffic loadings and surcharge due to construction equipment.

9.3.3 Subgrade Preparation and Bedding Placement in the Wet

As noted in Section 9.2, since dewatering the subgrade soil at this site is expected to be problematic in a lake environment, the culverts should be constructed in the wet. The following are recommendations for constructing in the wet:

- Consideration should be given to raising the culvert invert level as high as possible to limit the amount of excavation required below the lake water level for construction of the culvert bedding;
- Construction should be carried out when the lake level is lowest, to facilitate diversion of lake flow, which will require less unwatering of the excavation;

- The lake flow and surface water should be diverted away from the excavation and may require active pumping. Sandbag cofferdams may be used at the inlet and outlet of the existing culvert to create a stagnant pool of water;
- If the water level cannot be lowered below the bedding level, then placement of backfill and culvert bedding may have to be done in the wet using coarse 53 mm clear stone as described below.

When backfilling is conducted in the wet, clear stone may be used. The minimum thickness of clear stone bedding under the base of the culvert should be 300 mm.

The clear stone should be entirely wrapped in non-woven geotextile. The geotextile should meet the specifications for the OPSS 1860 Class II, and have a fabric opening size (FOS) not greater than 212 micro millimetres.

Clear stone below the water level may be placed by end dumping. All fill above water level must be compacted as per OPSS 501.

10. EMBANKMENT WIDENING AND TOE WALLS

It is understood that retaining walls are proposed at this site to retain the widening embankment fills associated with the proposed 1 m grade raise. The retaining walls are proposed along the south side of the embankment east and west of the culvert, and along the north side of the embankment west of the culvert, where there is limited space to accommodate the additional embankment widening.

The following options were considered for embankment widening at the site:

- Concrete toe walls
- Gabion walls
- Rockfill slope

Based on provided plan and profile drawings, the proposed walls will be constructed close to the edge of the lake. In light of the proximity of the walls to the lake, consideration should be given to installation of gabion walls, which are generally easier to construct in the wet, and more tolerant to differential settlement. Alternatively, the retaining walls could be eliminated and replaced with a sloped rockfill embankment. Further recommendations are provided below.

10.1 Concrete Toe Walls

Excavations for concrete toe walls will take place in close proximity to the lake and are expected to extend below the water level in the lake. Dewatering would be required to construct the toe



walls in the dry and maintaining a dry excavation base for concrete toe wall construction would be difficult. Consequently, concrete toe walls are not recommended, and this option has not been developed further.

10.2 Gabion Walls

Gabion walls are considered feasible to support the grade raise and embankment widening. It is recommended that gabion walls be supported on a minimum 300 mm thick layer of coarse 53 mm clear stone. The clear stone layer should be founded directly on the compact cohesionless fill or native loose to compact sand and gravel to sand deposit.

Gabion walls founded on a minimum 300 mm thick clear stone layer may be designed using the geotechnical resistances provided in Table 10.1.

Table 10.1 – Recommended Geotechnical Resistances

Geotechnical Resistance	2.5 m Wide Gabion Wall
Factored Geotechnical Resistance at ULS	150 kPa
Geotechnical Resistance at SLS (for up to 25 mm settlement)	100 kPa

The geotechnical bearing resistances provided above are based on a gabion base width of 2.5 m and estimated settlement not exceeding 25 mm. The resistances are also for concentric, vertical loading. Where eccentric or inclined loads are applied, the resistance values used in design must be reduced in accordance with the CHBDC 2019, Clause 6.10.3 and Clause 6.10.4.

The resistances should be reviewed if there are any changes to the retaining wall design.

The gabion wall must also be designed against various modes of failure including sliding and overturning. Resistance to sliding between the gabion wall and the underlying clear stone bedding material should be calculated assuming an ultimate coefficient of friction of 0.5. In addition, the gabion wall should be designed to resist external loadings including frost forces, lateral earth pressures, hydrostatic pressure, weight of backfill, and surcharge due to construction equipment.

It is noted that preparation of the subgrade below the gabion wall will be difficult in the lake environment.



A OPSS 1860 Class II non-woven geotextile with a maximum FOS of 212 micro millimeters should be installed behind the gabion wall to mitigate migration of fines into the backfill. The geotextile should be placed on the face of the excavation benches and the subgrade and wrapped behind the back of the wall.

The gabion wall should be installed in accordance with OPSS.PROV 512 and the gabion basket material specification should meet the requirements of OPSS.PROV 1430. Excavation and backfilling for the gabion wall should be carried out in accordance with OPSS.PROV 902. Special attention and care should be given to temporary excavation operations in order to not destabilize the existing embankment slopes.

Lateral earth pressures acting on the retaining walls should be computed based on parameters provided in Section 13. Since the walls are retaining sloping backfill, the appropriate earth pressure parameters for sloping backfill shows in Table 13.1 should be used.

Slope stability analyses were carried out to assess the global stability of a gabion wall. The stability analyses were carried out utilizing the commercially available slope stability program Slope/W (Version 10) of the GeoStudio software package developed by GEOSLOPE International Ltd using Morgenstern Price method of slices.

In light of the predominantly cohesionless soils present at the site, a Factor of Safety (F.S.) of 1.3 is considered appropriate for embankments for the long-term (drained) condition. Short-term (undrained) condition does not apply at this site.

The results of the analysis are presented in Figure I1 in Appendix I. The results indicate that a 2.5 m wide gabion wall will achieve the F.S. of 1.3 for the long-term (drained) condition. Based on the results of the analysis, gabion walls are expected to be stable provided the gabion wall has a minimum width of 2.5 m and the base of the wall is founded at a depth of approximately 500 mm below final ground surface in front of the wall on a 300 mm thick clear stone bedding layer.

The global stability of the wall should be reassessed once the wall design geometry is known.

10.3 Rockfill Slope

Consideration may be given to eliminating the proposed retaining walls and using rockfill slope constructed to 1.25H:1V. The results of a stability analysis for a rockfill slope are presented in Figure I2 in Appendix I. The analysis results indicate that a 1.25H:1V slope constructed with rock fill will achieve the minimum F.S. of 1.3 for the long-term (drained) condition. In order to achieve the target F.S., the proposed rock fill slope must be horizontally keyed (benched) 2m into the



existing embankment in accordance with OPSD 208.010, and the minimum thickness of the rockfill should be 1.5 m. The 1.25H:1V rockfill slopes should be gradually transitioned to match the 2H:1V embankment slopes beyond the toe walls.

Rockfill embankments should be constructed in accordance with OPSS.PROV 206. Rockfill used for embankment construction should be placed in a controlled manner (not end dumped) including blading and dozing of the rock to minimize voids and bridging. Rock fill must be compacted as per OPSS.PROV 206. The rockfill fragments shall not be greater than 250 mm in size, and shall be composed of durable rock materials (e.g., shale and sandstone rocks shall not be used).

At the pavement subgrade level or where granular fill is to be placed over rock fill, the rock fill subgrade must be blinded with spall material and rock fill chinking should be in accordance with OPSS.PROV 206.

The embankment construction should occur from bottom upwards. It is recommended that new fill placement occur in conjunction with slope benching such that first row of bench be backfilled prior to excavating the next bench.

Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, the existing slope must be benched in accordance with OPSD 208.010 prior to new fill placement.

11. EXCAVATION AND GROUNDWATER CONTROL

All excavations should be carried out in accordance with the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the embankment fill and native soils at this site are classified as Type 3 soils above the water level and Type 4 soils below the water level.

Excavation and backfilling for culvert and retaining wall construction should be carried out in accordance with SP FOUN0003 and OPSS.PROV 902. Excavations for culvert replacement will be carried out through the existing cohesionless embankment fill and into the native sand and gravel to sand deposit. Pieces of cobbles and boulders were noted in the sand and gravel to gravel deposit and boulders were noted in the cohesionless fill. The excavation equipment selected must be capable of penetrating the cobbles and boulders any other potential obstructions in the fill and native soil layers. The selection of the excavation equipment and the means and method of excavation is the responsibility of the Contractor. Suggested wording for an NSSP on obstructions is included in Appendix F.

The design of any dewatering systems is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the dewatering system



in accordance with SP FOUN0003, which amends OPSS 902, and SP 517F01, which amends OPSS 517. Suggested wording for an NSSP on dewatering is provided in Appendix F.

A preconstruction survey is not required at this site, this Designer Fill-In ** in SP FOUN0003 should be "N/A".

It is anticipated that excavation for culvert replacement will be carried out at or below the lake water level, and diversion of the channel flow will be required. Seepage should be anticipated from the embankment fill and the highly permeable native soils. Given the anticipated difficulties lowering the water level below the base of the culvert excavation, the culvert bedding (i.e. 53 mm clear stone) will need to be placed in the wet as previously described.

12. COFFERDAMS AND CHANNEL DIVERSION

Construction of cofferdams will be required to divert the lake water and facilitate construction of the culvert bedding in the wet in a stagnant pool of water. The design and selection of the cofferdam system is the responsibility of the Contractor. The Contractor should consider the ground conditions in selecting the type of cofferdam for this site.

13. BACKFILL AND LATERAL EARTH PRESSURES

Backfill to the replacement culvert and retaining walls above the lake water level should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II conforming to the requirements of OPSS PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 802.010 or 803.010 and CHBDC, as appropriate. Backfilling for the culvert should be in accordance with OPSS.PROV 902. All fills should be placed in regular lifts not exceeding 300 mm in thickness and be compacted in accordance with OPSS PROV 501. Compaction of the granular materials will not be feasible below the water level. Where the culvert backfill is placed below water, compaction should not commence until the backfill has been placed to approximately 500 mm above the water level. The backfill should be placed and compacted in simultaneous lifts on both sides of the culvert, and the top of backfill elevation should not differ more than 500 mm on both sides at all times for a box culvert or 200 mm on both sides at all times for a CSP. Heavy compaction equipment should not be used adjacent to the walls and within 300 mm of the roof of the culvert. Compaction equipment to be used adjacent to the culvert should be restricted in accordance with OPSS.PROV 501.

A OPSS 1860 Class II non-woven geotextile with a maximum FOS of 212 micro millimeters should be installed on the face of the excavation and the subgrade to mitigate migration of fines into the backfill. The geotextile should wrap over the top of the clear stone and separate the clear stone and overlying Granular A or B Type II.

Lateral earth pressures acting on the culvert walls and retaining walls may be assumed to be a triangular distribution. For a fully drained backfill, the pressures should be computed in accordance with the CHBDC 2019, but are generally given by the following expression:

$$p_h = K (\gamma h + q)$$

where	p_h	=	horizontal pressure on the wall at depth h (kPa)
	K	=	earth pressure coefficient (see table below)
	γ	=	bulk unit weight of retained soil (see table below)
	h	=	depth below top of fill where pressure is computed (m)
	q	=	value of any surcharge (kPa)

Earth pressure coefficients for backfill to the culvert walls and retaining walls are dependent on the material used as backfill. Recommended unfactored values are shown in Table 13.1 below.

Table 13.1 – Lateral Earth Pressure Coefficients (K)

Loading Condition	OPSS Granular A or Granular B Type II $\phi = 35^\circ; \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I or Type III $\phi = 32^\circ; \gamma = 21.2 \text{ kN/m}^3$		Rock Fill $\phi = 42^\circ; \gamma = 19 \text{ kN/m}^3$		
	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill (2H:1V)	Horizontal Backfill	Sloping Backfill	
						2H:1V	1.5H:1V
Active (Unrestrained Wall)	0.27	0.40	0.31	0.48	0.20	0.26	0.31
At-rest (Restrained Wall)	0.43	0.62	0.47	0.70	0.33	0.48	0.51
Passive	3.7	-	3.3	-	5.0	-	-

Note: Submerged unit weight should be used below the groundwater level/high lake level.

For rigid structures such as concrete box culverts, at-rest horizontal earth pressures should be used for design. Active pressures should be used for any unrestrained wall.

In accordance with Clause 6.12.3 of the CHBDC 2019, a compaction surcharge should be added.

14. SEISMIC CONSIDERATIONS

In accordance with the CHBDC 2019, the selection of the seismic site classification is based on the soil conditions encountered in the upper 30 m of the stratigraphy. The stratigraphy of the site generally consists of cohesionless fill overlying approximately loose to dense sand and gravel to

sand which is underlain by granite bedrock at a depth of about 13 m below road grade. This would correspond to a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of the CHBDC. The peak ground acceleration, PGA, for a 2% in 50-year probability of exceedance at this site is 0.035 g as per the National Building Code of Canada (NBCC).

In accordance with Clause 4.6.5 of the CHBDC 2014, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading. The coefficients of horizontal earth pressure for seismic loading presented in Table 14.1 may be used:

Table 14.1 – Earth Pressure Coefficients for Earthquake Loading

Condition	Earth Pressure Coefficient (K)	
	OPSS Granular A or Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$	OPSS Granular B Type I or Type III $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$
Active (K_{AE})*	0.29	0.33
Passive (K_{PE})	3.6	3.2
At Rest (K_{OE})**	0.49	0.53

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.

** After Woods

In view of the low potential for seismic activity in the area, liquefaction is not considered to be a concern at this site.

