FOUNDATION INVESTIGATION AND DESIGN REPORT
REPLACEMENT OF THE LOWER OPIKINIMIKA RIVER BRIDGE
HIGHWAY 560
NEW LISKEARD DISTRICT, ONTARIO
G.W.P. 5148-06-00, SITE NO. 46-021

Geocres Number: 41P-64

Report to:

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the existing Lower Opikinimika River Bridge along Highway 560, in the District of New Liskeard, 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, records of boreholes, stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained in the course of the investigation.

Thurber carried out the investigation as a sub-consultant to MMM Group Limited, under the Ministry of Transportation Ontario (MTO) Agreement Number 5014-E-0019.

2 SITE DESCRIPTION

The existing Lower Opikinimika River Bridge is located on Highway 560, southeast of the community of Gogama, approximately 40 km east of the intersection of Highways 560 and 144. The existing bridge is a single-span structure with a timber deck and steel girders, and the abutments are supported on timber piles. The bridge spans a length of approximately 21 m and is 10 m wide.

Lower Opikinimika River flows from south to north at the bridge location. The surrounding lands are heavily wooded with occasional clear areas including former roadbeds to the east of the bridge.

Photographs in Appendix C show the general nature of the site and the existing bridge.

The site lies within the Canadian Shield which is generally characterized by exposed Precambrian bedrock near the ground surface, covered by a discontinuous thin layer of drift. Locally, the soil deposits at the site comprise glaciofluvial outwash sands and gravels. The bedrock consists of granodiorite to granitic igneous and metamorphic rocks.

3 SITE INVESTIGATION AND FIELD TESTING

The field investigation program for this project was conducted in two phases. The first phase of the site investigation and field testing was carried out between May 29 and June 1, 2015 for the design of the rehabilitation work or replacement of the structure. The field investigation program involved drilling and sampling two boreholes, identified as Boreholes OR-01 and OR-02. The boreholes were advanced through the highway embankment in the area of the existing west and east abutments. Dynamic Cone Penetration Tests (DCPTs) were conducted below the sampled portion of the boreholes to total depths of 25.2 m and 25.9 m. The second phase of the field investigation program was carried out on July 12, 2016 and consisted of two boreholes numbered Borehole OR-03 and OR-04. The boreholes were advanced near the existing bridge abutments to a depth of 11.3 m below the top of the highway embankment. The main purpose of the second phase of the investigation was to confirm the conditions of the existing embankment fill.

The approximate locations of the boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field and utility clearances were obtained prior to drilling operations. The coordinates and ground surface elevations for the boreholes were derived from topographic plans provided to Thurber by MMM Group Limited.

Track-mounted CME 45 and CME-55 hi-torque drill rigs were used, respectively, during the first and second phases of the investigation to advance the boreholes in combination with NW casing/wash boring techniques. An NQ core barrel was used to penetrate through cobble and boulder layers. Soil samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) procedures as per ASTM D-1586-99.

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

Groundwater conditions in the open boreholes were observed throughout the drilling operations. The groundwater levels observed after completion of drilling were not representative of site conditions as water was used during wash boring operations. A standpipe piezometer was installed in Borehole OR-1 to monitor the groundwater level after drilling. The piezometer was subsequently decommissioned after final water level reading and prior to leaving the site. The boreholes were backfilled in general accordance with MOE Regulation 903 amended by Ontario Reg. 372.

Completion details of the piezometer and boreholes are summarized in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit	Boreholes	Borehole Depth/ Base Elevation (m)	Completion Details
West Abutment	OR-01	23.8 / 362.7	Piezometer installed. Sand from 23.8 m to 15.2 m, bentonite holeplug from 15.5 m to 15.2 m, bentonite holeplug and cuttings from 15.2 m to 0.1 m, then asphalt to surface.
	OR-04	11.3 / 375.2	Bentonite holeplug and cuttings from 11.3 m to 0.1 m then asphalt to surface.
East Abutment	OR-02	22.9 / 363.6	Bentonite holeplug and cuttings from 22.9 m to 0.1 m then asphalt to surface.
	OR-03	11.3 / 375.2	Bentonite holeplug and cuttings from 11.3 m to 0.1 m then asphalt to surface.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size analysis and Atterberg Limits testing. All the laboratory tests were carried out to MTO and / or ASTM Standards, as appropriate. The results of the laboratory testing are summarized on the Record of Borehole sheets in Appendix A and are presented on the figures included in Appendix B.

In order to assess the potential for sulphate attack on concrete foundations, as well as the potential for corrosion associated with the structure, a sample of the existing embankment fill soil, and a sample of surface water from the river upstream of the bridge were collected. The samples were submitted to AGAT Laboratories in Mississauga, Ontario for analytical testing of corrosivity parameters and sulphate. The results of the analytical testing are summarized in Section 6 below and are presented in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record of Borehole sheets included in Appendix A. Details of the encountered soil stratigraphy are presented in these sheets and on the “Borehole Locations and Soil Strata” drawing included in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole sheets governs any interpretation of the site conditions. It must be recognized that soil conditions may vary between and beyond the borehole locations.

A 1977 report by Dominion Soil Investigation Limited describes a foundation investigation that was conducted prior to construction of the existing bridge. The locations of the boreholes from the 1977 report (Geocres No. 41P-22) could not be determined with sufficient accuracy to reference in the subsurface stratigraphy described in the current report, however the 1977 factual information is presented in Appendix E for information purposes.

The soil stratigraphy typically comprises an embankment fill underlain by layers of native sand, silt and gravel. Occasional cobbles and boulders were encountered within the investigated soil strata. More detailed description of the individual strata are presented below.

5.1 Road Surface

The Highway 560 embankment is surface treated to depths of 25 to 125 mm. At some locations on the bridge deck, the asphalt had completely deteriorated and the timber deck was exposed.

5.2 Embankment Fill

The existing road base and highway embankment fill beneath the asphalt typically comprised brown gravelly sand to sand and gravel with trace to some silt. Occasional cobbles were encountered within the embankment fill. The thickness of the embankment fill ranged from 3.1 m to 4.3 m with a lower boundary between Elev. 383.4 and Elev. 382.2.

SPT 'N' values recorded in the fill ranged from 6 to 46 blows per 0.3 m penetration, indicating a loose to dense relative density. Measured moisture contents ranged from 2% to 15%, typically being between 4% and 10%.

The results of grain size analyses conducted on selected samples of the embankment fill are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A and on Figures B1 and B2 of Appendix B.

Soil Particles	%
Gravel	27 to 62
Sand	32 to 63
Silt & Clay	5 to 10

5.3 Upper Sand

An upper native deposit of brown sand with trace to some gravel and trace silt was encountered below the embankment fill in all boreholes. The deposit also contained occasional cobbles and boulders. The upper sand had a thickness of 5.3 m to 6.3 m, with a lower boundary at depths of 9.4 and 9.7 m (Elev. 377.1 and 376.8). A 0.2 m thick boulder was encountered and cored at a depth of 6.4 m (Elev. 380.1) in Borehole OR-02.

SPT 'N' values obtained in the sand ranged from 5 to 51 blows for 0.3 m penetration, indicating a loose to very dense relative density. One SPT 'N' value of greater than 50 blows for 0.125 m was obtained in Borehole OR-02, which is likely an indication of the presence of boulders in the deposit.

Selected samples of the sand underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figure B3 and B4 of Appendix B.

Soil Particles	%
Gravel	1 to 13
Sand	81 to 96
Silt & Clay	2 to 13

Measured moisture contents ranged from 10% to 30%; however, typically not exceeding 20%.

5.4 Silt

A layer of silt was encountered below the upper native sand in all boreholes. Some sand and trace to some clay with occasional clay seams were noted in the deposit. In borehole OR-02, the silt became sandy below approximately 13 m depth. The silt layer ranged in thickness from 3.6 to 3.9 m, with a lower boundary at a depth of 13.3 m (Elev. 373.2). Boreholes OR-03 and OR-04 were terminated in the silt deposit at 11.3 m depth or Elev. 375.2.

SPT 'N' values obtained in the silt ranged from 14 to 33 blows for 0.3 m penetration, indicating a compact to dense relative density. Measured moisture contents ranged from 18% to 27%.

Two samples of the silt underwent laboratory grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figure B5 of Appendix B.

Soil Particles	%
Gravel	0
Sand	11 to 17
Silt	75 to 81
Clay	8

5.5 Lower Sand

A native deposit of brown sand ranging to gravelly sand was encountered below the silt layer in Boreholes OR-01 and OR-02. This lower sand contained trace silt and occasional cobbles and boulders. A layer of gravel/sand and gravel some 1.9 m to 3.5 m thick was encountered within this deposit below Elevation 371; this layer is described in more detail in Sec. 5.6. Cobbles and boulders were encountered in Borehole OR-02 from 21.3 to 22.2 m depth.

Due to blowing-back/heaving sand causing difficulty to advance the drill casing, drilling and sampling were terminated in both boreholes at depths of 23.8 and 22.9 m (Elev. 362.7 and

363.6). DCPTs were conducted from the bottom of the drilled boreholes, and terminated upon reaching 100 blows per 0.3 m penetration at depths of 25.2 and 25.9 m (Elev. 361.3 and 360.6).

SPT 'N' values obtained in the lower sand ranged from 24 blows for 0.3 m penetration to 50 blows per 0.1 m penetration, indicating a compact to very dense relative density.

Two samples of the lower sand underwent grain size analysis testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curves for these samples are shown on Figure B3 of Appendix B.

Soil Particles	%
Gravel	2 to 28
Sand	65 to 93
Silt & Clay	5 to 7

Measured moisture contents ranged from 9% to 23%.

5.6 Gravel / Sand and Gravel

A layer of gravel to sand and gravel with cobbles and boulders was encountered within the lower sand deposit at depths of 15.7 to 15.2 m in Boreholes OR-01 and OR-02. The layer was 3.5 m and 1.9 m in thickness with a lower boundary at depths of 19.2 and 17.1 m (Elev. 367.3 and 369.4) in Boreholes OR-01 and OR-02, respectively.

SPT 'N' values obtained in this deposit varied from 29 blows per 0.3 m of penetration to greater than 50 blows per 0.1 m penetration, indicating a compact to very dense relative density. The higher 'N' values represent presence of cobbles and boulders.

A sample of the sand and gravel underwent laboratory grain size testing, the results of which are summarized below. These results are also presented on the Record of Borehole sheets included in Appendix A. The grain size distribution curve for the sample is shown on Figure B6 of Appendix B.

Soil Particles	%
Gravel	45
Sand	54
Silt & Clay	1

Measured moisture contents ranged from 10% to 18%.

5.7 Water Levels

Where possible, water levels were monitored in the open boreholes during drilling operations. Wash boring techniques were used to advance the boreholes and therefore water levels recorded during or immediately upon completion of drilling may not reflect natural groundwater levels. A standpipe piezometer was installed in one borehole to monitor the groundwater level after completion. The water levels measured in open boreholes and in the piezometer are shown in Table 5.1.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Level		Comment
		Depth (m)	Elev. (m)	
OR-01	June 2, 2015	4.1	382.4	In piezometer
OR-02	June 2, 2015	4.2	382.3	Open borehole
OR-03	July 12, 2016	4.7	381.8	Open borehole
OR-04	July 12, 2016	4.7	381.8	Open borehole

The above levels are short-term readings and seasonal fluctuations of the groundwater and river level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

The preliminary profile drawings provided by MMM Group Limited and archive drawings indicated several water level measurements in Lower Opikinimika River, which were recorded between September 1976 and May 2015, as follows:

September 28, 1976 - Elev. 382.9
November 23, 1983 - Elev. 382.8
April 18, 1984 - Elev. 383.5
May 26, 2015 - Elev. 382.2.

In general, the groundwater level is expected to be at or slightly above the water level in the river.

6 CORROSIVITY AND SULPHATE TEST RESULTS

A sample of the embankment fill and a sample of the surface water from the river were submitted for analytical testing of corrosivity parameters and sulphate. The results of the analytical tests are shown in Table 6.1. The laboratory certificates of analysis are presented in Appendix B.