15. TEMPORARY PROTECTION SYSTEM

A temporary protection system will need to be installed at the site to maintain a single lane of traffic on Highway 17 during construction of the replacement culvert.

The temporary protection system should be implemented in accordance with OPSS PROV 539 and designed for Performance Level 2.

Options for roadway protection are a soldier pile-lagging system or interlocking sheet piles. The protection system may encounter cobbles and boulders in the fill and native soils and the Contractor's method of installation will need to be able to penetrate or dislodge the cobbles and boulders and any other potential obstructions.

The soil parameters in Table 15.1 may apply for the design of the temporary protection system with horizontal backfill.

Table 15.1 –Soil Parameters for Temporary Protection System Design

Soil Parameter	Existing Cohesionless Fill	Native Sand and Gravel to Sand
Φ (angle of internal friction)	32°	31°
γ (total unit weight)	21.5 kN/m ³	21 kN/m ³
γ_w (Submerged unit weight)	11.5 kN/m ³	11 kN/m ³
K_a	0.30	0.32
K_p	3.3	3.1

Full hydrostatic pressure should be considered assuming a water level at least equal to the design lake water level.

The temporary protection system may be removed or partially removed upon completion of the work. Care must be taken when removing the temporary protection system, as to not incur damage to the subgrade of the newly installed culvert.

The design and construction of temporary protection system is the responsibility of the Contractor. The actual pressure distribution acting on the protection/shoring system is a function of the construction sequence and the relative flexibility of the wall, and these factors have to be considered when designing the shoring system. All protection systems should be designed by a Professional Engineer experienced in such designs. The Contractor shall retain a Professional Engineer to carry out the design of the shoring system.

16. EMBANKMENT CONSTRUCTION

Based on the alignment and profile drawings, the proposed design includes grade raise of approximately 1 m and placement of fill on the embankment side slopes. Prior to new fill placement, all vegetation, topsoil, organics, soft/loosened, wet soils or other deleterious materials should be removed from proposed footprint of the new fill and stripped from the surface of the existing embankment. The work should be carried out in the dry.

Embankment construction should be in accordance with OPSS.PROV 206. The embankments may be constructed using OPSS Granular A or B Type II constructed to 2H:1V or rockfill



constructed to 1.25H:1V The granular fill should be placed in lifts no thicker than 300 mm and compacted to 98% SPMDD.

The results of a slope stability analysis for a granular fill embankment are provided in Figure I3 in Appendix I. The results indicate that a granular fill embankment with 2H:1V side slopes will achieve the minimum F.S. of 1.3.

Rockfill slopes may be used for portions of the widening wherever limited space precludes construction of the 2H:1V slope within the right of way. Recommendations for rockfill are provided in Section 10.3.

Where new embankment fill is placed against existing embankment slopes or on a sloping ground surface steeper than 3H:1V, the existing slope must be benched in accordance with OPSD 208.010 prior to new fill placement.

16.1 Settlement

Provided that all buried topsoil, organics, disturbed material or otherwise loose/soft soils are stripped from the areas within the culvert footprint, the post-construction foundation settlement due to the proposed 1 m grade raise is expected to be less than 25 mm. The post-construction settlement will essentially be complete at the end of construction.

In accordance with the MTO document "Post-Construction Rock Fill Settlement and Guidelines for Estimating Rock Fill Quantity" (April 12, 2010), the magnitude of self-weight compression of compacted rock fill is expected to be approximately 0.75% of the embankment height within 1 year of embankment construction (90% in the first 6 months), and a further 0.1% of the embankment height after the 1 year period. For dumped rock fill (placed under the water level), these settlement values would be approximately doubled.

17. SCOUR AND EROSION PROTECTION

Erosion protection should be provided at the culvert inlet and outlet. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field and in accordance with OPSD 810.010, OPSS 511 and OPSS.PROV 1004.

Typically, rock protection should be provided over all surfaces with which lake water is likely to be in contact. A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion in general accordance with OPSS.PROV 804.



A concrete cut-off wall and a clay seal (only at the inlet) should be used to minimize the potential for erosion or piping around the culvert. The clay seal should extend to approximately 0.3 m above the high water level and laterally for the width of the granular material, and have a minimum thickness of 0.5 m. The material requirements should be in accordance with OPSS.PROV 1205. A geosynthetic clay liner may be used in place of a compacted clay seal.

Selection of streambed material should be in accordance with OPSS.PROV 1005.

Liaison between the Foundations Consultant, Structural Engineer and Hydraulic / Drainage Engineer will be required in design to ensure that scour protection is adequately addressed.

18. CORROSION AND SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the native soil and lake water samples indicate the following conditions at the locations tested:

- The potential for corrosion on concrete foundations from the surrounding surface water is considered to be low. The risk of sulphate attack on concrete from the native soil or surface water is low. The effect of road deicing salt should also be considered while selecting the class of concrete.
- The potential for lake water and native soil corrosion on metal is considered to be severe in light of the low resistivity values.
- Appropriate protection measures are recommended for concrete and metal structural elements. The effect of road deicing salt should be considered while selecting the corrosion protection measures.

19. CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

- Dewatering is not feasible or advisable at this site given the presence of cohesionless fill and native soils and the proximity of the culvert excavations to the lake.
- Due to the anticipated high volume of discharge water that may be generated from dewatering, it is important that construction be conducted during the low water level season. The lake level may fluctuate and be at a higher or lower elevation at the time of construction than indicated in this report.
- A suitable approach to constructing in the wet must be employed to enable culvert construction.

- Cobbles and boulders were encountered in the fills and native soils; therefore, cobbles and boulders should be anticipated and dealt with during construction as they may interfere with excavation and installation of roadway protection systems. The Contractor must be prepared to remove or otherwise penetrate these obstructions.
- The Contractor's selection of construction equipment and methodology should include assessment of the capability of the existing embankment to support the proposed construction equipment and any temporary structures or fill (i.e., as a pad for crane support). Site conditions may limit the type of equipment suitable for use during construction. The design and safety of any temporary works is the responsibility of the Contractor.

20. CLOSURE

Engineering analysis and preparation of this report were carried out by Mr. Geoff Lay, P.Eng. The report was reviewed Mr. Jason Lee, P.Eng., and Dr. P.K. Chatterji, P.Eng., the Designated Principal Contact for MTO Foundation Projects.

Thurber Engineering Ltd.
Report Prepared By:



Geoff Lay, P.Eng.
Geotechnical Engineer



Mr. Jason Lee, M.Sc.(Eng), P.Eng.
Principal / Senior Geotechnical Engineer

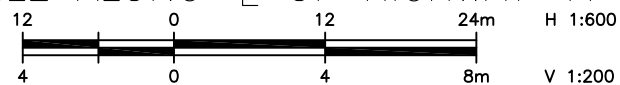
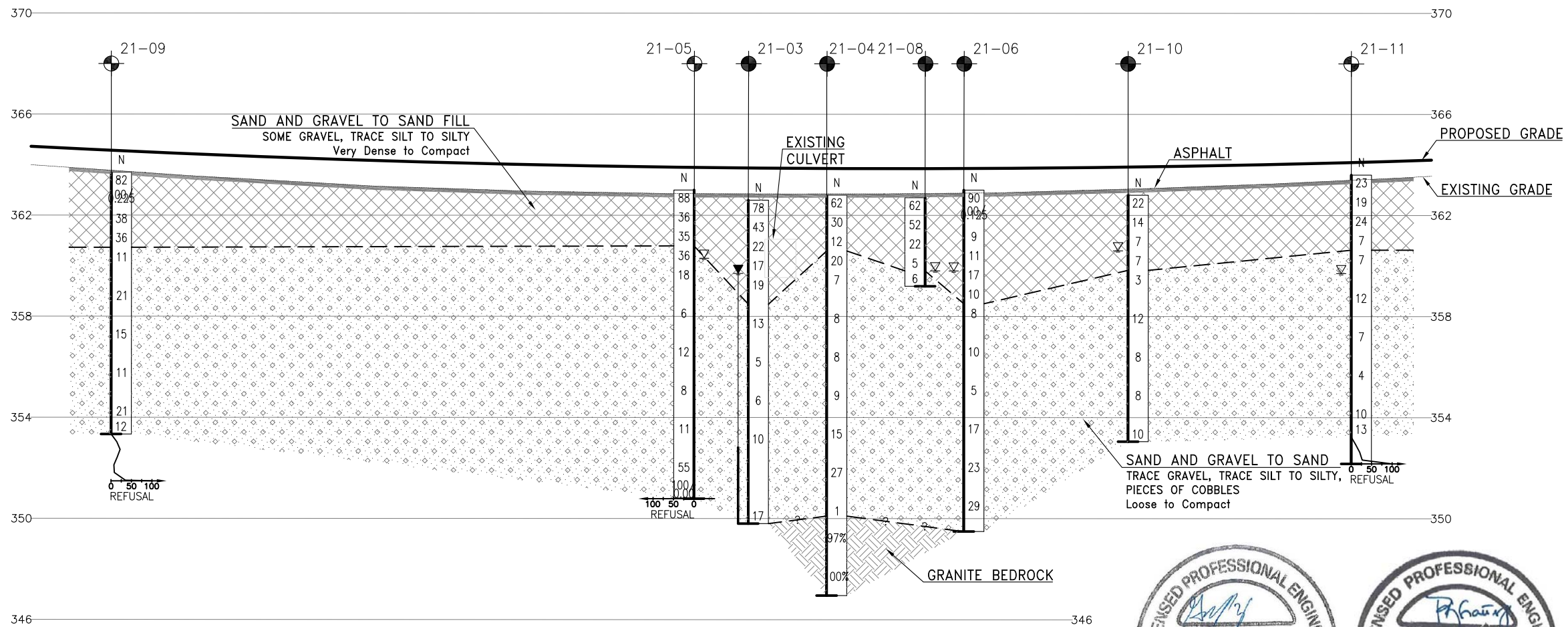
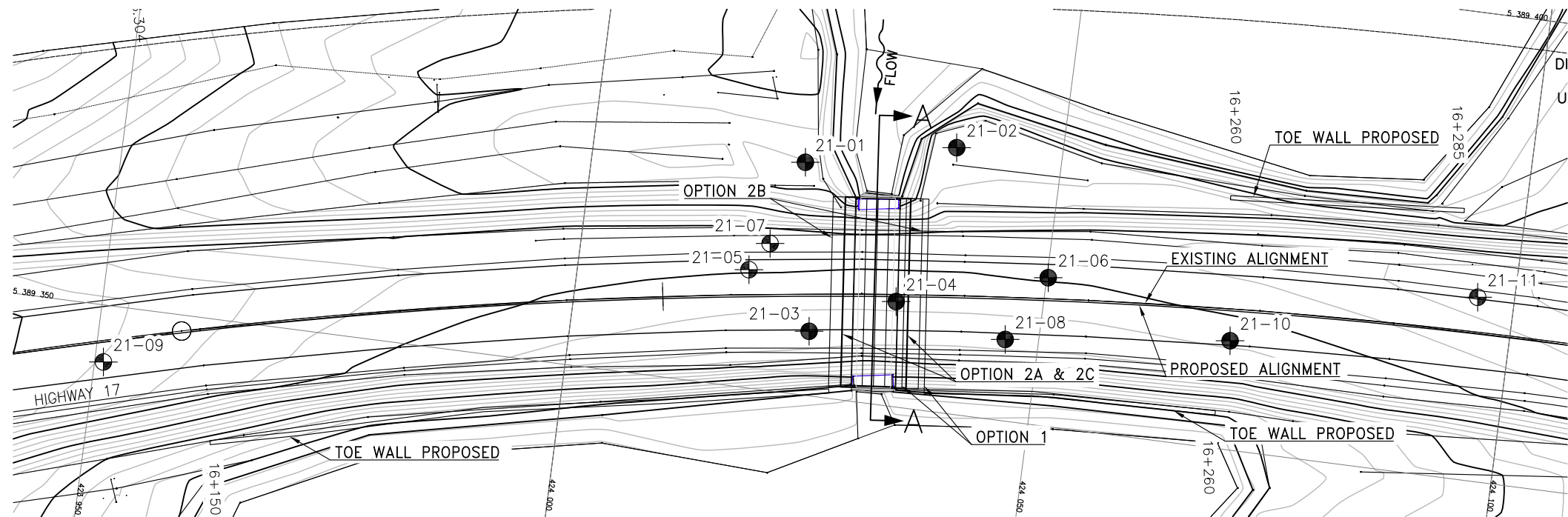