Table 6.1 – Analytical Test Results

Parameter	Units (Soil)	Units (Water)	Test Results	
			Borehole OR-2 Soil, 0.76-2.1 m SS#2/3	Lower Opikinimika River - Water
Sulphide	%	mg/L	<0.01	<0.05
Chloride	µg/g	mg/L	11	0.50
Sulphate	µg/g	mg/L	17	2.99
pH	pH Units	pH Units	7.89	7.14
Electrical Conductivity	mS/cm	µS/cm	0.225	64
Resistivity	ohm.cm	ohm.cm	4440	15600
Redox Potential	mV	mV	298	336
Langlier Index	-	-	-	-1.66
Total Hardness (as $CaCO_3$)	-	mg/L	-	32.6
Total Dissolved Solids	-	mg/L	-	56
Alkalinity (as $CaCO_3$)	-	mg/L	-	29
Calcium	-	mg/L	-	9.82
Magnesium	-	mg/L	-	1.95

7 MISCELLANEOUS

Borehole locations were selected and established in the field by Thurber Engineering Ltd. The coordinates and the ground surface elevations for the boreholes were established based on topographic survey information provided by MMM Group Limited.

Thurber obtained utility clearances for the borehole locations prior to drilling.

Eastern Ontario Diamond Drilling of Hawkesbury, Ontario supplied a track-mounted CME-45 and CME-55 hi-torque drill rigs and conducted the drilling, sampling and in-situ testing operations for the boreholes at both phases of the field work. The drilling operations were supervised by Ms. Deanna Pizycki during the first phase of the investigation and Mr. Zane Bourk during the second phase of the investigation, both of Thurber.

Overall supervision of the field program was carried out by Mr. Stephane Loranger, CET.

The report was prepared by Ms. Anna Piascik and reviewed by Mr. Alastair Gorman, P.Eng and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

8 GENERAL

This report presents interpretation of the geotechnical data in the factual report and provides geotechnical recommendations for both rehabilitation and replacement of the existing Lower Opikinimika River Bridge on Highway 560, in the District of New Liskeard, Ontario.

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

The discussion and recommendations presented in this report are based on the information provided by MMM Group Limited and on the factual data obtained in the course of the investigation.

At present, the bridge carries Highway 560 over the Lower Opikinimika River on a single-span structure with span length of 21 m and deck width of 10 m. Archive drawings dated July 1977 indicate that the existing bridge abutments are founded on single rows of #14 timber piles driven to support a design load of 25 tons (250 kN) per pile. This is assumed to be the allowable load in the working stress design. The drawings also show that the pile length was specified to be 14.6 m, although no record of the depth to which the piles were driven was available. If the full length of the pile was driven, it could be assumed that the pile tips are at approximately Elevation 371.

The existing approach fill heights above the surrounding ground are between 3.1 m to 4.3 m at the abutments.

Rehabilitation of the existing bridge was considered at the proposal/planning stage of the project, which envisioned replacement of the deck with no embankment widening or grade raise. Following further investigation, the option of replacement of the Lower Opikinimika River Bridge has been selected. The configuration of the proposed replacement bridge was provided on the Preliminary General

Arrangement - Alternative 1 drawing prepared by MMM Group, dated September 2016. It is understood that the proposed bridge will be approximately 22 m long, 11 m wide and constructed at a 20-degree skew. Integral abutments are envisioned for the bridge. The new superstructure will be CPCI 1200 prestressed concrete girder bridge supported on steel H-piles. The pile foundations are proposed to be installed a short distance in front of the existing piles at the new west abutment and approximately 2 m behind the existing piles at the east abutment. The construction will be carried out in stages with a single lane traffic maintained during construction.

This report provides discussion and recommendation for both rehabilitation and replacement alternatives for the Lower Opikinimika River Bridge.

9 BRIDGE FOUNDATIONS

9.1 Subsurface Conditions

In summary, the subsurface stratigraphy encountered at this site consists of embankment fill underlain by a compact to very dense cohesionless deposit ranging, generally, from silt to sand and gravel and extending to as much as 23.8 m and 22.9 m depths at the boreholes.

The existing embankment fill comprises gravelly sand to sand and gravel with trace to some silt. Occasional cobbles were encountered within the embankment fill during drilling operations. The thickness of the embankment fill ranged from 3.1 m to 4.3 m with a lower boundary between Elev. 383.4 and Elev. 382.2. The embankment fill was loose to dense at the borehole locations.

Underlying the fill is the native sand deposit interlayered with silt and gravel/sand and gravel. A layer of silt ranging in thickness from 3.6 m to 3.9 m was encountered below approximately Elevation 377, and a layer of gravel/sand and gravel from 1.9 m to 3.5 m in thickness was encountered below Elevation 371. Cobbles and boulders were inferred within the fill and native soils during drilling. Sampled boreholes were terminated at 23.8 m and 22.9 m depths (Elevations 362.7 and 363.6) and were followed by DCP testing advanced to 25.2 m and 25.9 m depths (Elevations 361.3 and 360.6). At this site, “blowing-back”/heaving sand into the casing was observed during drilling and sampling operations causing soil disturbance. It is probable that the relative density of the underlying soils immediately ahead of the drill/auger was affected by that phenomenon resulting in lower SPT N-values than would be recorded for the undisturbed soils.

The water level in the piezometer was measured at 4.1 m depth or Elev. 382.4, and the water level in the river was measured at Elev. 382.2 on May 26, 2015.

9.2 Bridge Rehabilitation Option

9.2.1 Assessment of the Existing Foundations

The archive drawings indicate that the existing bridge abutments are supported on timber piles. Based on the stratigraphy at the site and the design pile length of 14.6 m, it appears that the piles may have been driven to, or close to the compact to very dense layer of gravel/sand and gravel encountered at about Elevation 371.0, using the allowable design capacity of 250 kN.

Applying current procedures and standards, the analysis indicates that the following geotechnical capacities for a #14 timber pile 14.6 m in length could be used:

Factored geotechnical resistance at ULS of 400 kN

Geotechnical reaction at SLS of 330 kN (for up to 25 mm of settlement).

The above values indicate the geotechnical resistance and geotechnical reaction of the pile and do not in any way address the structural integrity of the 38 year old timber piles.

9.2.2 Augmented Foundations

The proposed replacement of the bridge deck may result in higher loadings on the bridge foundations than the existing loadings. Structural analyses should be conducted to ensure that the new loadings are appropriately accommodated by the factored geotechnical resistance at ULS and geotechnical reaction at SLS provided above. However, if the new loading cannot be accommodated, augmentation of the abutment foundations will be required.

To augment the abutment foundations, installation of additional piles could be considered, including:

- timber piles
- H-piles, or
- micropiles.

Additional timber piles or H-piles could be considered for transferring additional loads, however, due to the size of the piles and installation techniques, disturbance of the underlying soils and possible displacement of the existing piles should be expected. It should be noted that the underlying compact to dense sand and silt extending below the water level are prone to liquefaction.

Installation of the micropiles seems to be the least intrusive. The micropiles could be installed from the bridge deck level. If micropiles are selected, reinforcing of the existing pile cap will likely be required to ensure adequate transfer/distribution of the loadings. The connection between the top of the micropiles and the new reinforced pile cap to transfer both tension and compression loads should be designed by a structural engineer.

The design procedures outlined in the FHWA/NHI Micropile Design and Construction Reference Manual (Publication No. FHWA NHI-05-039, dated December 2005) could be utilized to establish the required dimensions for the micropiles (lengths of casing, central bar, uncased section, etc.). This work can be carried out after the need for additional capacity had been established.

9.3 Bridge Replacement Using Modular Bridge on Concrete Slab Foundations

In the process of design, a modular bridge to be erected on the same alignment as the existing structure was considered as a bridge replacement alternative.

The existing embankment fill materials extend to depths of 3.1 to 4.3 m (Elev. 383.4 to Elev. 382.2) at the borehole locations. The fill consists of gravelly sand to sand and gravel with trace to some silt and occasional cobbles.

Precast concrete bearing pads to support the new modular bridge can be placed on engineered fill pads over the existing embankment fill. The engineered fill pads are recommended to provide uniform founding conditions across the footprint of the bearing slab. These fill pads must be a minimum of 1.0 m thick and be constructed using OPSS Granular "B" Type II compacted to 100% standard Proctor maximum dry density (SPMDD) at a moisture content within 2% of the optimum value.

The engineered fill pads must be designed and constructed as follows:

1. The minimum size of the base of the excavation for the pad should be determined as follows:
    a. At the base of the bearing slab, the plan extent of the compacted fill must extend at least 500 mm beyond the slab, in all directions
    b. The dimensions of the base of the excavation may be determined by projecting downwards and outwards at 1V:1H
2. If any of the existing piles that intrude into the excavated space, they must be cut off at subgrade level (removal is not recommended unless the resulting void is grouted)
3. The fill or native soil exposed in the base of the excavation must be recompacted to 100% of SPMDD
4. The Granular "B" Type II fill must be placed in lifts not exceeding 150 mm (loose thickness) and be compacted to 100 % of SPMDD

The following values of factored Geotechnical Resistance at ULS and Geotechnical Reaction at SLS may be used for design of bearing pads approximately 1.5 m in width and placed on the engineered fill pad:

Factored Geotechnical Resistance at ULS (kPa)	-	250 kPa
Geotechnical Reaction at SLS (kPa)	-	170 kPa

The geotechnical resistance at SLS quoted above corresponds to 25 mm of settlement of an individual footing and are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as illustrated in the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

Resistance to lateral forces / sliding resistance between the concrete footing and the gravel at the founding level should be evaluated assuming an ultimate (unfactored) coefficient of friction of 0.5.

As the bearing pads will be placed on the engineered fill layer placed in the embankment fill and in proximity to the river banks, the following points must be observed:

- The forward edge of the foundation pads should be embedded at least 1.0 m below a 2H:1V forward slope face;
- Provision of erosion protection on the forward slopes will be critical to the performance of the bearing pads, and the permanent erosion protection must be provided.

9.4 Bridge Replacement Using Integral Abutments

9.4.1 Axial Pile Capacity

The Preliminary General Arrangement, Alternative 1 drawing presents the configuration of the proposed Lower Opikinimika River replacement bridge. The proposed bridge will be approximately 22 m long and 11 m wide using prestressed concrete girder supported on integral abutments founded on steel H-piles.

The ground conditions at the site are considered to be suitable for the use of driven steel H-pile foundations at the bridge abutments. The underside of the abutments were indicated at Elev. 382.9 and Elev. 382.8 at the west and east abutment, respectively. To develop required capacity, the piles should be driven into the dense to very dense cohesionless deposits comprising silt, sand and gravel to approximate Elev. 361.

The recommended geotechnical resistances and reactions for HP 310x110 piles are presented in Table 9-1.

Table 9-1. Axial Geotechnical Resistance and Reaction for HP 310x110 Piles

Foundation Element	Reference Borehole	Approximate Pile Tip Elevation, m	Factored Geotechnical Resistance at ULS (kN) per pile	Geotechnical Reaction at SLS (kN) per pile
West Abutment	OR-01 and OR-04	361.0	1200	1000
East Abutment	OR-02 and OR-03			

The values of geotechnical resistances at SLS quoted above refer up to 25 mm of settlement.

Oversize materials (e.g. greater than 75 mm nominal diameter) should not be used for any new fill through which the piles will be driven.

9.4.2 Downdrag

The subsurface conditions at this site consist of predominantly cohesionless soils, and no significant change in the grade of the road is anticipated. Therefore, downdrag loading on the piles will be negligible.

9.4.3 Pile Installation

Pile installation should be in accordance with OPSS. PROV 903.

Pile driving should be controlled in accordance with Standard Drawing SS103-11 (Hiley Formula) and an ultimate pile resistance should be specified by the designer. The Hiley formula need not be used until the piles are within 2.0 m of the design pile tip elevation. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile. "R" should have a minimum value of twice the design load at ULS as calculated by the Structural Engineer.

If the proposed bridge design requires that the deviation at the top of the pile be limited to tight tolerance, a driving template or other means may be required to achieve the specified maximum deviation.

As shown on the Preliminary General Arrangement drawing, piles for the bridge replacement would be installed approximately 0.75 m in front of the existing piles at the new west abutment and approximately 2 m behind the existing piles at the east abutment. The new piles must be situated so that the potential for interference from the existing timber piles is minimized.