Dr. P.K. Chatterji P.Eng.
Review Principal / MTO Foundation
Designated Contact



Appendix A

Borehole Location and Soil Strata Drawings



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

CONT No
WP No

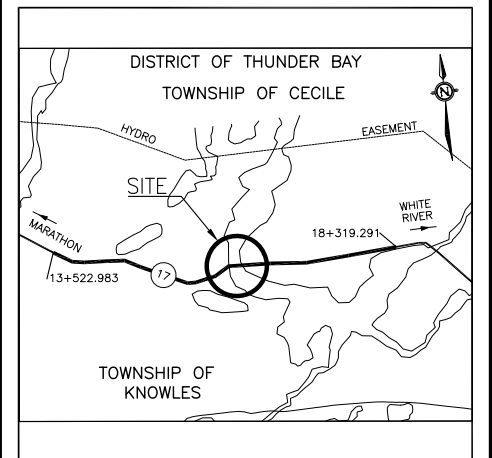
HIGHWAY 17
CROCKER LAKE
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
21-01	360.8	5 389 374.8	424 022.8
21-02	361.3	5 389 378.4	424 038.7
21-03	362.6	5 389 356.9	424 025.5
21-04	362.8	5 389 361.2	424 034.3
21-05	363.0	5 389 286.5	424 028.0
21-06	363.0	5 389 365.8	424 050.2
21-07	363.1	5 389 365.7	424 020.1
21-08	362.6	5 389 358.7	424 046.4
21-09	363.7	5 389 343.9	423 950.9
21-10	362.8	5 389 361.6	424 070.3
21-11	363.6	5 389 369.7	424 096.0

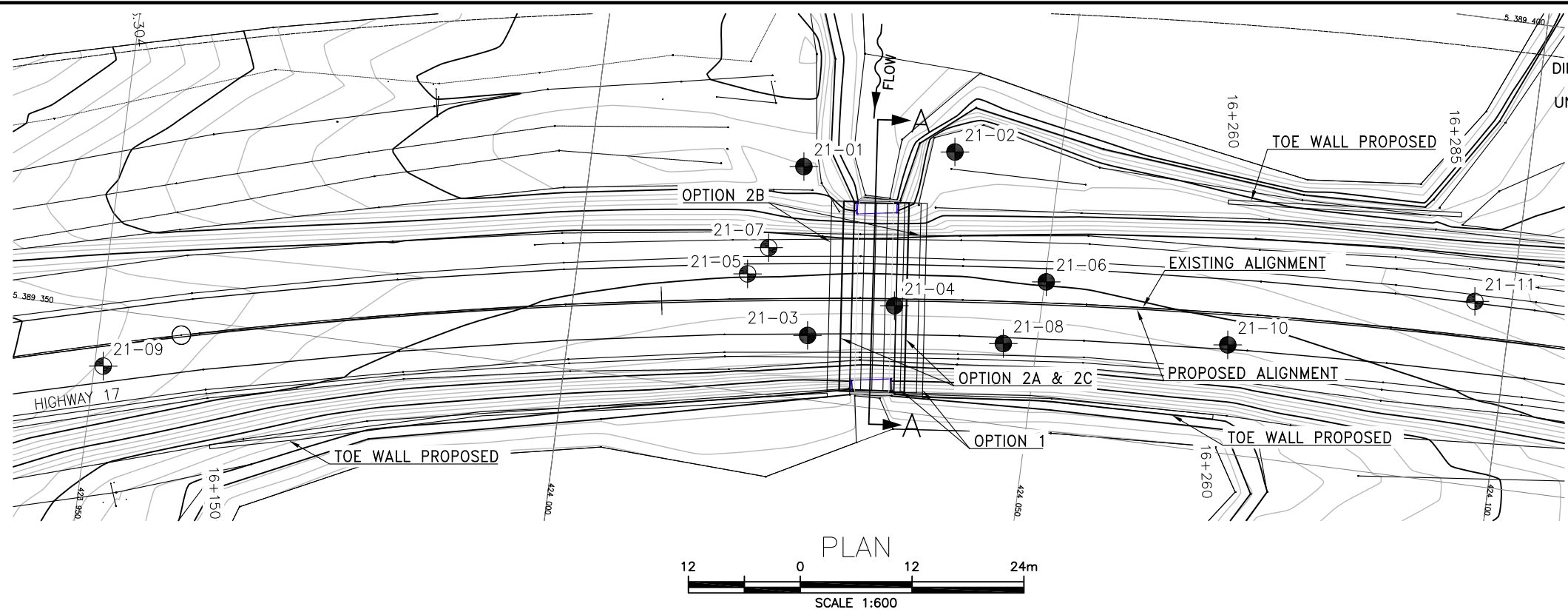
-NOTES-

- 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. 42C-49



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GF	CHK -	CODE
DRAWN	BH	CHK GF	SITE
			LOAD
			STRUCT
			DWG 1
			DATE JAN 2022



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

CONT No
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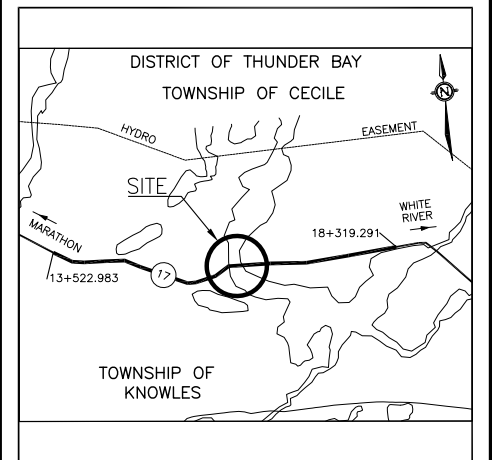
HIGHWAY 17
CROCKER LAKE
CULVERT REPLACEMENT
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

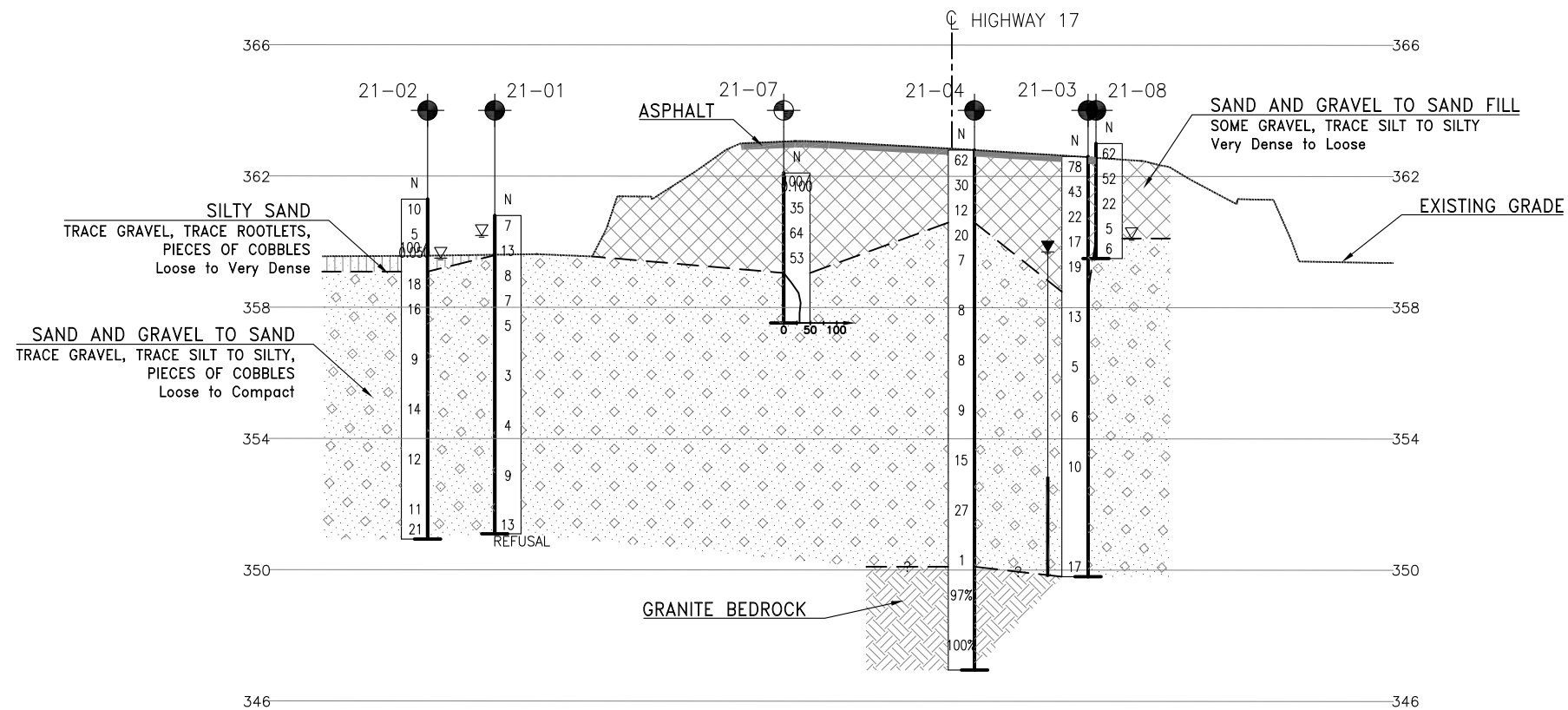
	Borehole
	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
21-01	360.8	5 389 374.8	424 022.8
21-02	361.3	5 389 378.4	424 038.7
21-03	362.6	5 389 356.9	424 025.5
21-04	362.8	5 389 361.2	424 034.3
21-05	363.0	5 389 286.5	424 028.0
21-06	363.0	5 389 365.8	424 050.2
21-07	363.1	5 389 365.7	424 020.1
21-08	362.6	5 389 358.7	424 046.4
21-09	363.7	5 389 343.9	423 950.9
21-10	362.8	5 389 361.6	424 070.3
21-11	363.6	5 389 369.7	424 096.0

-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. 42C-49



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	GF	CHK -	CODE
DRAWN	BH	CHK GF	SITE
LOAD	DATE	JAN 2022	
STRUCT	DWG 2		



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

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


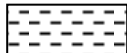



 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (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	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Very thinly bedded	20 to 60mm				
Laminated	6 to 20mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Thinly Laminated	Less than 6mm				

<u>TERMS</u>					
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
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.	Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail
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 21-01

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 034.0 E 202 918.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2021.08.14 - 2021.08.14 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100	20	40	60			
360.8	GROUND SURFACE																
0.0	SAND , some silt, trace gravel Loose Brown Moist (FILL)		1	SS	7												
360.0	SAND and GRAVEL to SAND , trace gravel, trace silt to silty Compact to Very Loose Brown Wet		2	SS	13											21 69 9 1	
			3	SS	8												
			4	SS	7											10 60 30 (SI+CL)	
			5	SS	5												
			6	SS	3												
			7	SS	4												
			8	SS	9											5 93 2 (SI+CL)	
			9	SS	13												
351.1	END OF BOREHOLE AT 9.7m UPON SPOON AND DCPT REFUSAL ON																
9.7																	

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-01

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 034.0 E 202 918.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2021.08.14 - 2021.08.14 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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			20	40	60	80	100					
	Continued From Previous Page																
	PROBABLE BEDROCK. WATER LEVEL AT 0.6m UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.																

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RECORD OF BOREHOLE No 21-02

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 037.0 E 202 934.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Hilti COMPILED BY BH
 DATUM Geodetic DATE 2021.08.20 - 2021.08.20 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
361.3	GROUND SURFACE															
0.0	Silty SAND , trace gravel, trace rootlets Loose Brown Moist		1	SS	10											
			2	SS	5											
	No recovery from 1.5m to 2.3m Pieces of cobble		3	SS	100/0.050											
359.1																
2.2	SAND and GRAVEL to SAND , trace gravel, trace silt to silty Compact to Loose Brown Wet		4	SS	18											
			5	SS	16											
			6	SS	9											
			7	SS	14											
			8	SS	12											
			9	SS	11											

Continued Next Page

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

RECORD OF BOREHOLE No 21-02

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 037.0 E 202 934.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Hilti COMPILED BY BH
 DATUM Geodetic DATE 2021.08.20 - 2021.08.20 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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			20	40	60	80	100	W _p	W	W _L		
	Continued From Previous Page		10	SS	21												
351.0																	
10.4	END OF BOREHOLE AT 10.4m. WATER LEVEL AT 1.8m UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.																


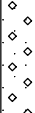
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RECORD OF BOREHOLE No 21-03

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 016.0 E 202 920.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.09 - 2021.08.09 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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												
362.6	GROUND SURFACE							20	40	60	80	100								
0.0	ASPHALT(200mm)																			
0.2	Gravelly SiltySAND Very Dense to Compact Light Brown Moist (FILL)		1	SS	78															
			2	SS	43															
			3	SS	22															
			4	SS	17															
	switch to casing																			
	Wet																			
			5	SS	19															
358.5																				
4.1	SAND and GRAVELto SAND, trace gravel, trace silt to silty Loose to Compact Brown Wet																			
			6	SS	13															
			7	SS	5															
	pieces of cobble																			
			8	SS	6															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-03

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 016.0 E 202 920.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.09 - 2021.08.09 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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					WATER CONTENT (%)				
							20	40	60	80	100	W _p	W	W _L			
	Continued From Previous Page																
							352										
							351										
349.8			10	SS	17		350					○				50 31 19 (SI+CL)	
12.8	END OF BOREHOLE AT 12.8m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.05m slotted screen. WATER LEVEL READINGS DATE DEPTH(m) ELEV.(m) 2021.08.10 2.9 359.7																

RECORD OF BOREHOLE No 21-04

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 020.0 E 202 929.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.11 - 2021.08.11 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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								
362.8	GROUND SURFACE							20	40	60	80	100	PLASTIC LIMIT W _P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	
0.0	ASPHALT(200mm)							20	40	60	80	100	WATER CONTENT (%)			
0.2	SAND, some silt, some to trace gravel Very Dense to Compact Brown Moist (FILL)		1	SS	62		362									
			2	SS	30											
			3	SS	12		361									
360.6																
2.2	SAND and GRAVEL to SAND, trace gravel, trace silt to silty Compact to Loose Brown Wet		4	SS	20		360									
			5	SS	7											
							359									
			6	SS	8		358									32 65 3 (SI+CL)
			7	SS	8		357									
							356									
			8	SS	9		355									
							354									
	Compact		9	SS	15											34 60 6 (SI+CL)
	Boulders from 9.9m to 10.6m						353									

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10



(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-04

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 020.0 E 202 929.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.11 - 2021.08.11 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL LIMIT MOISTURE LIQUID CONTENT 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 (%)					
								○ UNCONFINED + FIELD VANE					w _p w w _L					
								● QUICK TRIAXIAL × LAB VANE										
	Continued From Previous Page							20	40	60	80	100		20	40	60		
350.1	pieces of cobbles		10	SS	27		352							○				
							351											
	Very Loose		11	SS	1													
12.7	GRANITE slightly weathered to fresh, grey, medium strong to very strong		1	RUN		350											FI	
	sub horizontal fractures (325mm) at 12.9m and (25mm) at 14.2m																	
	horizontal fractures at 13.0m, 13.4m, 13.5m, and 13.8m						349											0
	horizontal fractures at 14.4m, 14.5m, 14.8m, 15.1m, 15.2m, 15.4m, and 15.5m		2	RUN														2
347.0																		
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE BACKFILLED WITH CUTTINGS AND HOLEPLUG.						347										1	
																	2	
																	0	

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RECORD OF BOREHOLE No 21-05

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 022.0 E 202 913.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.13 - 2021.08.13 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
363.0	GROUND SURFACE															
0.0	ASPHALT(175mm)															
0.2	SAND, some silt, some to trace gravel Very Dense to Dense Brown Moist (FILL)		1	SS	88											
			2	SS	36											13 53 34 (SI+CL)
			3	SS	35											
360.8																
2.2	SAND and GRAVEL to SAND, trace gravel, trace silt to silty, pieces of cobbles Dense to Loose Brown Wet		4	SS	36											
			5	SS	18											
			6	SS	6											4 59 36 1
			7	SS	12											
			8	SS	8											
			9	SS	11											34 40 26 (SI+CL)

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-05

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 022.0 E 202 913.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.13 - 2021.08.13 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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			20	40	60	80	100	W _p	W	W _L		
	Continued From Previous Page																
	pieces of cobble Very Dense		10	SS	55		352										
350.8							351										
12.2	END OF BOREHOLE AT 12.8m UPON SPOON AND DCPT REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 2.7m UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.		11	SS	100/ 0.00												

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RECORD OF BOREHOLE No 21-06

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 024.0 E 202 945.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2021.08.12 - 2021.08.12 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100	20	40	60			
363.0	GROUND SURFACE																
0.0	ASPHALT(150mm)																
0.2	SAND, some silt, trace gravel Very Dense to Loose Brown Moist (FILL) boulder (500mm) from 1.0m to 1.5m		1	SS	90												
			2	SS	100/ 0.125												
	no recovery		3	SS	9												
			4	SS	11												
	pieces of wood		5	SS	17												
			6	SS	10												
358.5																	
4.5	SAND and GRAVEL to SAND, trace gravel, trace silt to silty, pieces of cobbles Loose to Compact Brown Wet		7	SS	8												
			8	SS	10												
			9	SS	5												
	occasional cobbles and boulders		10	SS	17												

Continued Next Page

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

RECORD OF BOREHOLE No 21-06

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 024.0 E 202 945.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2021.08.12 - 2021.08.12 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100						
	Continued From Previous Page																
			11	SS	23		352										
							351										
			12	SS	29												
							350										
349.5																	
13.5	END OF BOREHOLE AT 13.5m UPON SPOON AND CASING REFUSAL ON PROBABLE BEDROCK. WATER LEVEL AT 3.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.																

RECORD OF BOREHOLE No 21-07

1 OF 1

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 025.0 E 202 915.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2021.08.12 - 2021.08.12 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE								
							20	40	60	80	100	20	40	60		
363.1	GROUND SURFACE															
0.0	ASPHALT(125mm)		1	SS	100/											
0.1	Gravelly SAND to SAND , some gravel, some silt Very Dense to Dense Brown Moist (FILL)		2	SS	35											24 57 19 (SI+CL)
			3	SS	64											
			4	SS	53											12 72 16 (SI+CL)
360.1	END OF SAMPLING START OF DCPT															
3.0																
358.6	END OF DCPT AT 4.6m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.															
4.6																

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-08

1 OF 1

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 017.0 E 202 941.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers COMPILED BY BH
 DATUM Geodetic DATE 2021.08.11 - 2021.08.11 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100		20	40	60		
362.6	GROUND SURFACE																
0.0	ASPHALT(150mm)																
0.2	SAND and GRAVEL, some silt Very Dense Brown Moist (FILL)		1	SS	62												
			2	SS	52												
	Compact																
			3	SS	22												
	Loose																
			4	SS	5												
359.7																	
2.9	SAND, trace silt, trace gravel Loose Brown Wet		5	SS	6												
359.1																	
3.5	END OF BOREHOLE AT 3.5m. WATER LEVEL AT 2.9m UPON COMPLETION.																

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

CONTMT4S2 2020LIBRARY(MTO) - COPY.GLB MTO-31730.GPJ 1/14/22

RECORD OF BOREHOLE No 21-09

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 006.0 E 202 845.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.13 - 2021.08.13 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
	Continued From Previous Page		10	SS	12												
353.4	10.4																
	END OF SAMPLING START OF DCPT																
351.5	12.2																
	END OF DCPT AT 12.2m UPON DCPT REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.																

+³, ×³: Numbers refer to
Sensitivity



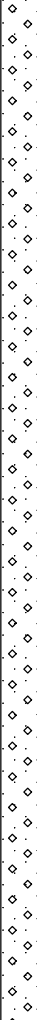
20
15
10
5
0
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-10

1 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 019.0 E 202 965.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.10 - 2021.08.10 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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							WATER CONTENT (%)					
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							W _P	W	W _L			
362.8	GROUND SURFACE							20	40	60	80	100		20	40	60				
0.0	ASPHALT(125mm)							20	40	60	80	100		20	40	60				
0.1	SAND, silty, trace gravel Compact to Loose Brown Moist (FILL)		1	SS	22									○				8 59 33 (SI+CL)		
												○								
			2	SS	14									○						
														○						
			3	SS	7										○					
															○					
			4	SS	7											○				
359.8										360										
3.0	SAND and GRAVEL to SAND, trace gravel, trace silt to silty Very Loose to Compact Brown Wet Switch to Casing		5	SS	3									○				14 47 39 (SI+CL)		
			6	SS	12										○					
			7	SS	8										○					
			8	SS	8			355						○						
					</															

Continued Next Page

+³, ×³: Numbers refer to
Sensitivity

20
15
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 21-10

2 OF 2

METRIC

W.P. _____ LOCATION MTM NAD83-13; N 5 389 019.0 E 202 965.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.10 - 2021.08.10 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

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			20	40	60	80	100					
	Continued From Previous Page																
	WATER LEVEL AT 2.2m UPON COMPLETION. BOREHOLE BACKFILLED WITH SAND AND HOLEPLUG.																

ONTMT4S2 2020LIBRARY(MTO) - COPY.GLB MTO-31730.GPJ 1/14/22

METRIC

[illegible]

+³, ×³: Numbers refer to Sensitivity

RECORD OF BOREHOLE No 21-11

2 OF 2

METRIC

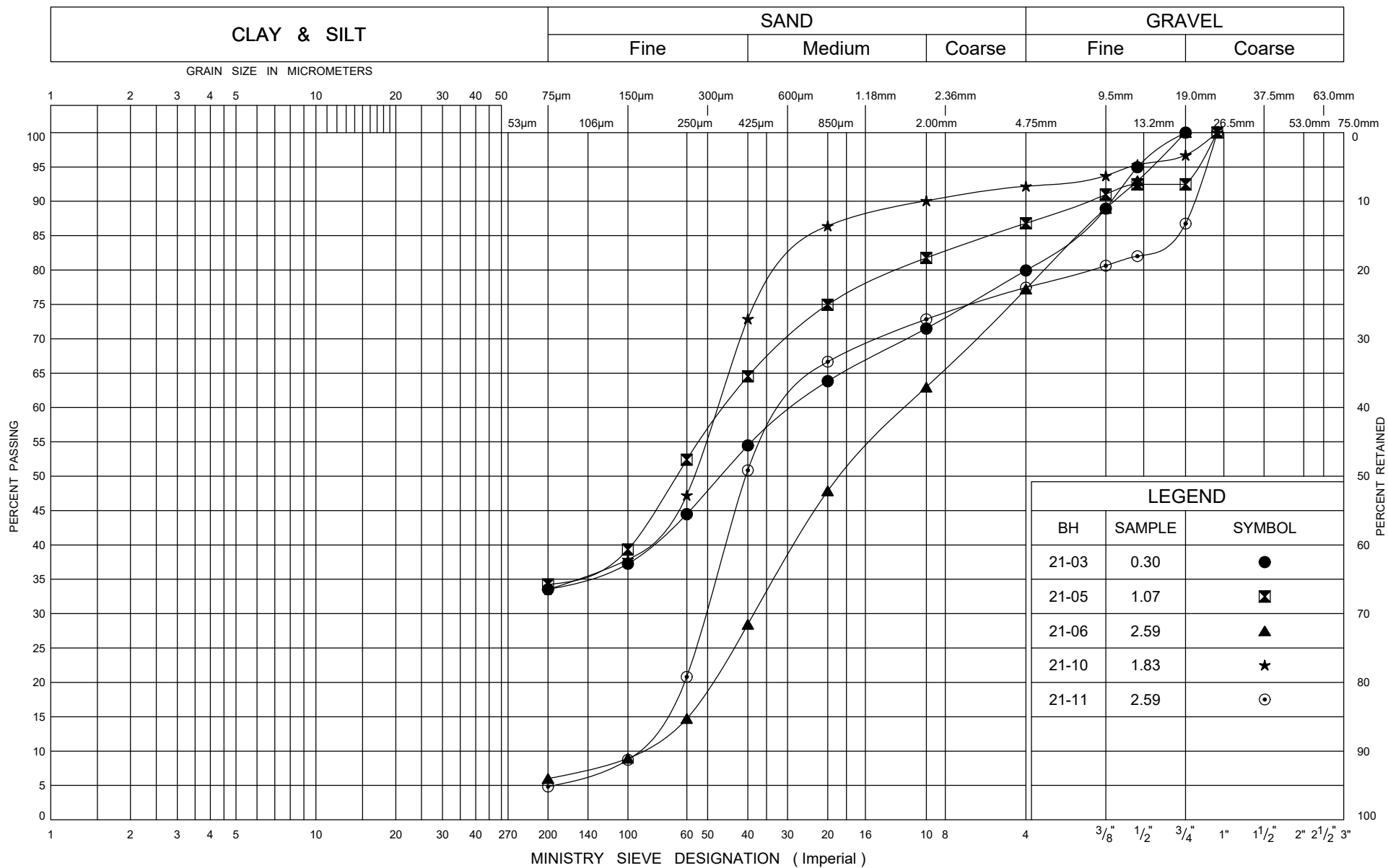
W.P. _____ LOCATION MTM NAD83-13; N 5 389 026.0 E 202 991.0 ORIGINATED BY AF
 DIST _____ HWY _____ BOREHOLE TYPE Solid Stem Augers/NW Casing COMPILED BY BH
 DATUM Geodetic DATE 2021.08.12 - 2021.08.12 LATITUDE _____ LONGITUDE _____ CHECKED BY GRL