9.4.4 Pile Tips

Cobbles and/or boulders were encountered in the embankment fill and in the underlying native deposits. To reduce the potential for pile damage during installation, piles should be equipped with tip protections.

All driven H-piles should be fitted with pile tip protection from an approved manufacturer such as Titus Steel (Standard H-point), Skyline Steel or approved equivalent.

9.4.5 Abutment Type

The subsurface conditions at this site are considered suitable for integral, semi-integral or conventional abutment design. The use of H-piles at the abutments allows for the design of integral abutments, as proposed for the replacement bridge and indicated on the Preliminary General Arrangement Drawing.

The integral abutment design requires that the piles possess flexibility in the upper 3 m of the pile length. To provide the required flexibility for piles to be installed through the compacted fill, the upper 3 m of the piles should be surrounded by a 600 mm diameter CSP as specified by the integral abutment design procedures. After the pile is installed, the space between the pile and the CSP should be filled with loose, uniformly graded sand. An NSSP should be included in the contract documents specifying the grain size distribution of the sand as listed in Table 9-2.

Table 9-2. Grading for Integral Abutment Sand Backfill

MTO Sieve Designation		Percentage Passing
2 mm	#10	100%
600 µm	#30	80%-100%
425 µm	#40	40%-80%
250 µm	#60	5%-25%
150 µm	#100	0%-6%

For an integral abutment installation, the following procedure is suggested:

1. At each pile centre, auger a hole of sufficient diameter to accept a 600 mm CSP to a depth of 3.0 m below the underside of the abutment stem.
2. Install the CSP.
3. Drive the pile; care should be taken to prevent soil or debris from entering the CSP.
4. After completion of pile driving, fill the CSP using sand as specified in Table 9-2.

9.4.6 Pile Lateral Resistance

The geotechnical lateral resistance of an H-pile embedded in compact to dense soil may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

$$k_s = n_h z / D \quad (kN/m^3)$$

$$p_{ult} = 3 \gamma' z K_p \quad (kPa)$$

where
- z = depth of embedment of pile (m)
- D = pile width or diameter (m)
- n_h = coefficient related to soil relative density (kN/m^3)
- γ' = effective unit weight (kN/m^3)
- K_p = passive earth pressure coefficient

The above equations and recommended parameters in Table 9-3, below, may be used to analyse the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

Table 9-3. Lateral Resistance Parameters

Elevations (m)	γ' (kN/m^3)	K_p (-)	S_u (kPa)	n_h (kN/m^3)	Soil Conditions
West Abutment					
Surface to 382.8	20	3.0	-	3,000	Sand and Gravel Fill
382.8 – 376.8	10	3.2	-	3,000	Sand below water level
376.8 – 373.2	9	3.2	-	3,500	Silt
373.2 – 370.8	10	3.5	-	5,500	Sand
370.8 -367.3	10	3.7	-	6,500	Sand and Gravel
367.3 -361.3	11	3.8	-	7,500	Sand
East Abutment					
Surface to 382.2	20	3.0	-	3,000	Sand and Gravel Fill
382.2 – 377.1	10	3.2	-	3,000	Sand below water level
377.1 – 373.2	9	3.2	-	3,500	Silt
373.2 – 371.3	10	3.2	-	3,500	Sand
371.3 – 369.4	10	3.7	-	6,500	Gravel
369.4 – 360.6	10	3.5	-	5,500	Sand

The subgrade reaction modulus of loose sand against the CSP for an integral abutment arrangement is in the order of 1300 kN/m^3.

The spring constant, K_s, for analysis may be obtained by the expression, $K_s = k_s \times L \times D$ (kN/m), where L is the length (m) of the pile segment or element used in the analysis and remaining variables are as defined earlier. The ultimate lateral resistance, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult} \times L \times D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements.

The modulus of subgrade reaction may have to be reduced due to pile interaction, based on the center-to-center pile spacing. The reduction factors to be used for a pile group oriented perpendicular and/or parallel to the direction of loading are provided in Table 9-4 with intermediate values to be obtained by linear interpolation.

Table 9-4. Reduction Factors for Subgrade Reaction due to Pile Spacing

Condition	Pile Spacing, Centre to Centre	Reduction Factor
Pile group oriented ***perpendicular*** to direction of loading	4D	1.0
	1D	0.5
Pile group oriented ***parallel*** to direction of loading	8D	1.0
	6D	0.7
	4D	0.4
	3D	0.25

Horizontal loads may be resisted by means of battered piles (i.e. for H-pile case) if load requirements exceed the available lateral pile resistances.

9.5 Frost Cover

The depth of frost penetration at this site is approximately 2.3 m.

If piles are used, the base of pile caps should be provided with a minimum of 2.3 of earth cover as protection against frost action. If it is not practical to provide 2.3 m of earth cover, consideration can be given to augmenting the frost protection by using expanded polystyrene insulation (EPS). Typically, 25 mm of EPS can be considered equivalent to 600 mm of earth cover. If EPS is used, it must be provided with long term protection against erosion, environmental degradation and spills.

Concrete bearing slab foundations for a modular bridge may be founded on an engineered fill pad with a minimum embedment as described in the previous section.

10 SCOUR AND EROSION CONTROL

The existing forward slopes appear to be experiencing significant erosion, as shown on photographs in Appendix C. Design of the erosion protection measures will be critical for the performance of the foundations. The design should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

A vegetation cover should be established on all other exposed earth surfaces to protect against surficial erosion, in general accordance with OPSS 804.

11 EXCAVATION AND GROUNDWATER CONTROL

Excavation for works associated with the construction of the abutments/bearing pads for support of the bridge is expected to be limited to the existing granular embankment fill. The excavation will be carried out close to the river and near the groundwater level.

All excavations should be carried out in accordance with OPSS.PROV 902 and the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the approach fill within the depth of excavation may be classed as Type 3 soil above the water table, and Type 4 below the water table.

The selection of the method of excavation is the responsibility of the Contractor and should be based on the Contractor's experience, equipment and interpretation of the site conditions. It is anticipated that a hydraulic excavator will be suitable. Provision should be made for the handling of paved surface of the embankment, potential obstructions in the fill, and cobbles and boulders.

Temporary protection system, if required, should be provided in accordance with OPSS.PROV 539 and designed for Performance Level 2.

Protection system can consist of steel soldier pile and timber lagging walls or sheet pile walls. However, the existing embankment fill and underlying native soils contain occasional cobbles and boulders which may interfere with installation of soldier piles or sheet piles. The Contractor should be advised of potential obstructions in the fill during installation. Suggested text for an NSSP on "Installation of Roadway Protection System" is included in Appendix F.

Design of any protection system or dewatering system that may be required is the responsibility of the Contractor. All shoring systems should be designed by a Professional Engineer experienced in such designs.

12 CORROSION & SULPHATE ATTACK POTENTIAL

The results of the corrosivity and sulphate analytical tests conducted on the embankment fill soil and the river water indicate the following:

- The potential for sulphate attack on concrete foundations from the surrounding soil or surface water is considered to be negligible due to the low concentration of sulphate in the samples tested.
- The potential for soil or water corrosion on metal structural elements is considered to be moderate.
- Appropriate protection measures are recommended to address the moderate potential for corrosion on metal structure elements in contact with the soil or the river water.

13 APPROACH EMBANKMENTS

Based on the preliminary General Arrangement drawing, no embankment grade raise or widening is proposed at this bridge site. No evidence of instability or excessive settlements of the existing approach embankments were noted during the foundation site investigation. Settlements at the abutment/deck locations were evident; however, these settlements could be attributed to the loss/washout of abutment fill.

In view of the soil conditions at this site, settlement or stability issues are not anticipated for the approach embankments, providing properly designed erosion protection is implemented and the embankments are reconstructed with side slopes inclined at not steeper than 2H:1V.

14 CONSTRUCTION CONCERNS

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

- Occasional cobbles and boulders were noted in the existing embankment fill and native soils; some of the boulders required coring to advance the borehole. Cobbles and boulders may interfere with excavations or installation of temporary protection system.
- Seasonal fluctuations of the groundwater and river level are to be expected. In particular, the water level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, which may impact the construction.
- Conflict of the existing timber piles with the new pile foundations at the west abutment of the replacement bridge may arise during new abutment construction. The existing timber pile should be exposed before the new piles construction to determine their locations in relation to the new piles. The Contract Documents must address the possibility of interference and the possible extraction of timber piles and backfilling of the void.

15 CLOSURE

Engineering analysis and preparation of the report were carried out by Ms. Anna Piascik, P.Eng. The report was reviewed by Mr. Alastair Gorman, P.Eng. and Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Appendix A

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

C_{pen} 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.

RECORD OF BOREHOLE No OR-01

METRIC

GWP#	5148-06-00	LOCATION	Lower Opikinimika River Bridge N 5 261 794.8 E 280 485.1	ORIGINATED BY	DJP
HWY	560	BOREHOLE TYPE	NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2015.05.29 - 2015.05.30	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
386.5	GROUND SURFACE				
0.0 / 0.1	**ASPHALT:**(75mm)				
	Gravelly **SAND** to **SAND** and **GRAVEL**, some silt, occasional cobbles Compact to Dense Brown Moist (FILL)	1	SS	46	27 63 10 (SI+CL)
		2	SS	23	
		3	SS	12	
	Cobbles dislodged with augers between 2.5m and 3.0m depth	4	SS	37	
		5	SS	24	
382.8 / 3.7	**SAND**, trace to some gravel, trace silt, occasional cobbles Compact to Dense Brown to Grey Moist				
		6	SS	18	
		7	SS	14	
		8	SS	20	5 92 3 (SI+CL)
		9	SS	31	
376.8 / 9.7	**SILT**, some sand, trace clay, occasional clay seams				

Elevation scale: 386, 385, 384, 383, 382, 381, 380, 379, 378, 377

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No OR-01

METRIC

GWP# 5148-06-00
LOCATION Lower Opikinimika River Bridge N 5 261 794.8 E 280 485.1
ORIGINATED BY DJP
HWY 560
BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test
COMPILED BY AN
DATUM Geodetic
DATE 2015.05.29 - 2015.05.30
CHECKED BY MEF

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Soil Profile

ELEV / DEPTH	DESCRIPTION
	SILT, some sand, trace clay, occasional clay seams; Compact to Dense; Grey; Wet
	Occasional sand seams
373.2 / 13.3	**SAND**, trace silt, occasional cobbles; Dense to Very Dense; Brown; Moist
	Becoming gravelly below 14.6m depth
370.8 / 15.7	**SAND** and **GRAVEL**, trace silt, occasional cobbles; Compact to Very Dense; Brown; Moist
367.3 / 19.2	**SAND**, trace gravel, trace silt, occasional cobbles; Very Dense; Brown; Moist

Samples

NUMBER	TYPE	"N" VALUES	Elevation (approx.)	Water content	Remarks & Grain Size Distribution (%) GR SA SI CL
10	SS	31	375.5	~19	
11	SS	27	374.0	~27	0 17 75 8
12	SS	30	372.5	~17	
13	SS	50/ 0.100	371.0	~10	
14	SS	29	369.5	~11	45 54 1 (SI+CL)
15	SS	33	368.0	~18	

Elevation scale: 376, 375, 374, 373, 372, 371, 370, 369, 368, 367

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100
PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L
WATER CONTENT (%) 20 40 60
UNIT WEIGHT γ kN/m³
REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

Ministry of Transportation Ontario

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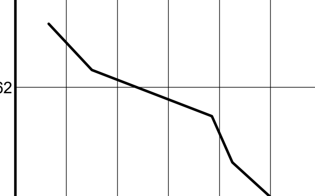
RECORD OF BOREHOLE No OR-01

METRIC

GWP#	5148-06-00	LOCATION	Lower Opikinimika River Bridge N 5 261 794.8 E 280 485.1	ORIGINATED BY	DJP
HWY	560	BOREHOLE TYPE	NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2015.05.29 - 2015.05.30	CHECKED BY	MEF

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%)

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Continued From Previous Page											
	SAND, trace gravel, trace silt, occasional cobbles Very Dense Brown Moist		16	SS	64		366, 365, 364, 363	○	2	93	5 (SI+CL)	
362.7 23.8	Casing refusal at 23.8m due to blowing back sand. Start DCPT at 23.8m.						362					
361.3 25.2	END OF BOREHOLE AT 25.2m. Sand inside casing to 19.3m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 3.0m slotted screen.											



WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2015.06.02	4.1	382.4

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No OR-02

METRIC

GWP#	5148-06-00	LOCATION	Lower Opikinimika River Bridge N 5 261 784.8 E 280 514.1	ORIGINATED BY	DJP
HWY	560	BOREHOLE TYPE	NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY	AN
DATUM	Geodetic	DATE	2015.05.30 - 2015.06.01	CHECKED BY	MEF

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
386.5	GROUND SURFACE						
0.0	**ASPHALT:** (45mm)						
0.0	**SAND** and **GRAVEL** to Sandy **GRAVEL**, some silt, occasional cobbles Compact to Dense Brown Dry to Moist (FILL) Cobbles dislodged with auger at 1.2m depth	1	SS	44		386	
		2	SS	45			34 56 10 (SI+CL)
		3	SS	23		385	
		4	SS	22		384	
383.4 3.1	**SAND**, trace to some gravel, trace silt, occasional cobbles Compact to Very Dense Brown Moist Cobbles dislodged with auger at 4.3m depth	5	SS	51		383	
					▽	382	
		6	SS	12		381	
		7	SS	50/0.125			
380.1 6.4	Boulders, cored from 6.4m to 6.6m					380	
379.9 6.6						379	
		8	SS	17		378	
377.1		9	SS	33		377	12 86 2 (SI+CL)
9.4	**SILT**, some sand, trace clay, occasional clay seams Dense						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No OR-02

METRIC

GWP# 5148-06-00
LOCATION Lower Opikinimika River Bridge N 5 261 784.8 E 280 514.1
ORIGINATED BY DJP
HWY 560
BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test
COMPILED BY AN
DATUM Geodetic
DATE 2015.05.30 - 2015.06.01
CHECKED BY MEF

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	SILT, some sand, trace clay, occasional clay seams Compact to Dense Grey Wet				376					
		10	SS	31		~24	0	11	81	8
	Becoming sandy below 13.0m depth				375					
		11	SS	26	374	~16				
373.2 / 13.3	**SAND**, trace silt Compact Brown Moist				373					
		12	SS	24	372	~25				
371.3 / 15.2	**GRAVEL**, with cobbles and boulders Very Dense Grey Moist Cored from 15.2m to 17.1m	13	SS	50/ 0.100	371					
		14	SS	50/ 0.100	370					
369.4 / 17.1	**SAND**, trace gravel, trace silt, occasional cobbles Dense Brown Moist 6.0m of heaving sand at 18.3m				369					
		15	SS	34	368	~15				
					367					

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No OR-02

METRIC

GWP# 5148-06-00	LOCATION Lower Opikinimika River Bridge N 5 261 784.8 E 280 514.1	ORIGINATED BY DJP
HWY 560	BOREHOLE TYPE NW Casing/NQ Coring/Dynamic Cone Penetration Test	COMPILED BY AN
DATUM Geodetic	DATE 2015.05.30 - 2015.06.01	CHECKED BY MEF

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) | SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (20 40 60 80 100) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20 40 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	GR	SA	SI	CL
	SAND, trace gravel, trace silt, occasional cobbles Compact to Dense Brown Moist		16	SS	26	○ (~15)				
365.2 21.3	**COBBLES** and **BOULDERS**, cored between 21.3m and 22.2m depth									
364.3 22.2	Becoming gravelly below 22.2m depth		17	SS	41	○ (~15)	28	65	7 (SI+CL)	
363.6 22.9	End of sampling at 22.9m and start DCPT									
360.6 25.9	END OF BOREHOLE AT 25.9m. WATER IN OPEN BOREHOLE AT 4.2m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO SURFACE.									

Elevation scale: 366, 365, 364, 363, 362, 361

+³, ×³: Numbers refer to Sensitivity

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No OR-03

METRIC

GWP# 5148-06-00	LOCATION Lower Opikinimika River Bridge N 5 261 790.0 E 280 516.6		ORIGINATED BY ZRB
HWY 560	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY AN
DATUM Geodetic	DATE 2016.07.12 - 2016.07.12		CHECKED BY AMP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
386.5	GROUND SURFACE					
0.0	**ASPHALT:** (125mm)					
0.1	**SAND** and **GRAVEL**, trace silt, occasional cobbles, Loose to Dense, Brown, Moist (FILL)	1	GS			51 43 6 (SI+CL)
		2	SS	16		
		3	SS	6		48 42 10 (SI+CL)
		5	SS	9		
		6	SS	37		59 36 5 (SI+CL)
382.5 / 4.0	**SAND**, trace to some gravel, trace silt, occasional cobbles, Compact to Dense, Brown, Moist	8	SS	28		
		9	SS	13	∇	13 81 6 (SI+CL)
		10	SS	44		
		11	SS	6		
		12	SS	17		
377.1 / 9.4	**SILT**, some sand, trace clay, occasional clay seams, Compact	13	SS			

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (386, 385, 384, 383, 382, 381, 380, 379, 378, 377); DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued Next Page

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

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RECORD OF BOREHOLE No OR-03

METRIC

GWP# 5148-06-00	LOCATION Lower Opikinimika River Bridge N 5 261 790.0 E 280 516.6		ORIGINATED BY ZRB
HWY 560	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY AN
DATUM Geodetic	DATE 2016.07.12 - 2016.07.12		CHECKED BY AMP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	SILT, some sand, trace clay, occasional clay seams Compact Brown Moist						376				
			14	SS	14				○ (approx. 20)		
375.2 11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 4.7m. BOREHOLE BACKFILLED WITH CUTTINGS, ASPHALT COLD PATCH TO SURFACE.										

+ 3, × 3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 19-5161-251.GPJ 2015TEMPLATE(MTO).GDT 7/28/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No OR-04

METRIC

GWP#	5148-06-00	LOCATION	Lower Opikinimika River Bridge N 5 261 789.3 E 280 486.4	ORIGINATED BY	ZRB
HWY	560	BOREHOLE TYPE	Hollow Stem Augers	COMPILED BY	AN
DATUM	Geodetic	DATE	2016.07.12 - 2016.07.12	CHECKED BY	AMP

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	STRAT PLOT	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	GR	SA	SI	CL
386.5	GROUND SURFACE									
0.0	**ASPHALT:** (25mm)									
	SAND and **GRAVEL**, trace silt, occasional cobbles Loose to Compact Brown Moist (FILL)		1	GS			41	53	6 (SI+CL)	
			2	SS	13					
	Interlayer of sandy gravel at 1.5m		3	SS	11		62	32	6 (SI+CL)	
			4	SS	6					
			5	SS	9		37	56	7 (SI+CL)	
			7	SS	7					
382.2 / 4.3	**SAND**, trace gravel, trace to some silt, occasional wood fragments in upper 0.5m zone Loose to Compact Brown Wet		8	SS						
			9	SS	5	▽				
			10	SS	11		1	96	3 (SI+CL)	
			11	SS	7					
			12	SS	14		1	86	13 (SI+CL)	
			13	SS	23					
376.9 / 9.6	**SILT**, some sand, trace clay Compact		14	SS						

Elevation scale: 386, 385, 384, 383, 382, 381, 380, 379, 378, 377

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE — 20 40 60 80 100

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L

WATER CONTENT (%): 20 40 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

20 / 15 ◐ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 19-5161-251.GPJ 2015TEMPLATE(MTO).GDT 8/2/16

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No OR-04

METRIC

GWP# 5148-06-00 LOCATION Lower Opikinimika River Bridge N 5 261 789.3 E 280 486.4 ORIGINATED BY ZRB
HWY 560 BOREHOLE TYPE Hollow Stem Augers COMPILED BY AN
DATUM Geodetic DATE 2016.07.12 - 2016.07.12 CHECKED BY AMP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page								
	SILT, some sand, trace clay Compact Grey Moist					376			
		15	SS	18			○		
375.2 11.3	END OF BOREHOLE AT 11.3m. WATER LEVEL AT 4.7m. BOREHOLE BACKFILLED WITH CUTTINGS, ASPHALT COLD PATCH TO SURFACE.								

Chart legend: DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; STRAT PLOT

+3, ×3: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

Appendix B

Geotechnical and Analytical Laboratory Test Results

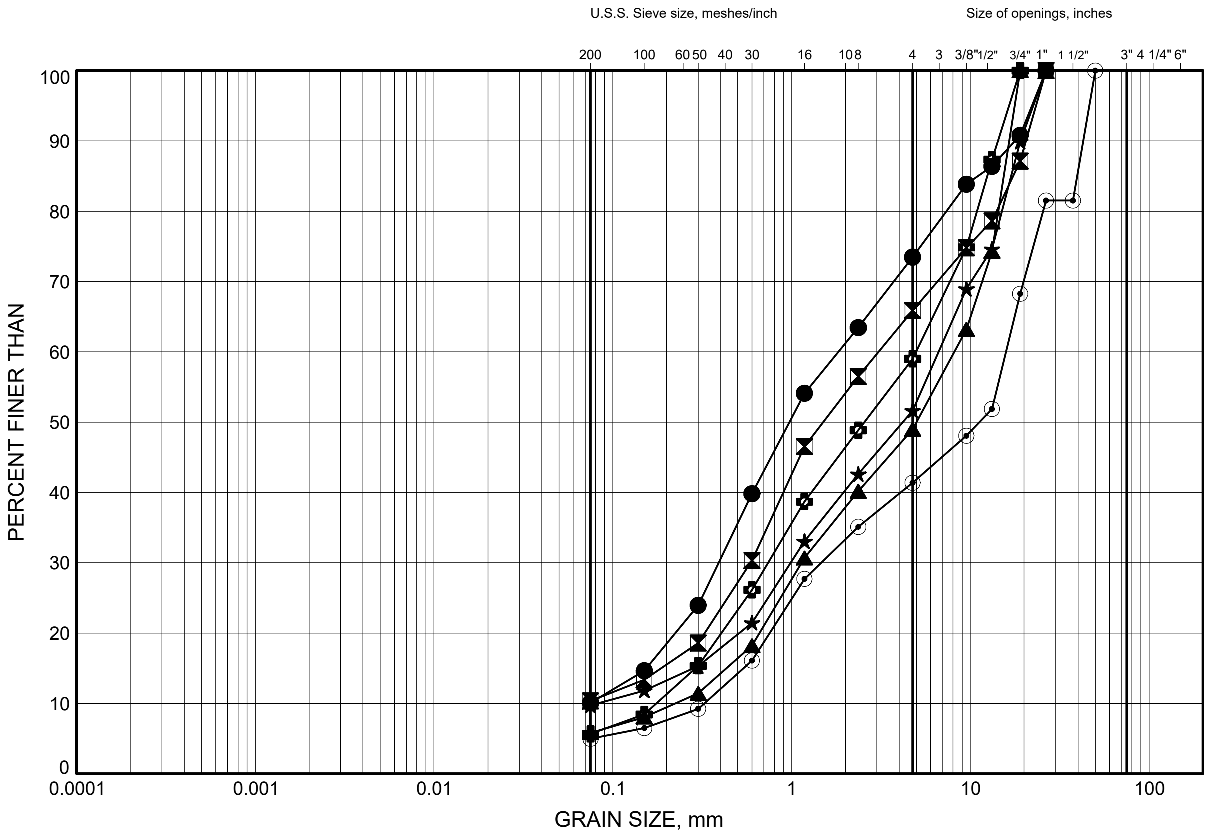
THURBER

Lower Opikinimika River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B1

Embankment FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OR-01	0.34	386.16
⧗	OR-02	1.07	385.43
▲	OR-03	0.38	386.12
★	OR-03	1.83	384.67
⊙	OR-03	3.43	383.07
✿	OR-04	0.38	386.12