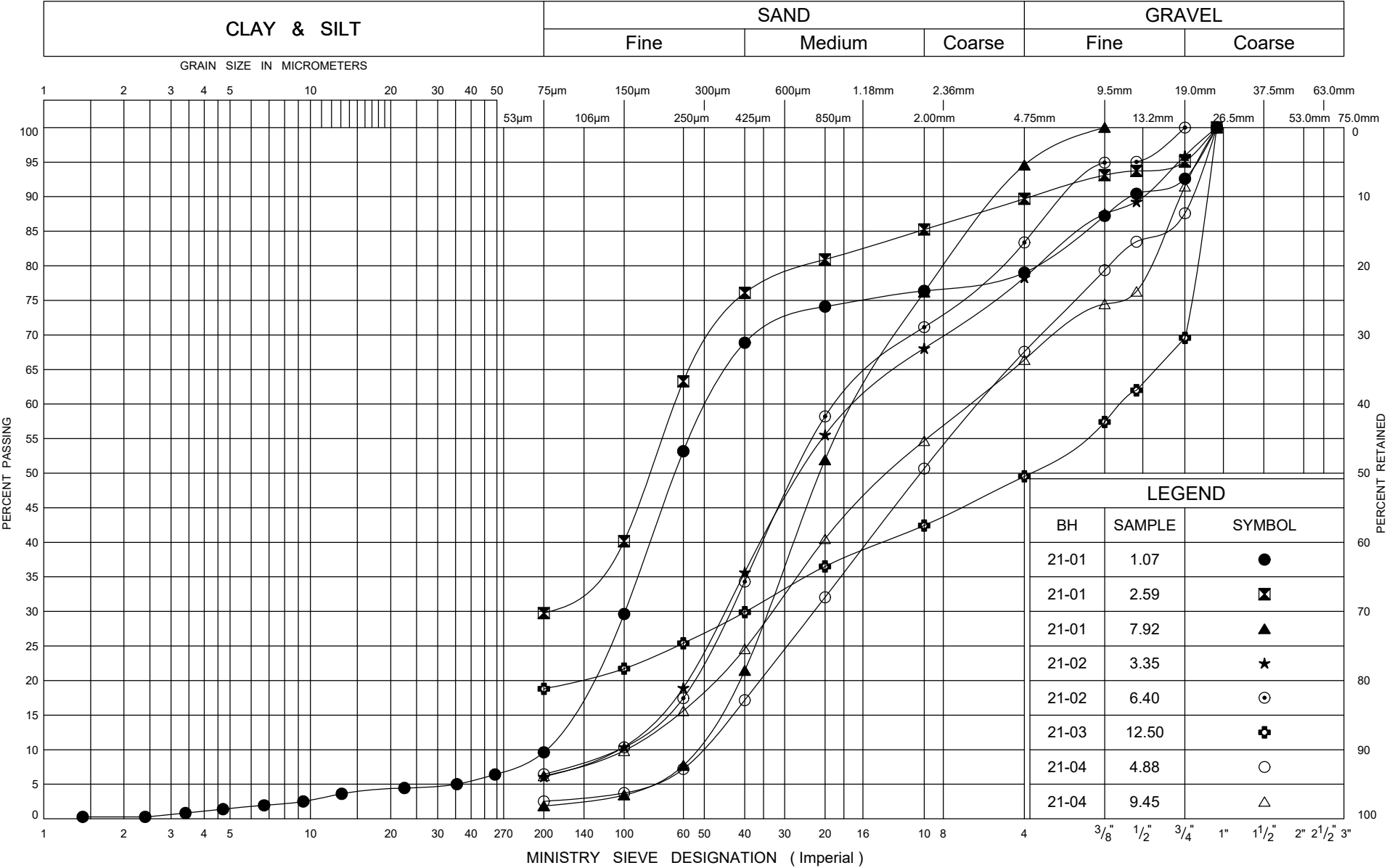
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT <div> <div>20 40 60 80 100</div> <div> <div>○ UNCONFINED + FIELD VANE</div> <div>● QUICK TRIAXIAL × LAB VANE</div> </div> </div>	PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES								
	Continued From Previous Page		10	SS	13								
353.3													
10.4	END OF SAMPLING START OF DCPT						353						
352.2													
11.4	END OF DCPT AT 11.4m UPON DCPT REFUSAL ON PROBABLE BEDROCK. BOREHOLE BACKFILLED WITH CUTTINGS AND HOLEPLUG. WATER LEVEL AT 3.9m UPON COMPLETION.												

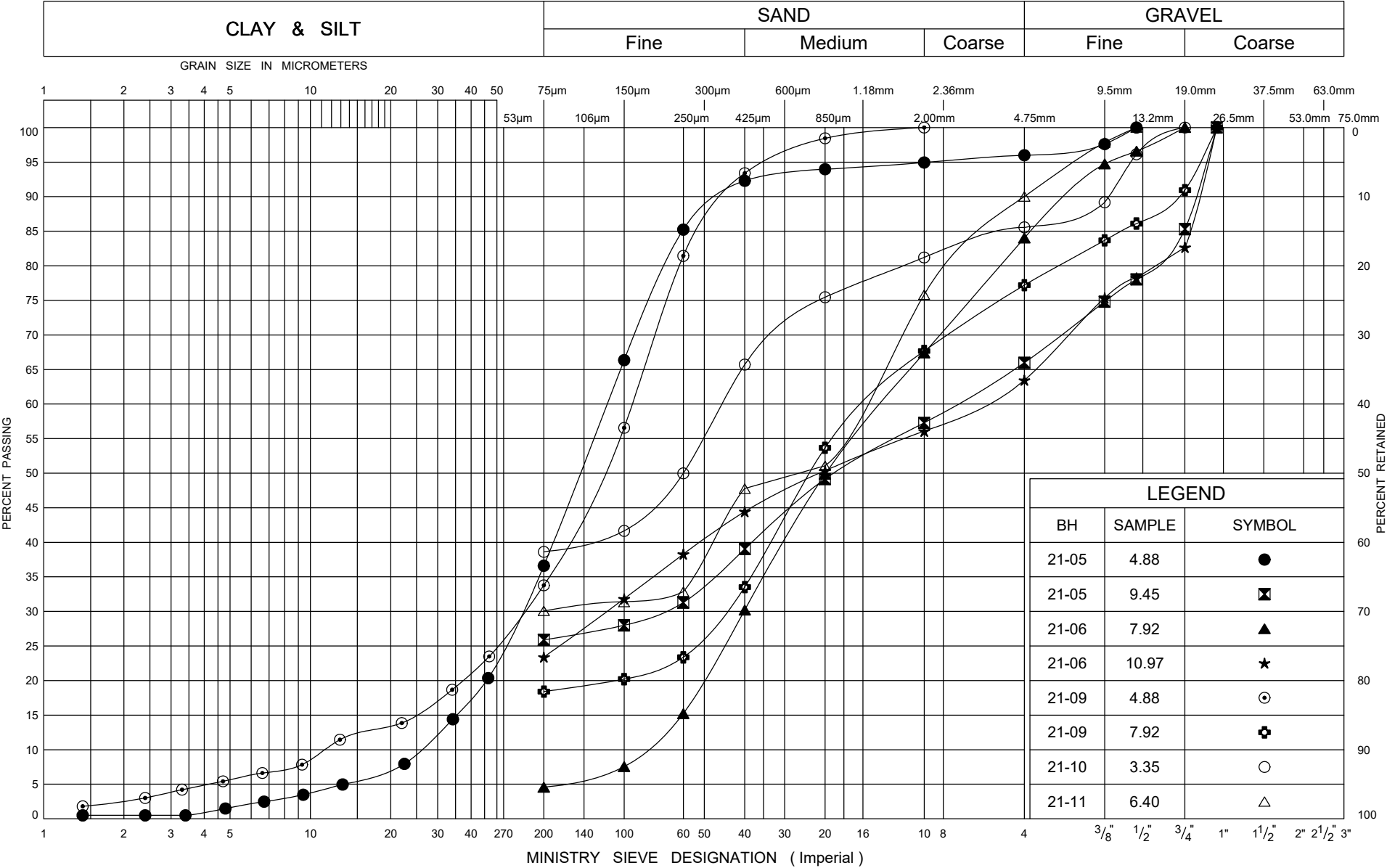


Appendix C

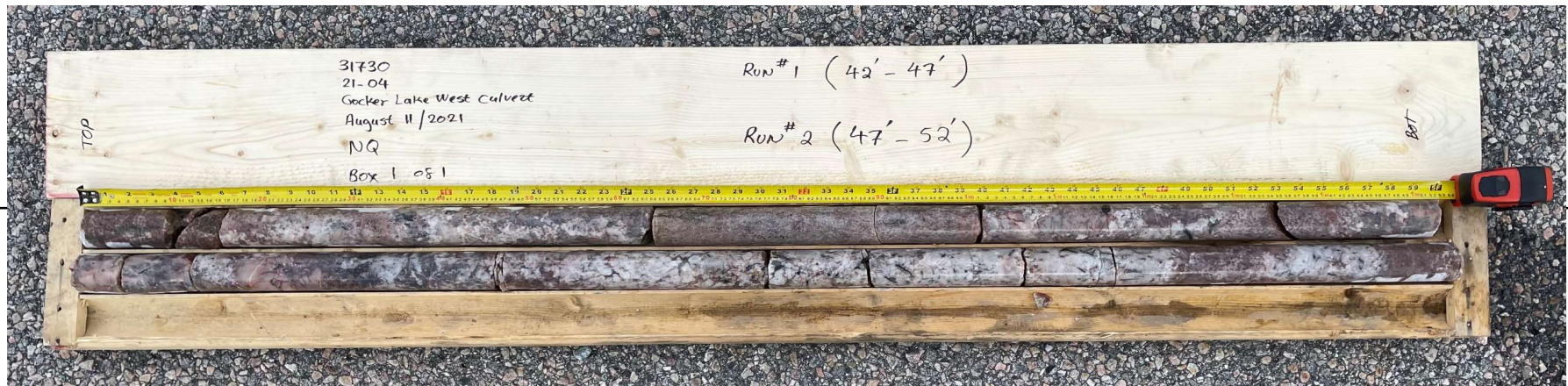
Geotechnical Laboratory Test Results







BOREHOLE: **21-04**
CORE RUN #1: 42' - 47'
CORE RUN #2: 47' - 52'



**THURBER ENGINEERING LTD.****POINT LOAD TEST SHEET****ASTM D5731-08**

Job No: 31370
 Client: Consor
 Project Name: Crocker Lake West Culvert
 Core Size: NQ BH No : 21-04

Date Drilled: 23-Aug-21
 Date Tested: 17-Sep-21
 Tester: GF
 Reviewed by: WM

Test No.	Run No.	Depth (m)	Axial or Diametral	Gauge (MPa)	Diameter (mm)	Length (mm)	$I_{s(50)}$ (MPa)	UCS (MPa)	Rock Type	Rock Strength (after Hoek & Brown, 1997)
1	1	12.8	D	20.70	47.55	62.70	8.5	203.6	Granite	Very Strong
2	1	13.5	D	17.50	47.49	63.89	7.2	172.5	Granite	Very Strong
3	1	14.1	D	20.54	47.50	66.02	8.4	202.4	Granite	Very Strong
4	2	14.5	D	14.96	47.45	63.69	6.2	147.7	Granite	Very Strong
5	2	15.1	D	16.24	47.44	64.41	6.7	160.3	Granite	Very Strong
6	2	17.3	D	15.08	47.51	64.52	6.2	148.5	Granite	Very Strong
7										
8										
9										
10										
11										
12										
13										
14										
15										
16										
17										
18										
19										
20										
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32										
33										
34										
35										

- * It is ideal to perform axial test on core specimens with D/L ratio of 1.1 ± 0.1
Long pieces of core can be tested diametrically to produce suitable lengths for axial testing
- * Diametral Test should have $0.7 \times D$ on either side of test point.
- * Correlation factor to obtain UCS values is 24.

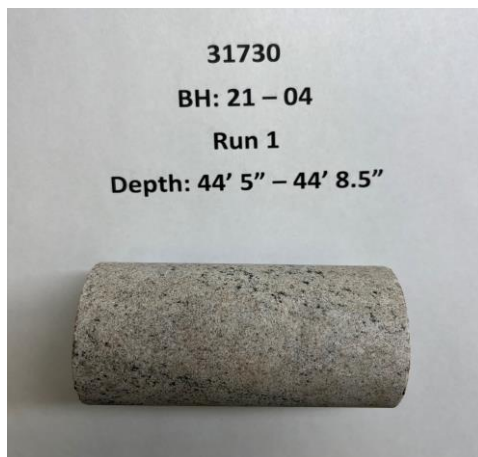
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

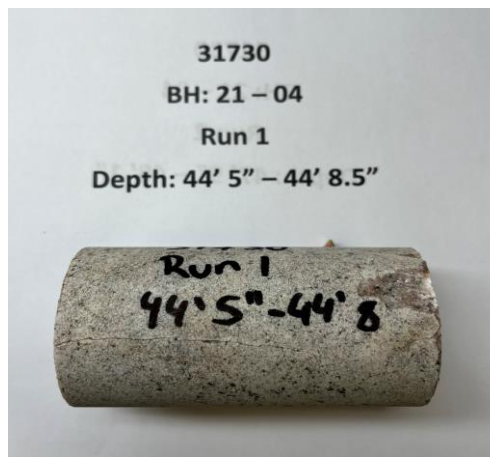
CLIENT:	Conсор	FILE NUMBER:	31730
PROJECT NAME:	Crocker Lake West Culvert	REPORT DATE:	4-Nov-21
BOREHOLE No.:	BH 21-04	TEST DATE:	5-Oct-21
SAMPLE No.:	Run 1		
SAMPLE DEPTH:	13.54 - 13.63 m		
DESCRIPTION:	Granite		