Date August 2016

GWP# 5148-06-00

THURBER

Prep'd AN

Chkd. AMP

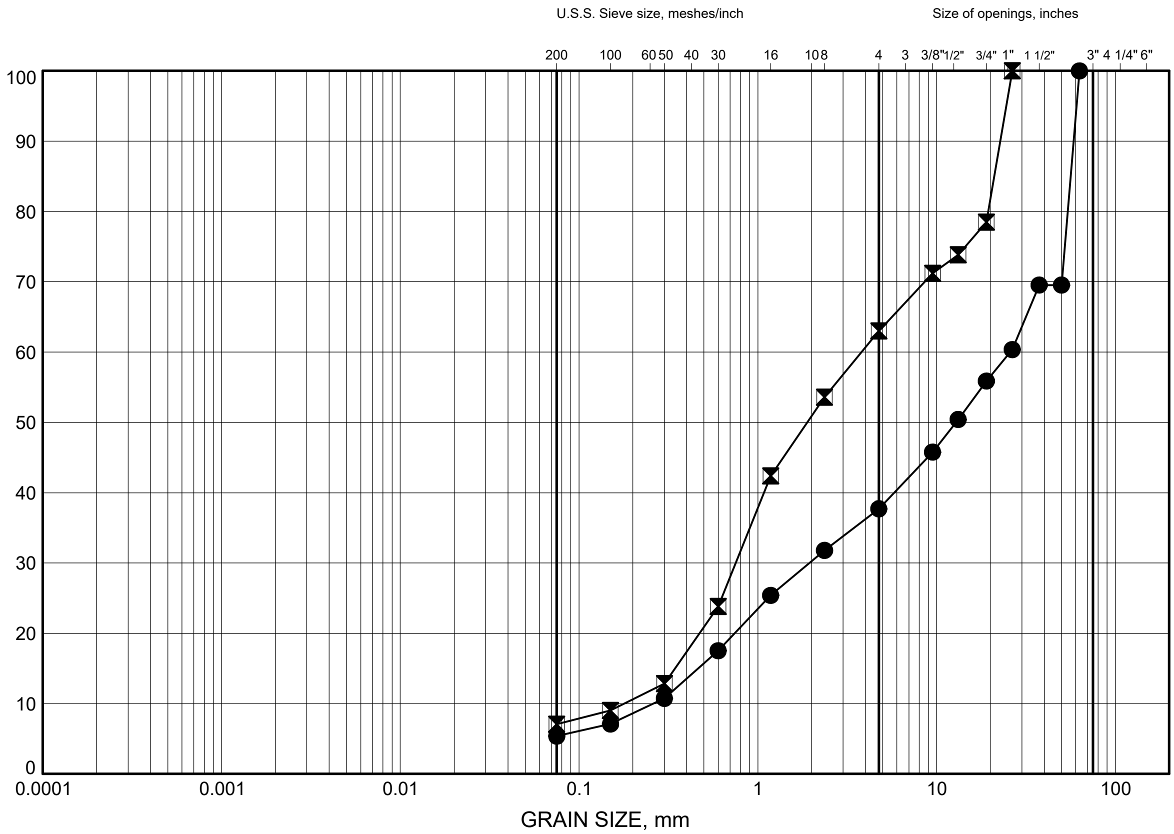
GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 8/2/16

Lower Opikinimika River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B2

Embankment FILL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OR-04	1.83	384.67
⧗	OR-04	3.35	383.15

Date August 2016

GWP# 5148-06-00

THURBER

Prep'd AN

Chkd. AMP

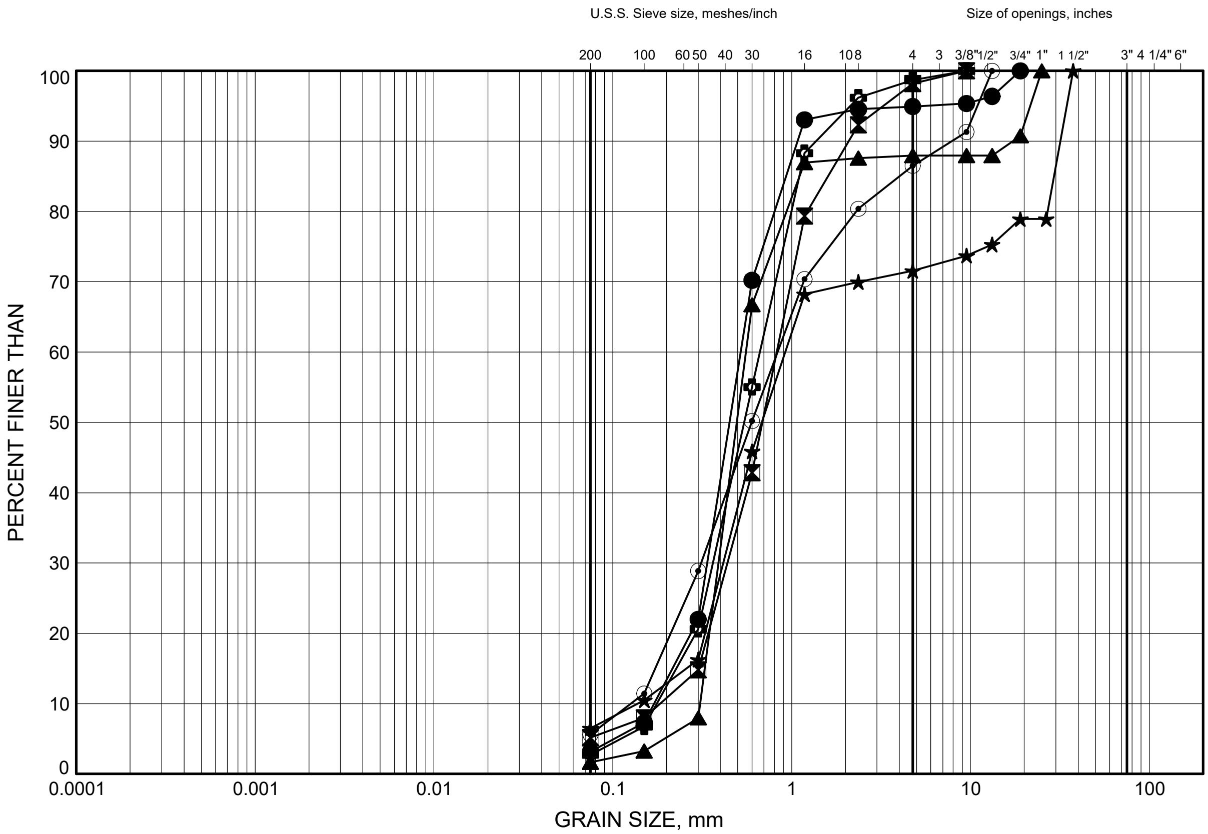
GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 8/2/16

Lower Opikinimika River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OR-01	7.92	378.58
⧗	OR-01	20.12	366.38
▲	OR-02	9.30	377.20
★	OR-02	22.56	363.94
⊙	OR-03	4.88	381.62
✿	OR-04	5.64	380.86

Date August 2016

GWP# 5148-06-00

THURBER

Prep'd AN

Chkd. AMP

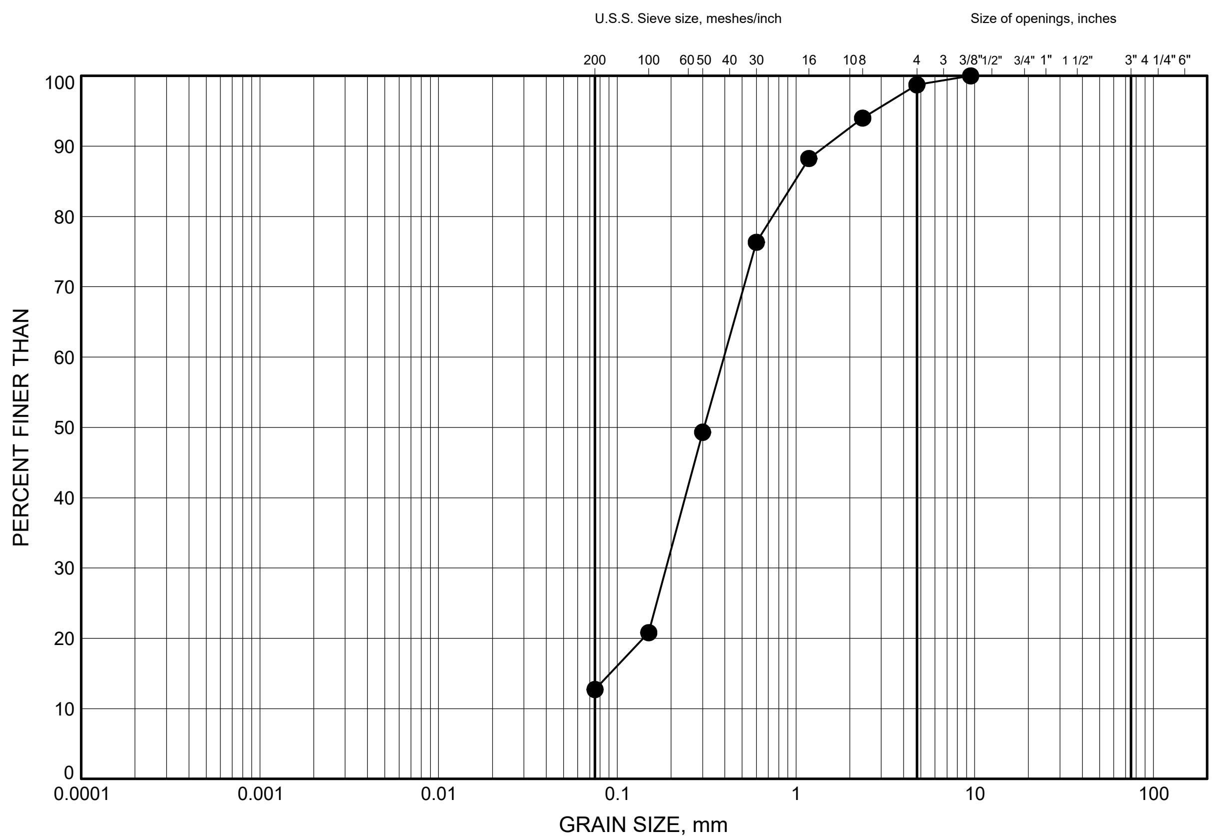
GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 8/2/16

Lower Opikinimika River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B4

SAND



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OR-04	7.92	378.58

GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 8/2/16

Date August 2016

GWP# 5148-06-00

THURBER

Prep'd AN

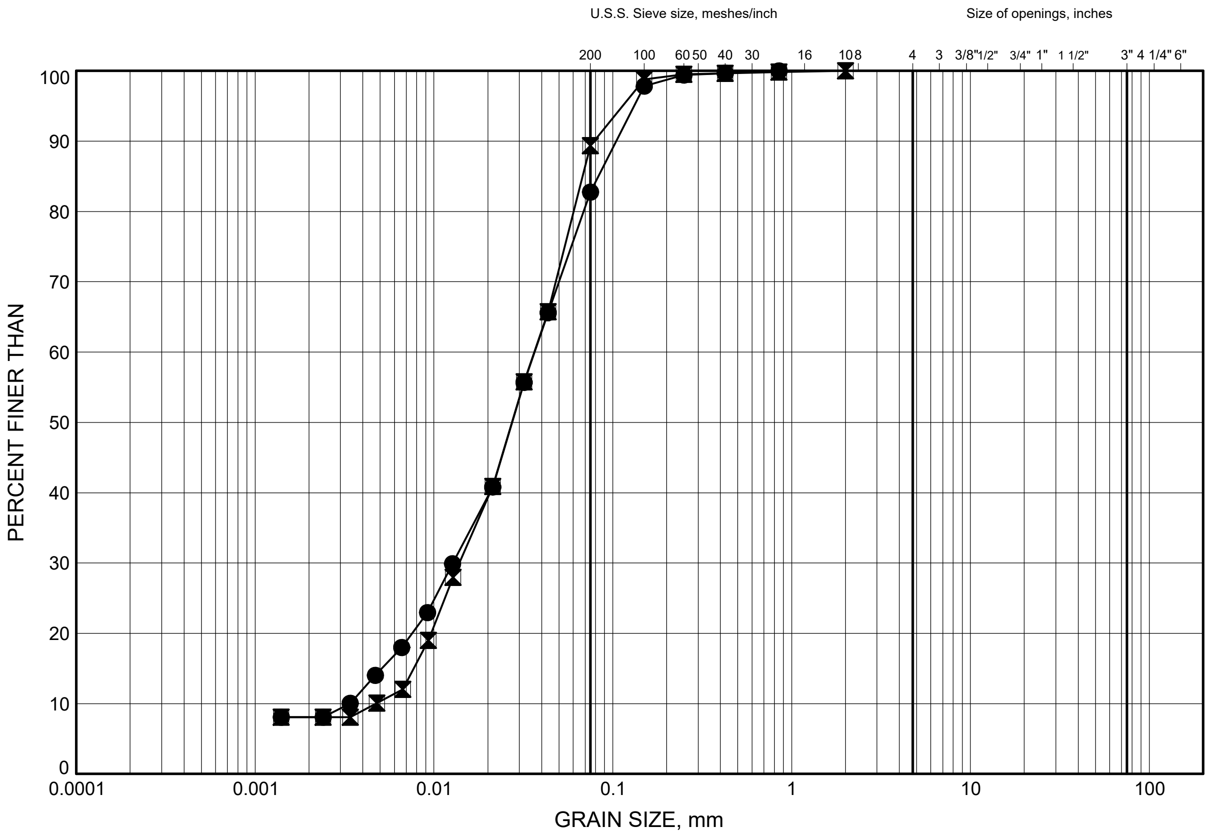
Chkd. AMP

Lower Opikinimika River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILT



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OR-01	12.50	374.00
⧗	OR-02	10.97	375.53

Date July 2016

GWP# 5148-06-00

THURBER

Prep'd AN

Chkd. AMP

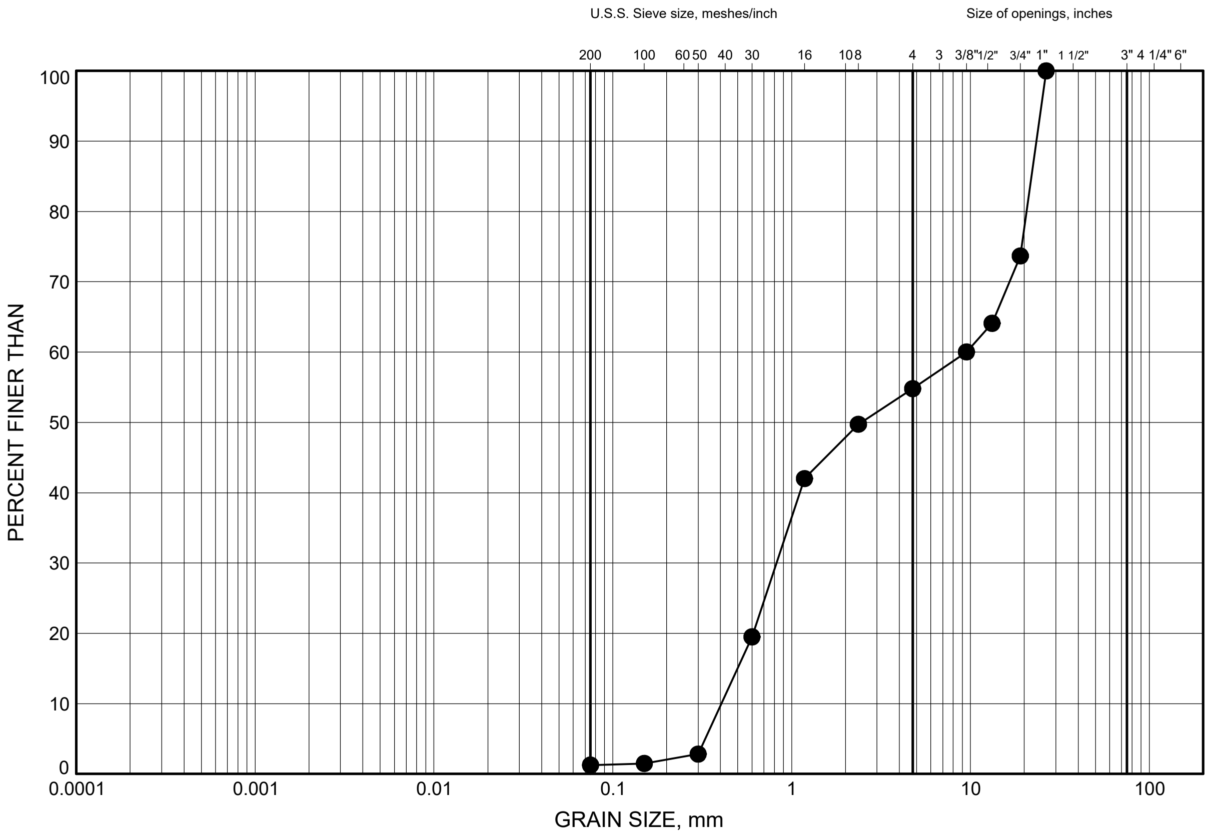
GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 7/28/16

Lower Opikinimika River Bridge

GRAIN SIZE DISTRIBUTION

FIGURE B6

SAND and GRAVEL



SILT and CLAY	FINE	MEDIUM	COARSE	FINE	COARSE	COBBLE SIZE
FINE GRAINED	SAND			GRAVEL		

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	OR-01	17.07	369.43

Date July 2016

GWP# 5148-06-00

THURBER

Prep'd AN

Chkd. AMP

GRAIN SIZE DISTRIBUTION - THURBER 19-5161-251.GPJ 7/28/16

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 15T980722
PROJECT: 19-5161-251

CLIENT NAME: THURBER ENGINEERING LTD
ATTENTION TO: MARK FARRANT
SAMPLING SITE:
SAMPLED BY:

Corrosivity Package

DATE RECEIVED: 2015-06-03
DATE REPORTED: 2015-06-09

Parameter	Unit	G / S	RDL	6613457
SAMPLE DESCRIPTION:				OR-Z SS2/3, 2'6"-7'
SAMPLE TYPE:				Soil
DATE SAMPLED:				5/30/2015
Sulfide	%		0.01	<0.01
Chloride (2:1)	µg/g		2	11
Sulphate (2:1)	µg/g		2	17
pH (2:1)	pH Units		NA	7.89
Electrical Conductivity (2:1)	mS/cm		0.005	0.225
Resistivity (2:1)	ohm.cm		1	4440
Redox Potential (2:1)	mV		5	298

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
6613457 * Sulphide analysis was performed at AGAT Laboratories Vancouver.

EC/Resistivity, pH, Chloride, Sulphate and Redox Potential were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil).

Certified By:

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

Certificate of Analysis

AGAT WORK ORDER: 15T980722

PROJECT: 19-5161-251

CLIENT NAME: THURBER ENGINEERING LTD

ATTENTION TO: MARK FARRANT

SAMPLING SITE:

SAMPLED BY:

Inorganic Chemisty (Water)

DATE RECEIVED: 2015-06-03

DATE REPORTED: 2015-06-09

			SAMPLE DESCRIPTION:	Opikinimika
			SAMPLE TYPE:	Water
			DATE SAMPLED:	6/2/2015
Parameter	Unit	G / S	RDL	6613455
Electrical Conductivity	uS/cm		2	64
pH	pH Units		NA	7.14
Langlier Index				-1.66
Total Hardness (as CaCO3)	mg/L		0.5	32.6
Total Dissolved Solids	mg/L		20	56
Alkalinity (as CaCO3)	mg/L		5	29
Chloride	mg/L		0.10	0.50
Sulphate	mg/L		0.10	2.99
Calcium	mg/L		0.05	9.82
Magnesium	mg/L		0.05	1.95
Sulphide	mg/L		0.05	<0.05
Resistivity	ohms.cm			15600
Redox Potential	mV		5	336

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Certified By:

Appendix C

Site Photographs

Photograph 1 – East approach, looking west

Photograph 2 – West approach, looking east

Photograph 3 – South Elevation, looking northeast

Photograph 4 – East Abutment, looking southeast

Photograph 5 – West Abutment

Appendix D

Borehole Locations and Soil Strata Drawing

THURBER

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No

GWP No 5148-06-00

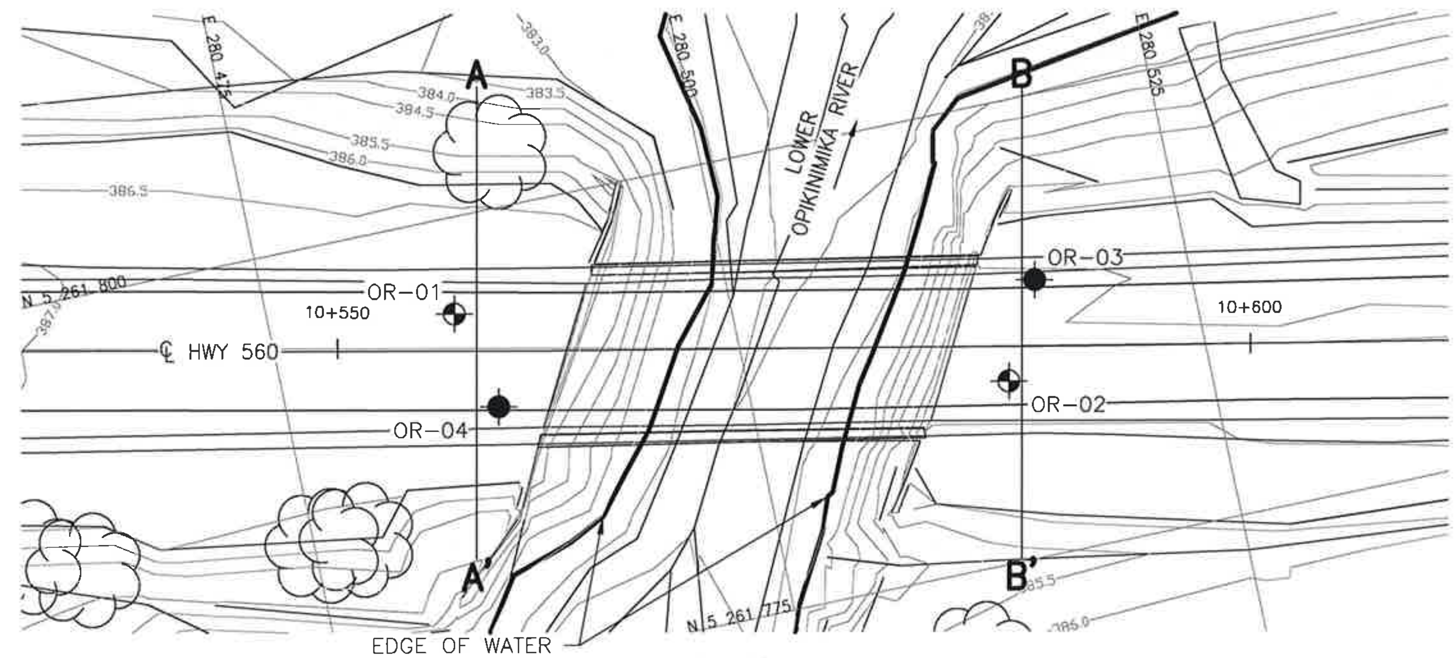
HIGHWAY 560
LOWER OPIKINIMIKA RIVER BRIDGE
REHABILITATION

BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

MMM GROUP

THURBER ENGINEERING LTD.