Avg. Height (cm):	9.2	Weight (g):	426.1
Avg. Diameter (cm):	4.8	Wet Density (kg/m ³):	2,586
H. to Dia. Ratio**:	1.9:1	Dry Density (kg/m ³):	2,586
Cross Sectional Area (cm ²):	17.95	Moisture Content* (%):	N/A
Sample Volume (cm ³):	164.74		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.252 MPa/s
MAXIMUM COMPRESSIVE LOAD:	107.5 kN
UNCONFINED COMPRESSIVE STRENGTH:	59.9 MPa

Note: * The moisture content was obtained before the test.
 ** Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: GF
 REVIEWED BY: WM

31730 BH 21-04 Run 1 - UCS

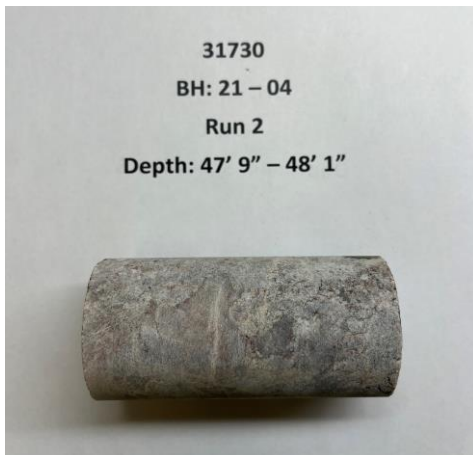
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

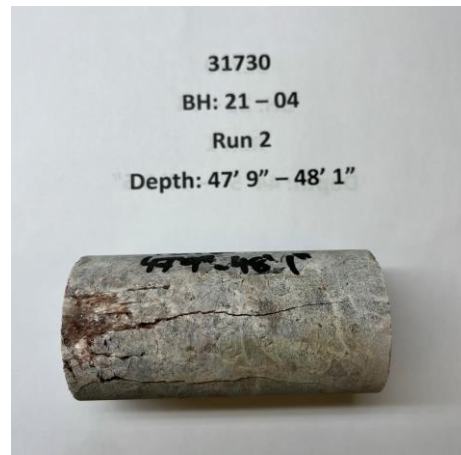
CLIENT:	Conсор	FILE NUMBER:	31730
PROJECT NAME:	Crocker Lake West Culvert	REPORT DATE:	4-Nov-21
BOREHOLE No.:	BH 21-04	TEST DATE:	5-Oct-21
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	14.55 - 14.66 m		
DESCRIPTION:	Granite		

Avg. Height (cm):	9.4	Weight (g):	431.5
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,624
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,624
Cross Sectional Area (cm ²):	17.57	Moisture Content* (%):	N/A
Sample Volume (cm ³):	164.44		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.247 MPa/s
MAXIMUM COMPRESSIVE LOAD:	85.9 kN
UNCONFINED COMPRESSIVE STRENGTH:	48.9 MPa

Note: * The moisture content was obtained before the test.
** Dimensions of Specimen do not conform to ASTM D 4543-04.

TEST DONE BY: GF
REVIEWED BY: WM

31730 BH 21-04 Run 2 trial 1 - UCS

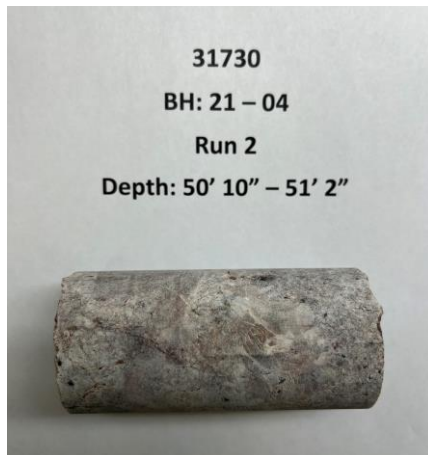
UNCONFINED COMPRESSION TEST REPORT

ASTM D7012-14

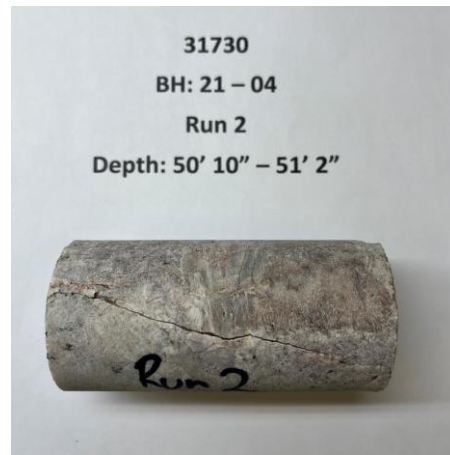
CLIENT:	Conсор	FILE NUMBER:	31730
PROJECT NAME:	Crocker Lake West Culvert	REPORT DATE:	4-Nov-21
BOREHOLE No.:	BH 21-04	TEST DATE:	5-Oct-21
SAMPLE No.:	Run 2		
SAMPLE DEPTH:	15.49 - 15.60 m		
DESCRIPTION:	Granite		

Avg. Height (cm):	9.5	Weight (g):	439.1
Avg. Diameter (cm):	4.7	Wet Density (kg/m ³):	2,622
H. to Dia. Ratio**:	2:1	Dry Density (kg/m ³):	2,622
Cross Sectional Area (cm ²):	17.62	Moisture Content* (%):	N/A
Sample Volume (cm ³):	167.44		

ORIGINAL SPECIMEN



FRACTURED SPECIMEN



AVG. RATE OF STRAIN TO FAILURE:	0.246 MPa/s
MAXIMUM COMPRESSIVE LOAD:	84.1 kN
UNCONFINED COMPRESSIVE STRENGTH:	47.7 MPa

Note: * The moisture content was obtained before the test.
 ** Dimensions of Specimen conform to ASTM D 4543-04.

TEST DONE BY: GF
 REVIEWED BY: WM

31730 BH 21-04 Run 2 trial 2 -UCS



Appendix D

Analytical Test Results



FINAL REPORT

CA14397-AUG21 R1

31730, Crocker Lake West

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 Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 31730, Crocker Lake West

Order Number

Samples Soil (1)

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 CA14397-AUG21

Received 08/23/2021

Approved 08/27/2021

Report Number CA14397-AUG21 R1

Date Reported 08/27/2021

COMMENTS

Temperature of Sample upon Receipt: 4 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number:025622

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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FINAL REPORT

CA14397-AUG21 R1

Client: Thurber Engineering Ltd.

Project: 31730, Crocker Lake West

Project Manager: Joshua Alexander

Samplers: N/A

PACKAGE: - Corrosivity Index (SOIL)

Sample Number 5
Sample Name BH21-04 SS4
Sample Matrix Soil
Sample Date 11/08/2021

Parameter	Units	RL	Result
Corrosivity Index			
Corrosivity Index	none	1	14
Soil Redox Potential	mV	-	263
Sulphide (Na ₂ CO ₃)	%	0.04	< 0.04
pH	pH Units	0.05	9.26
Resistivity (calculated)	ohms.cm	-9999	1160

PACKAGE: - General Chemistry (SOIL)

Sample Number 5
Sample Name BH21-04 SS4
Sample Matrix Soil
Sample Date 11/08/2021

Parameter	Units	RL	Result
General Chemistry			
Conductivity	uS/cm	2	862

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number 5
Sample Name BH21-04 SS4
Sample Matrix Soil
Sample Date 11/08/2021

Parameter	Units	RL	Result
Metals and Inorganics			
Moisture Content	%	0.1	9.9
Sulphate	µg/g	0.4	18



FINAL REPORT

CA14397-AUG21 R1

Client: Thurber Engineering Ltd.

Project: 31730, Crocker Lake West

Project Manager: Joshua Alexander

Samplers: N/A

PACKAGE: - Other (ORP) (SOIL)

Sample Number 5
Sample Name BH21-04 SS4
Sample Matrix Soil
Sample Date 11/08/2021

Parameter	Units	RL	Result
Other (ORP)			
Chloride	µg/g	0.4	360



FINAL REPORT

CA14397-AUG21 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	DIO0410-AUG21	µg/g	0.4	<0.4	1	35	100	80	120	102	75	125
Sulphate	DIO0410-AUG21	µg/g	0.4	<0.4	1	35	99	80	120	99	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)	ECS0053-AUG21	%	0.04	< 0.04	ND	20	99	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	EWL0437-AUG21	uS/cm	2	< 2	ND	20	99	90	110	NA		



QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-1ENVIEWL-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	EWL0426-AUG21	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

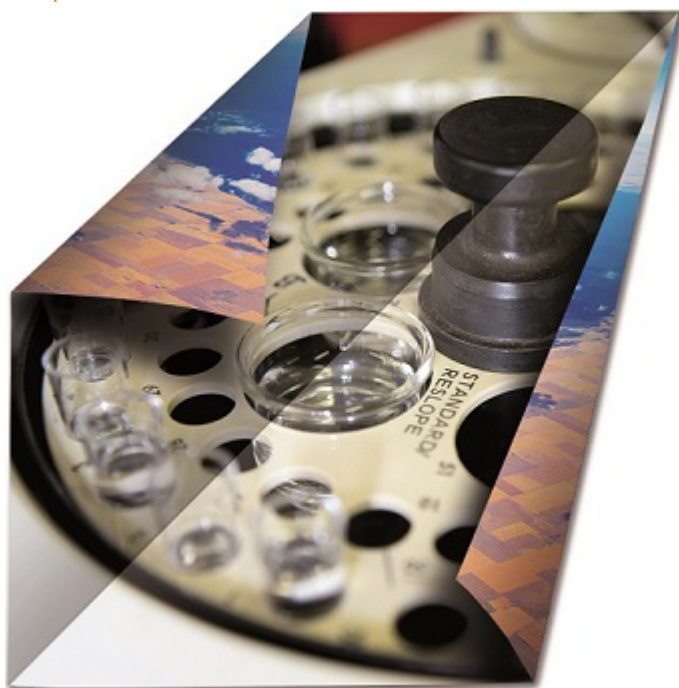
Samples analysed as received. Solid samples expressed on a dry weight basis. "Temperature Upon Receipt" is representative of the whole shipment and may not reflect the temperature of individual samples.

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" 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. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

This report must not be reproduced, except in full. This report supersedes all previous versions.

-- End of Analytical Report --



FINAL REPORT

CA14473-AUG21 R1

31730, Crocker Lake West, Culvert

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 Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 31730, Crocker Lake West, Culvert

Order Number

Samples Soil (1)

LABORATORY DETAILS

Project Specialist Brad Moore Hon. B.Sc

Laboratory SGS Canada Inc.

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

Telephone 705-652-2143

Facsimile 705-652-6365

Email brad.moore@sgs.com

SGS Reference CA14473-AUG21

Received 08/27/2021

Approved 09/02/2021

Report Number CA14473-AUG21 R1

Date Reported 09/02/2021

COMMENTS

Temperature of Sample upon Receipt: 7 degrees C

Cooling Agent Present: Yes

Custody Seal Present: Yes

Chain of Custody Number: 022133

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

Brad Moore Hon. B.Sc

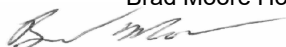




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FINAL REPORT

CA14473-AUG21 R1

Client: Thurber Engineering Ltd.

Project: 31730, Crocker Lake West, Culvert

Project Manager: Joshua Alexander

Samplers: Joshua Alexander

PACKAGE: - Corrosivity Index (SOIL)

Sample Number 5
Sample Name BH21-11, SS5
Sample Matrix Soil
Sample Date 12/08/2021

Parameter	Units	RL	Result
Corrosivity Index			
Corrosivity Index	none	1	9
Soil Redox Potential	mV	-	222
Sulphide (Na ₂ CO ₃)	%	0.04	< 0.04
pH	pH Units	0.05	8.77
Resistivity (calculated)	ohms.cm	-9999	1960

PACKAGE: - General Chemistry (SOIL)

Sample Number 5
Sample Name BH21-11, SS5
Sample Matrix Soil
Sample Date 12/08/2021

Parameter	Units	RL	Result
General Chemistry			
Conductivity	uS/cm	2	510

PACKAGE: - Metals and Inorganics (SOIL)

Sample Number 5
Sample Name BH21-11, SS5
Sample Matrix Soil
Sample Date 12/08/2021

Parameter	Units	RL	Result
Metals and Inorganics			
Moisture Content	%	0.1	14.5
Sulphate	µg/g	0.4	11



FINAL REPORT

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Client: Thurber Engineering Ltd.

Project: 31730, Crocker Lake West, Culvert

Project Manager: Joshua Alexander

Samplers: Joshua Alexander

PACKAGE: - Other (ORP) (SOIL)

Sample Number 5
Sample Name BH21-11, SS5
Sample Matrix Soil
Sample Date 12/08/2021

Parameter	Units	RL	Result
Other (ORP)			
Chloride	µg/g	0.4	150



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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	DIO0502-AUG21	µg/g	0.4	<0.4	6	35	100	80	120	105	75	125
Sulphate	DIO0502-AUG21	µg/g	0.4	<0.4	15	35	93	80	120	93	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)	ECS0064-AUG21	%	0.04	< 0.04	ND	20	112	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	EWL0512-AUG21	uS/cm	2	< 2	0	20	99	90	110	NA		



FINAL REPORT

CA14473-AUG21 R1

QC SUMMARY

pH
Method: SM 4500 | Internal ref.: ME-CA-IENVIEWL-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	EWL0512-AUG21	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

Samples analysed as received. 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" 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. This document is issued, on the Client's behalf, by the Company under its General Conditions of Service available on request and accessible at http://www.sgs.com/terms_and_conditions.htm. The Client's attention is drawn to the limitation of liability, indemnification and jurisdiction issues defined therein. Any other holder of this document is advised that information contained hereon reflects the Company's findings at the time of its intervention only and within the limits of Client's instructions, if any. The Company's sole responsibility is to its Client and this document does not exonerate parties to a transaction from exercising all their rights and obligations under the transaction documents.

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-- End of Analytical Report --



FINAL REPORT

CA14398-AUG21 R

31730, Crocker Lake West

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 Joshua Alexander

Telephone 613-606-7303

Facsimile

Email jalexander@thurber.ca

Project 31730, Crocker Lake West

Order Number

Samples Ground Water (1)

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 CA14398-AUG21

Received 08/23/2021

Approved 08/25/2021

Report Number CA14398-AUG21 R

Date Reported 08/25/2021

COMMENTS

Temperature of Sample upon Receipt: 4 degrees C

Cooling Agent Present:Yes

Custody Seal Present:Yes

Chain of Custody Number: 025622

SIGNATORIES

Maarit Wolfe, Hon.B.Sc





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Client: Thurber Engineering Ltd.

Project: 31730, Crocker Lake West

Project Manager: Joshua Alexander

Samplers: N/A

PACKAGE: - **General Chemistry** (WATER)

Sample Number 6
Sample Name Crocker Lake
West
Sample Matrix Ground Water
Sample Date 20/08/2021

Parameter	Units	RL	Result
General Chemistry			
Conductivity	uS/cm	2	275
Redox Potential	mV	-	289
Sulphide	µg/L	6	< 6

PACKAGE: - **Metals and Inorganics** (WATER)

Sample Number 6
Sample Name Crocker Lake
West
Sample Matrix Ground Water
Sample Date 20/08/2021

Parameter	Units	RL	Result
Metals and Inorganics			
Sulphate	mg/L	0.04	1.8

PACKAGE: - **Other (ORP)** (WATER)

Sample Number 6
Sample Name Crocker Lake
West
Sample Matrix Ground Water
Sample Date 20/08/2021

Parameter	Units	RL	Result
Other (ORP)			
pH	No unit	0.05	8.37
Chloride	mg/L	0.04	13



FINAL REPORT

CA14398-AUG21 R

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	DIO0411-AUG21	mg/L	0.04	<0.04	1	20	98	90	110	90	75	125
Sulphate	DIO0433-AUG21	mg/L	0.04	<0.04	0	20	100	90	110	101	75	125

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	EWL0418-AUG21	uS/cm	2	< 2	0	20	99	90	110	NA		

pH
Method: SM 4500 | 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
pH	EWL0418-AUG21	No unit	0.05	NA	0		100			NA		



FINAL REPORT

CA14398-AUG21 R

QC SUMMARY

Redox Potential
Method: SM 2580 I

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
Redox Potential	EWL0391-AUG21	mV	no	NA	1	20	103	80	120	NA		

Sulphide by SFA
Method: SM 4500 I Internal ref.: ME-CA-IENVISFA-LAK-AN-008

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	SKA0239-AUG21	ug/L	6	<0.006	ND	20	83	80	120	NA	75	125

QC SUMMARY

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

Samples analysed as received. 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.

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-- End of Analytical Report --



Appendix E

Site Photographs



Photograph 1: Looking West towards Culvert [taken August 2021]



Photograph 2: Crocker Lake south of Highway 17 [taken August 2021]



Photograph 3: Culvert Inlet [taken August 2021]



Appendix F

List of Specifications and Suggested Wording for NSSP



1. List of Applicable Codes

- CHBDC 2019

2. List of OPSS and OPSD Documents Relevant to this Project

- OPSS 511
- OPSS.PROV 902
- OPSS 1860
- OPSS.PROV 206
- OPSS.PROV 209
- OPSS.PROV 501
- OPSS.PROV 512
- OPSS.PROV.517
- OPSS.PROV 539
- OPSS.PROV 804
- OPSS.PROV 1005
- OPSS.PROV 1010
- OPSS.PROV 1004
- OPSS.PROV 1205
- OPSS.PROV 1430OPSD 208.010
- OPSD 802.010
- OPSD 803.010
- OPSD 810.010
- OPSD 3120.100
- SP FOUN0003
- SP 517F01

2. Suggested Wording for NSSP on Obstructions

Excavations for installation of the replacement culverts, cofferdams, and roadway protection systems may encounter obstructions such as cobbles and boulders in the embankment fill and native soils. Such obstructions may impede excavation progress. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions to achieve the design depths.

3. Suggested Wording for NSSP on Dewatering



It is anticipated that the culvert will be constructed in the wet. It should be noted that the Contractor shall attempt to lower the groundwater level to a sufficient depth in order to place and compact the culvert bedding / backfill in the dry.

The dewatering system shall be designated in accordance with SP FOUN0003, which amends OPSS 902, and SP 517F01, which amends OPSS 517. A preconstruction survey is not required, thus Designer Fill-In ** in SP FOUN0003 should be "N/A". Considering the conditions on site, it is recommended that a dewatering engineer with a minimum of 5 years of experience in designing dewatering systems should be retained by the Contractor for design of an effective dewatering system.



Appendix G

Foundation Comparison



COMPARISON OF ALTERNATIVE CULVERT TYPES

Corrugated Steel Pipe (CSP) or Structural Plate CSP Culvert	Precast Concrete Box Culvert
<p><u>Advantages:</u></p> <ul style="list-style-type: none"> i. Ease of construction. ii. Less stringent requirement for soil geotechnical resistances iii. CSPs culverts can accommodate some potential differential settlement along culvert axis iv. Steel pipes may be more cost effective than concrete box or open footing culverts. v. Excavation below frost depth not required. 	<p><u>Advantages:</u></p> <ul style="list-style-type: none"> i. Relatively rapid installation and less disturbance to subgrade soils if pre-cast segments are used. ii. Can be installed in wet conditions if necessary. iii. Segmental option can accommodate some potential differential settlement along culvert axis. iv. Excavation below frost depth not required.
<p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> i. Steel pipes may have shorter design life than concrete culverts. ii. Multiple pipes maybe needed to meet hydraulic requirements. 	<p><u>Disadvantages:</u></p> <ul style="list-style-type: none"> i. More expensive than a Concrete pipe or CSP culvert. iii. Multiple box culverts maybe needed to meet hydraulic requirements.
FEASIBLE	RECOMMENDED



Appendix H

NBCC Seismic Hazard Values

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 48.631N 85.382W

User File Reference: Crocker Lake

2021-11-10 16:59 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.045	0.023	0.013	0.003
Sa (0.1)	0.063	0.034	0.020	0.005
Sa (0.2)	0.060	0.035	0.022	0.007
Sa (0.3)	0.050	0.031	0.020	0.006
Sa (0.5)	0.040	0.026	0.017	0.005
Sa (1.0)	0.024	0.015	0.009	0.002
Sa (2.0)	0.012	0.006	0.004	0.001
Sa (5.0)	0.003	0.001	0.001	0.000
Sa (10.0)	0.001	0.001	0.001	0.000
PGA (g)	0.035	0.019	0.011	0.003
PGV (m/s)	0.030	0.018	0.011	0.002

Notes: Spectral ($S_a(T)$, where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s . Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information



Natural Resources
Canada

Ressources naturelles
Canada

Canada

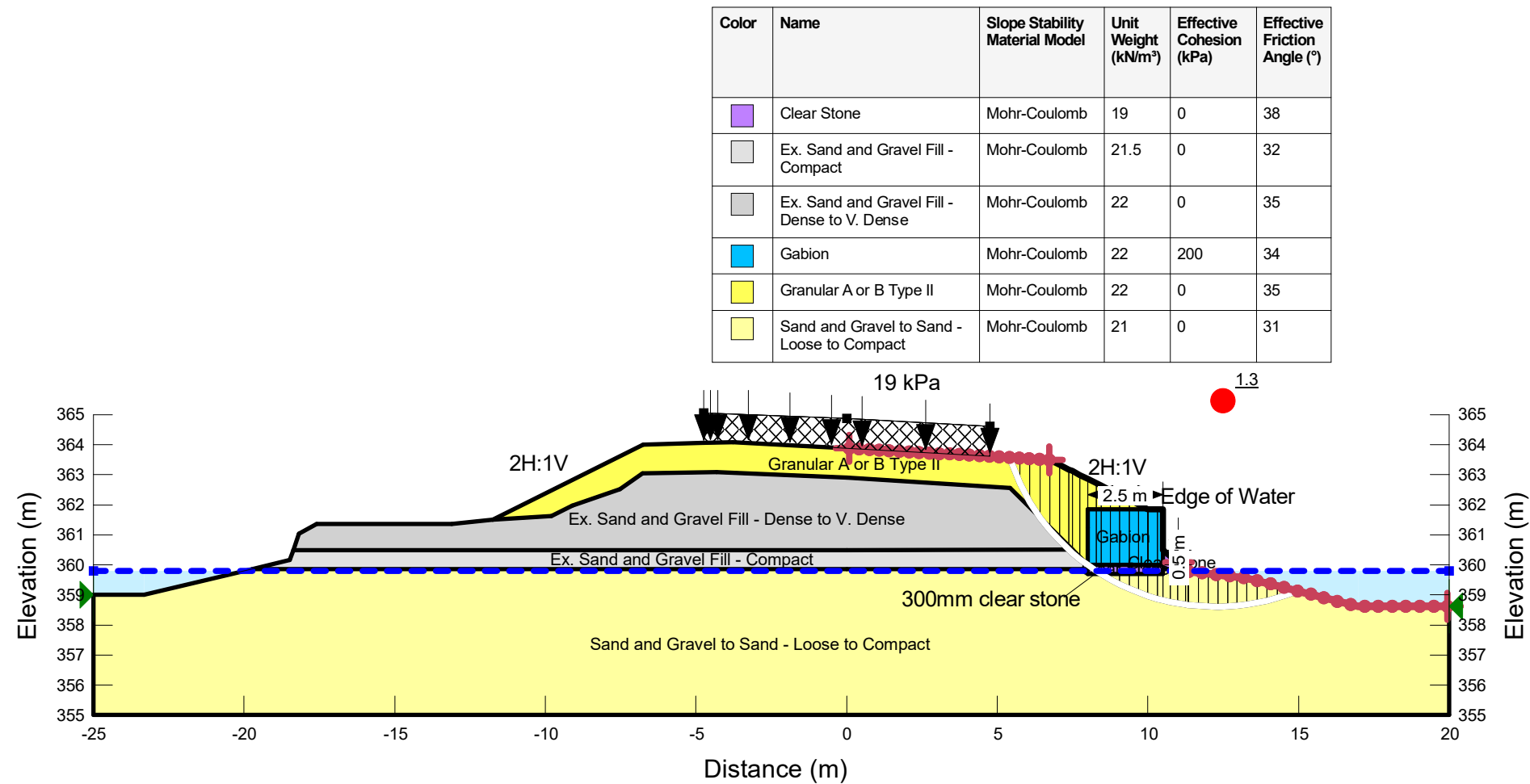


Appendix I

Stability Analyses

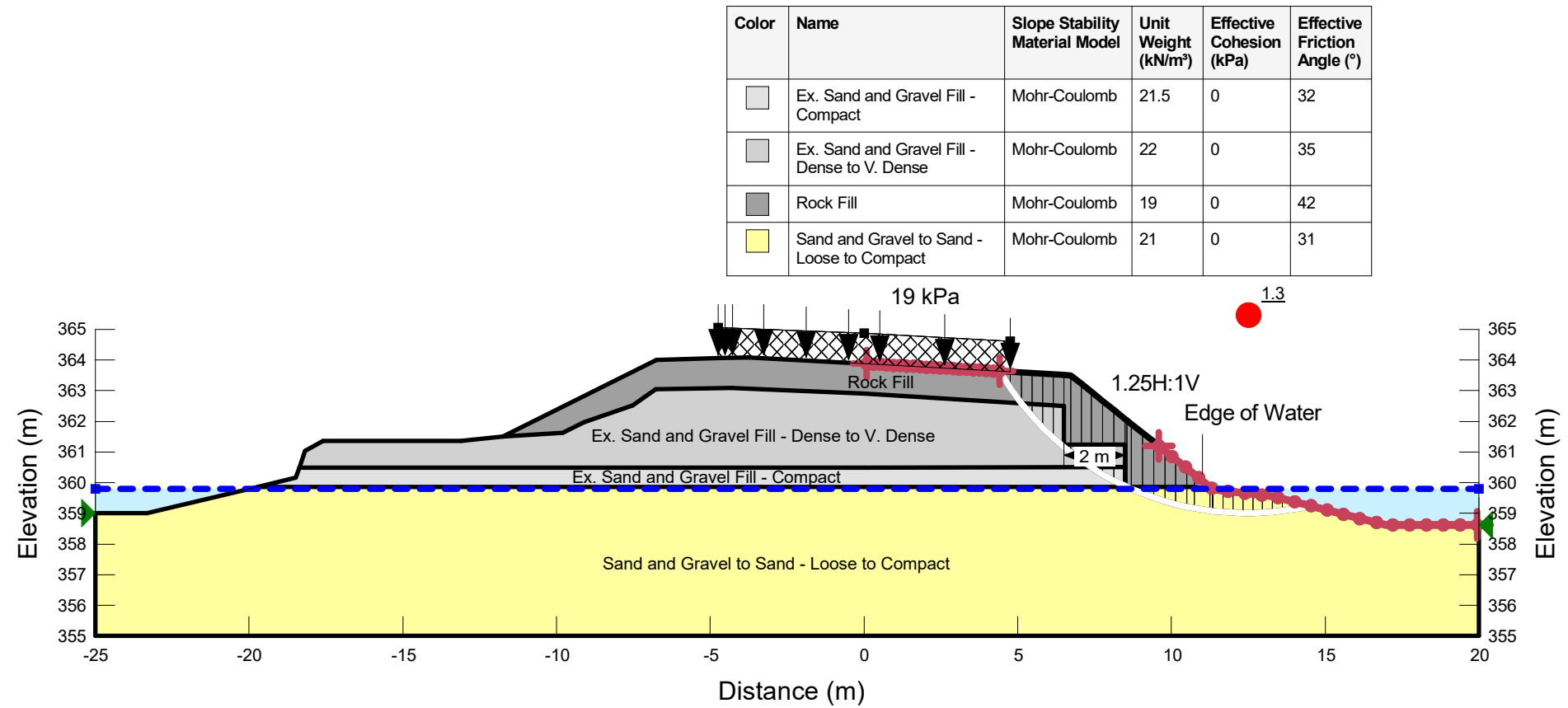
CROCKER LAKE CULVERT REPLACEMENT
GABION WALL (STA. 16+230)
LONG-TERM CONDITION

FIGURE I1



**CROCKER LAKE CULVERT REPLACEMENT
1.25H:1V ROCKFILL SLOPE (STA. 16+230)
LONG-TERM CONDITION**

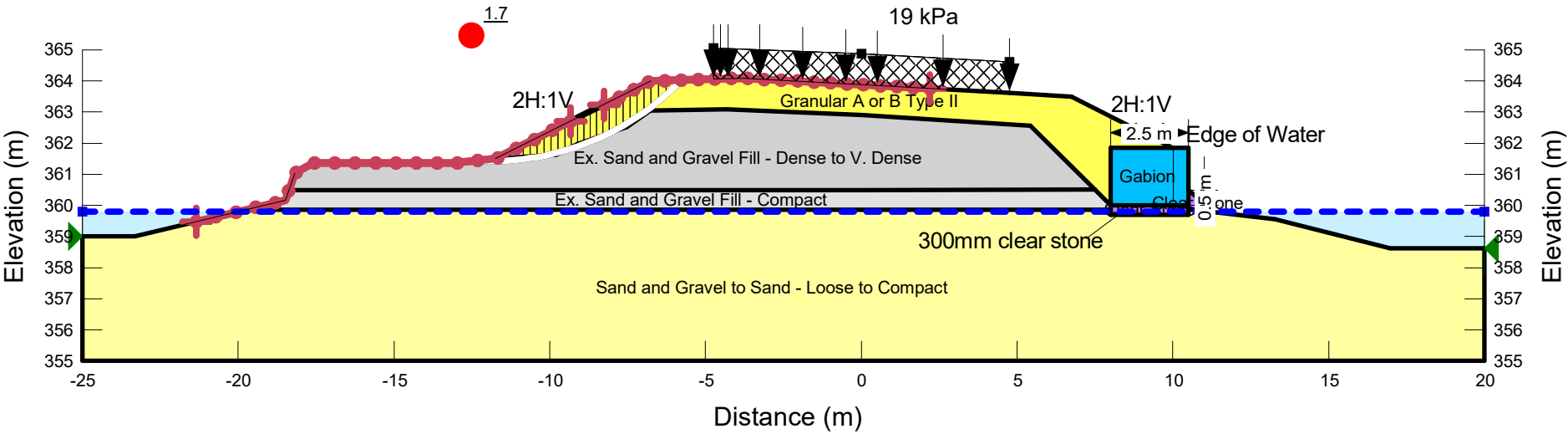
FIGURE 12



CROCKER LAKE CULVERT REPLACEMENT
2H:1V GRANULAR FILL SLOPE (STA. 16+230)
LONG-TERM CONDITION

FIGURE 13

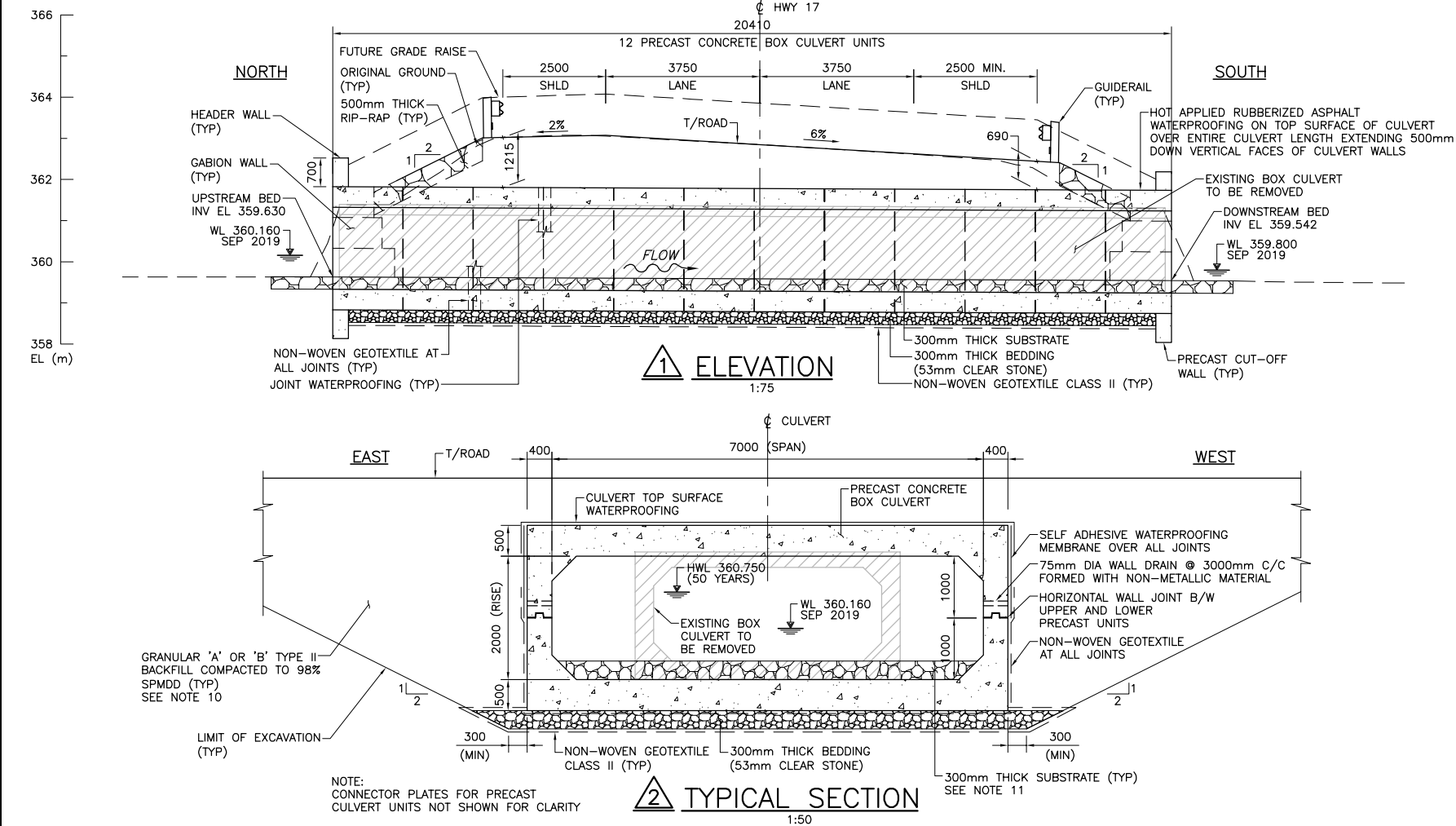
Color	Name	Slope Stability Material Model	Unit Weight (kN/m³)	Effective Cohesion (kPa)	Effective Friction Angle (°)
	Clear Stone	Mohr-Coulomb	19	0	38
	Ex. Sand and Gravel Fill - Compact	Mohr-Coulomb	21.5	0	32
	Ex. Sand and Gravel Fill - Dense to V. Dense	Mohr-Coulomb	22	0	35
	Gabion	Mohr-Coulomb	22	200	34
	Granular A or B Type II	Mohr-Coulomb	22	0	35
	Sand and Gravel to Sand - Loose to Compact	Mohr-Coulomb	21	0	31





Appendix J

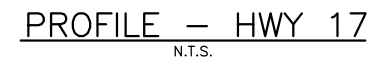
General Arrangement (GA) Drawing



SHEET



2. EXPOSED EDGES TO BE CHAMFERED 20X20 EXCEPT AS NOTED.
3. PROVIDE WATER TIGHT JOINTS BETWEEN ALL PRECAST CONCRETE SEGMENTS AS PER MANUFACTURER SPECIFICATIONS.
4. SOIL BEARING CAPACITY:
 - SERVICEABILITY LIMIT STATE FOR 25mm OF SETTLEMENT... 150KPa
 - ULTIMATE LIMIT STATE..... 250KPa
5. TEMPORARY PROTECTION SYSTEM SHALL BE DESIGNED FOR PERFORMANCE LEVEL 2. LIMITS OF ROADWAY PROTECTION SYSTEM TO BE DETERMINED BY THE CONTRACTOR.
6. BACKFILL SHALL BE PLACED SIMULTANEOUSLY BEHIND BOTH CULVERT WALLS KEEPING THE HEIGHT OF THE BACKFILL APPROXIMATELY THE SAME. AT NO TIME SHALL THE DIFFERENCE IN ELEVATION BE GREATER THAN 500mm.
7. CULVERT SUBGRADE TO BE INSPECTED BY CA FOLLOWING SUB-EXCAVATION TO ENSURE THAT ALL ORGANICS AND OTHER UNSUITABLE MATERIALS HAVE BEEN REMOVED.
8. DEBRIS FROM STRUCTURE REMOVAL SHALL BE PREVENTED FROM ENTERING THE WATERCOURSE.
9. CONTRACTOR SHALL ISOLATE CONSTRUCTION WORK AREAS FROM THE WATERCOURSE FLOW AS REQUIRED.
10. COMPACTION OF GRANULAR MATERIALS IS NOT FEASIBLE BELOW WATER LEVEL. WHERE THE CULVERT BACKFILL IS PLACED BELOW WATER, COMPACTION SHALL NOT COMMENCE UNTIL THE BACKFILL HAS BEEN PLACED TO APPROXIMATELY 500mm ABOVE THE WATER LEVEL.
11. INCORPORATE FINER MATERIAL TO CULVERT SUBSTRATE TO FILL THE VOIDS. PROVIDE 300mm THICK SUBSTRATE WITH WB-200 STONES INCLUDING 100mm NATIVE MATERIAL ON TOP.
12. DEWATERING AND TEMPORARY FLOW PASSAGE SYSTEM SHALL BE DESIGNED BY THE CONTRACTOR AS PER SPECIAL PROVISION FOUR 0003.
13. LAKE FLOW AND SURFACE WATER SHOULD BE DIVERTED AWAY FROM THE EXCAVATION AND MAY REQUIRE ACTIVE PUMPING. SEEPAGE IS ANTICIPATED FROM EMBANKMENT FILL AND PERMEABLE NATIVE SOILS.
14. COFFERDAMS MAY BE USED AT INLET AND OUTLET OF THE EXISTING CULVERT TO CREATE A STAGNANT POOL OF WATER. DESIGN AND SELECTION OF COFFERDAM SYSTEM TO BE DETERMINED BY THE CONTRACTOR.
15. CONSTRUCTION SHOULD BE CARRIED OUT WHEN LAKE LEVEL IS LOWEST TO FACILITATE DIVERSION OF LAKE FLOW AND LESS UNWATERING OF THE EXCAVATION.



W.P. No.	STATION	NORTHING	EASTING
1	16+222.811	5389361.692	424032.065

PRELIMINARY
NOT FOR CONSTRUCTION

DRAWING NOT TO BE SCALED
100mm ON ORIGINAL DRAWING

REVISIONS										
	DATE	BY	DESCRIPTION							
DESIGN	GM	CHK	YV	CODE	CHBDC	2019	LOAD	CL-625-ONT	DATE	JAN/22
DRAWN	WA	CHK	GM	SITF	48E-0073/CO	STRUCT	SCHFME	DWG	RO-1	