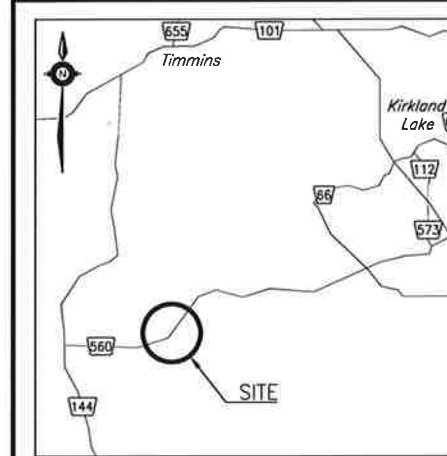
PLAN

8 0 8 16m

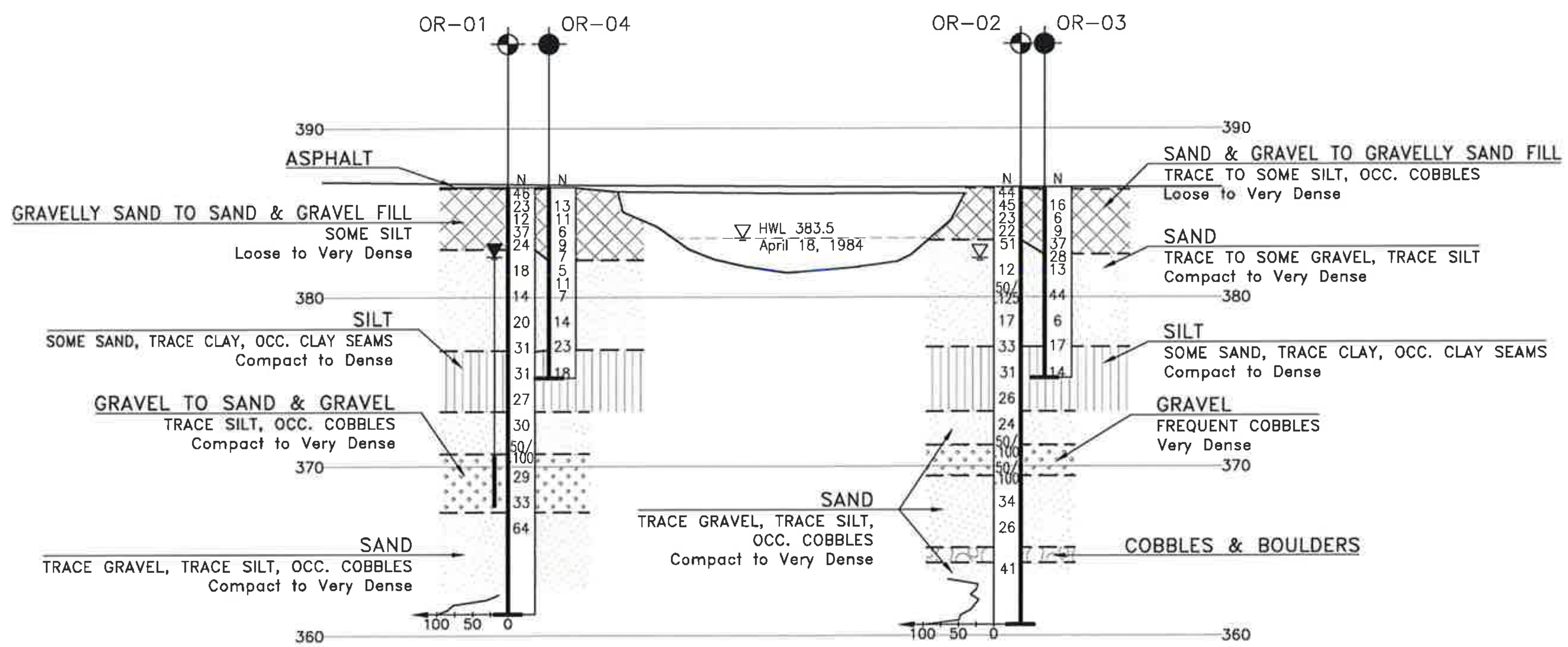
SCALE 1:400

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 12/16
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
A. E. GORMAN
16670010
OCT 12/16
PROVINCE OF ONTARIO



KEYPLAN



PROFILE ALONG ℄ HWY 560

8 0 8 16m

SCALE 1:400

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
▼	Water Level in Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
OR-01	386.5	5 261 794.8	280 485.1
OR-02	386.5	5 261 784.8	280 514.1
OR-03	386.5	5 261 790.0	280 516.6
OR-04	386.5	5 261 789.3	280 486.4

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41P-64

REVISIONS | DATE | BY | DESCRIPTION

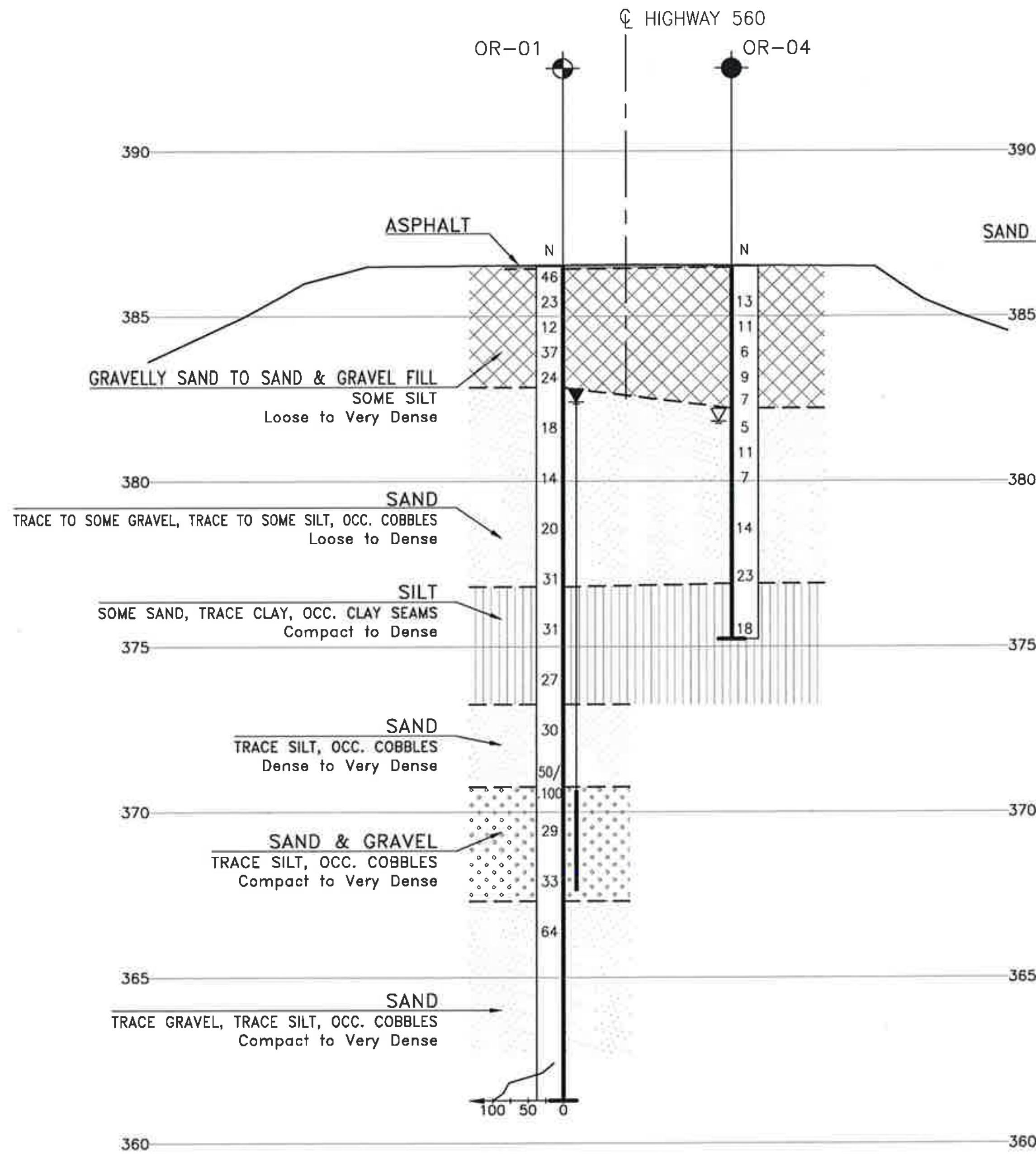
DESIGN MEF | CHK PKC | CODE | LOAD | DATE AUG 2016

DRAWN AN/MEF | CHK MEF | SITE 46-021 | STRUCT | DWG 1

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Oct 12/16
PROVINCE OF ONTARIO

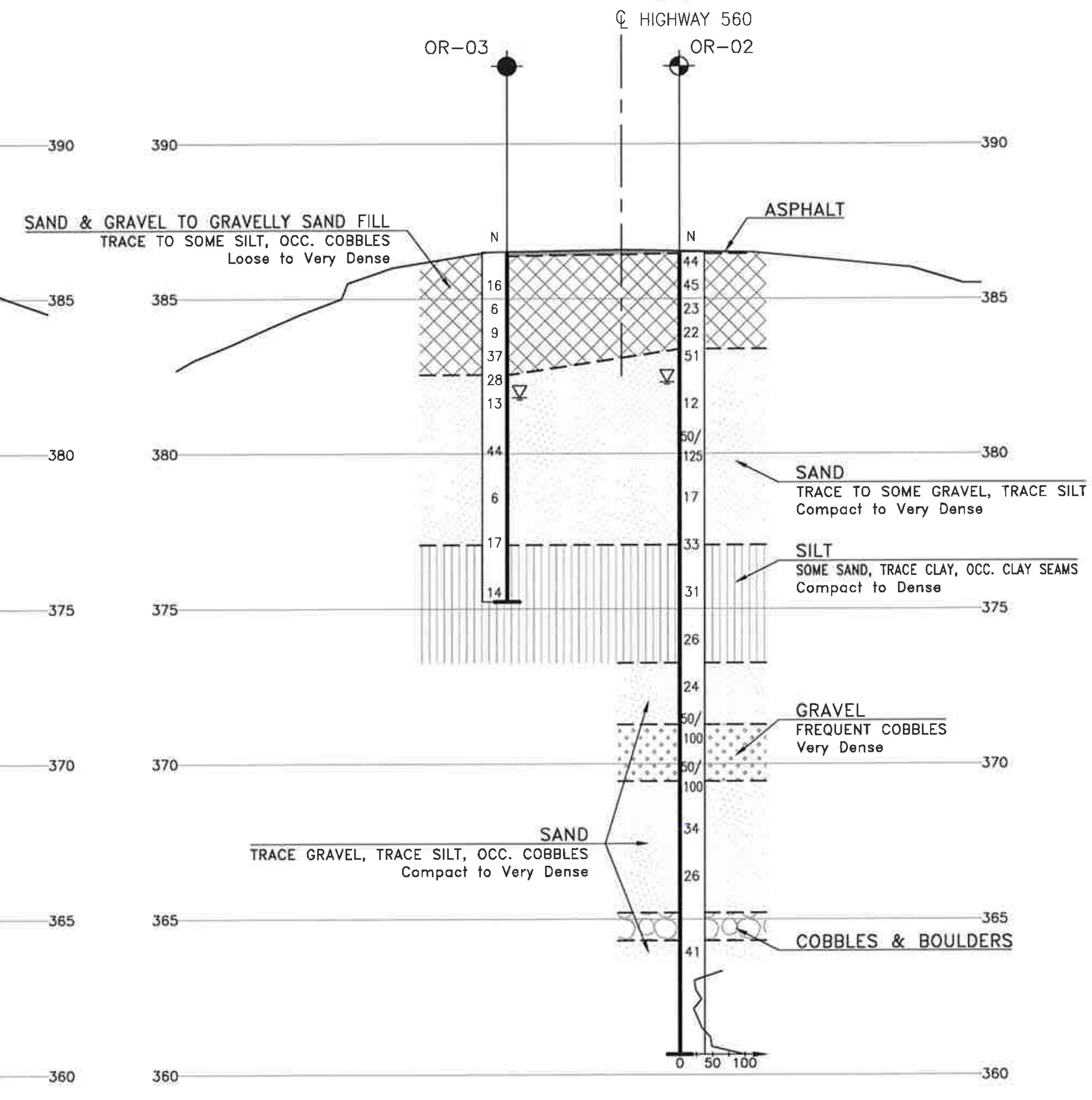
LICENSED PROFESSIONAL ENGINEER
A. E. GORMAN
16670010
Oct 12/16
PROVINCE OF ONTARIO

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



SECTION A–A'

SCALE 1:200



SECTION B–B'

SCALE 1:200

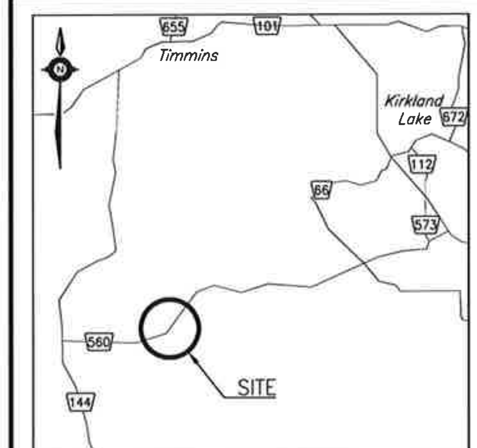
CONT No
GWP No 5148–06–00

HIGHWAY 560
LOWER OPIKINIMIKA RIVER BRIDGE REHABILITATION
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

MMM GROUP

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
	Water Level in Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
OR–01	386.5	5 261 794.8	280 485.1
OR–02	386.5	5 261 784.8	280 514.1
OR–03	386.5	5 261 790.0	280 516.6
OR–04	386.5	5 261 789.3	280 486.4

-NOTES-

1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 41P-64

REVISIONS	DATE	BY	DESCRIPTION

DESIGN MEF	CHK PKC	CODE	LOAD	DATE AUG 2016
DRAWN MFA	CHK MEF	SITE 46–021	STRUCT	DWG 2

FILENAME: H:\Drafting\19\5161\251\ted1251–Plan&Profile(LowerOpikinimikaCreekBridge).dwg
PLOTDATE: 8/29/2016 12:55 PM

Appendix E

Factual Data from 1977 Foundation Investigation Report
Geocres No.: 41P-22

Encl. No. 1

DOMINION SOIL INVESTIGATION LIMITED

RECORD OF BOREHOLE № 1

WP 42-76-01 | LOCATION Station 134 + 40; ℄ | ORIGINATED BY B.H.
DIST 14 HWY 560 | BORING DATE November 19, 1976 | COMPILED BY I.R.
DATUM Geodetic | BOREHOLE TYPE Wahsboring (N & B size) | CHECKED BY I.P.L.

ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	WATER CONTENT %	REMARKS % GR SA SI CL
1257.1	Ground Surface							
0.0	COMPACT brown SAND poorly graded some gravel occasional cobbles; wet		1	SS	17	▽		
			2	SS	11			
			3	SS	40/6"	1250		
			4	SS	15			0,96,4,0
			5	SS	19			0,96,4,0
			6	SS	19	1240		
1236.6 / 20.5	GREY DENSE compact SILT non-plastic, dilatant occasional dark grey clay lenses (1/4" thick) trace of fine sand		7	SS	44			
			8	SS	18	1230	o	0,16,83,1
			9	SS	18			
1223.1 / 34.0	DENSE GREY SAND silty fine well graded		10	SS	31	1220	o	0,93,7,0
1218.3			11	SS	30/1"			
38.8	END OF BOREHOLE REFUSAL. PROBABLY BOULDER							

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W; WATER CONTENT % 20 40 60
UNIT WEIGHT γ

20
% STRAIN AT FAILURE

DOMINION SOIL INVESTIGATION LIMITED

Encl. No. 2

RECORD OF BOREHOLE Nº 2

WP 42-76-01 | LOCATION Station 134 + 76; 16' L T | ORIGINATED BY B.H.

DIST 14 HWY 560 | BORING DATE November 20, 1976 | COMPILED BY I.R.

DATUM Geodetic | BOREHOLE TYPE Washboring (N and B size) | CHECKED BY I.P.L.

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH	WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
1256.2	RIVER ICE								
0.0	WATER								
1251.2	RIVER BOTTOM								
5.0	decayed wood, soft organic silt & sand								
1249.2 7.0	COMPACT SAND poorly graded				1250				
		1	SS	11					
		2	SS	21					
		3	SS	14	1240				3,91,6,0
1236.7		4	SS	10					
19.5	COMPACT TO DENSE grey SILT non-plastic dilatent occasional thin(1/4") dark grey clay lenses	5	SS	34			o		0,8,87,5
		6	SS	25			o		0,0,95,5
		7	SS	30	1230				
1221.2		8	SS	24					
35.0	COMPACT fine to medium SAND BOULDER gravel and cobbles	9	SS	23	1220				CORED THROUGH 24" BOULDER UNABLE TO ADVANCE CASING FURTHER
1213.7 42.5	END OF BOREHOLE								

Shear strength legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. Dynamic cone scale: 20 40 60 80 100. Liquid limit — W_L; Plastic limit — W_P; Water content — W. Water content scale: 20 40 60.

Encl. No. 3

DOMINION SOIL INVESTIGATION LIMITED

RECORD OF BOREHOLE Nº 3

VP 42-76-21 | LOCATION Station 135 + 15; 20' RT | ORIGINATED BY B.H.

DIST 14 HWY 560 | BORING DATE December 6 & 7, 1976 | COMPILED BY I.R.

DATUM Geodetic | BOREHOLE TYPE Washboring (N and B size) & dynamic cone test | CHECKED BY I.P.L.

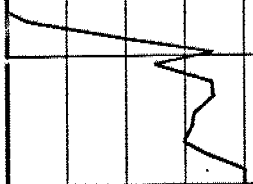
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	WATER CONTENT %	REMARKS % GR SA SI CL
1256.2	RIVER ICE							
0.0	6" ICE WATER river bottom					1250		
1250.5 5.7	boulders Loose to compact SAND fine to medium trace of silt		1	SS	62			
			2	SS	5			
			3	SS	20	1240		2,96,2,0
238.0 18.2	COMPACT grey SILT some fine sand non-plastic, dilatant occasional 1/4" thick clay lenses		4	SS	25			
			5	SS	18	1230	o	0,15,83,2
225.7 30.5	COMPACT TO DENSE some cobbles SAND well graded some gravel		6	SS	19			
			7	SS	20	1220		
			8	SS	15			
			9	SS	30	1210		
1204.2 52.0	end of sampled B.H. Drove cone		10	SS	54			4,87,9,0
	Dense Sand (Inferred)					1200		
192.2 64.0	END OF BOREHOLE							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W — WATER CONTENT %: 20 40 60

UNIT WEIGHT γ



Encl. No. 4

DOMINION SOIL INVESTIGATION LIMITED

RECORD OF BOREHOLE Nº 4

W P 42-76-01	LOCATION Station 134 + 66; 14' R.T.	ORIGINATED BY B.H.
DIST 14 HWY 560	BORING DATE December 11, 12 & 13, 1976	COMPILED BY I.R.
DATUM Geodetic	BOREHOLE TYPE Washboring (N and B size)	CHECKED BY I.P.L.

Column headings: SOIL PROFILE (ELEV / DEPTH, DESCRIPTION, STRAT. PLOT); SAMPLES (NUMBER, TYPE, 'N' VALUES); GROUND WATER ELEV; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE); LIQUID LIMIT W_L, PLASTIC LIMIT W_P, WATER CONTENT W (W_P — W — W_L), WATER CONTENT % (20, 40, 60); UNIT WEIGHT γ; REMARKS (% GR SA SI CL)

ELEV / DEPTH	DESCRIPTION	REMARKS % GR SA SI CL
1256.1	RIVER ICE	
0.0	10" ICE WATER	
1252.1 / 4.0	RIVER BOTTOM 18" ORGANIC SILT	0,95,5,0
	V. loose to loose SAND fine to medium trace-of silt	0,8,87,5
1237.1 / 19.0	COMPACT grey SILT sand some fine sand occasional 1/4" thick clay non-plastic	
1223.1 / 33.0	COMPACT to VERY DENSE SAND generally well graded fine to coarse with a trace of gra- vel and silt	9.87,4,0
1179.1 / 77.0	END OF BOREHOLE	slight artesian pressure observed at El 1180 measured head at El. 1256.6 feet

NUMBER	TYPE	'N' VALUES
1	SS	1/18"
1A	SS	2
2	SS	3
3	SS	7
3A	SS	2
4	SS	12
5	SS	11
6	SS	16
7	SS	31
8	SS	36
9	SS	29
10	SS	16
11	SS	57
12	SS	76
13	SS	52
14	SS	33
15	SS	31

ELEV scale: 1250, 1240, 1230, 1220, 1210, 1200, 1990, 1980

DOMINION SOIL INVESTIGATION LIMITED

Encl. No. 5

RECORD OF BOREHOLE № 5

WP 42-76-01 | LOCATION Station 136 + 50; 3' RT | ORIGINATED BY B.H.
DIST 14 HWY 560 | BORING DATE December 9 & 10, 1976 | COMPILED BY I.R.
DATUM Geodetic | BOREHOLE TYPE Washboring, BXL rock core | CHECKED BY I.P.L.

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	NUMBER	TYPE	'N' VALUES	GROUND WATER ELEV	REMARKS
1256.1	RIVER ICE					
0.0	11" ICE WATER					
1251.4	RIVER BOTTOM					
4.7	16" ORGANIC SILT LOOSE TO COMPACT SAND	1A	SS	2		
		1B	SS	29	1250	
		2	SS	17		
		3	SS	7		
1237.6		4	SS	20	1240	
18.5	COMPACT grey SILT occasional thin clay lenses	5	SS	15		
1227.1	non-plastic	6	SS	17	1230	
29.0	COMPACT TO V. DENSE SAND well graded	7	SS	14		
		8	SS	50/2"	1220	cored through 30" boulder
1217.5	boulder	9	BXL R.C.	100%		
38.6						

Column headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; LIQUID LIMIT — W_L, PLASTIC LIMIT — W_P, WATER CONTENT — W; WATER CONTENT %; UNIT WEIGHT γ; REMARKS % GR SA SI CL

20 / 15 -5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

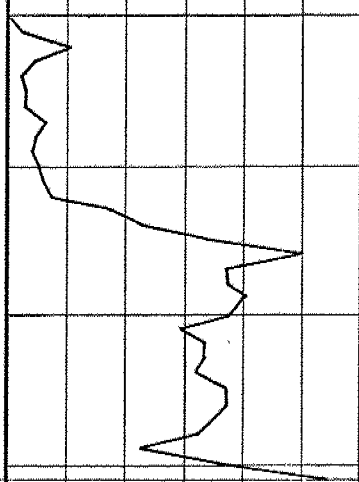
DOMINION SOIL INVESTIGATION LIMITED

Encl. No. 6

RECORD OF CONE TEST Nº C-1

WP 42-76-01	LOCATION Station 134 + 65; 17' RT	ORIGINATED BY B.H.
DIST 14 HWY 560	BORING DATE November 20, 1976	COMPILED BY I.R.
DATUM Geodetic	BOREHOLE TYPE Dynamic cone test	CHECKED BY I.P.L.

SOIL PROFILE			SAMPLES			GROUND WATER	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE	LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	'N' VALUES	ELEV				
1256.0 / 0.0	RIVER ICE / WATER									
1251.0 / 5	river bottom					1250				
1249.5 / 6.5	soft silt									
1238.0 / 18.0	loose to COMPACT SAND (INFERRED)					1240				
1221.0 / 35.0	SILT (INFERRED)					1230				
1219.0 / 37.0	DENSE SAND (INFERRED)					1220				
	END OF CONE TEST refusal probably on boulder									



20
15 ⌖ 5 % STRAIN AT FAILURE
10

DOMINION SOIL INVESTIGATION LIMITED

Encl. No. 7

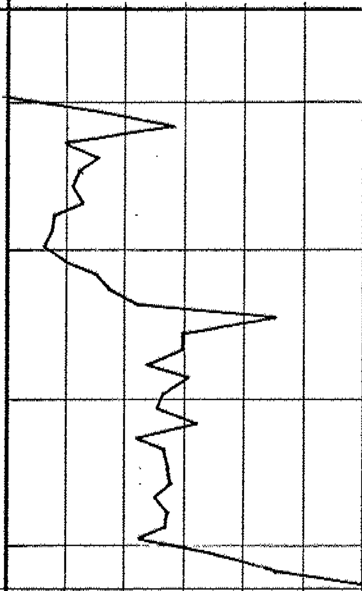
RECORD OF CONE TEST Nº C-2

WP 42-76-01 | LOCATION Station 135 + 25; 19' LT | ORIGINATED BY B.H.

DIST 14 HWY 560 | BORING DATE December 8, 1976 | COMPILED BY I.R.

DATUM Geodetic | BOREHOLE TYPE Dynamic cone test | CHECKED BY I.P.L.

SOIL PROFILE: ELEV / DEPTH	DESCRIPTION	STRAT. PLOT	SAMPLES: NUMBER	TYPE	'N' VALUES	GROUND WATER / ELEV	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE	LIQUID LIMIT — W_L; PLASTIC LIMIT — W_P; WATER CONTENT — W; WATER CONTENT %	UNIT WEIGHT γ	REMARKS % GR SA SI CL
1256.2	RIVER ICE									
0.0	WATER									
1250.4	river bottom									
5.8	compact SAND (inferred)									
1238.2 / 18.0	compact to dense SILT (inferred)									
1220.2 / 36.0	dense SAND (inferred)									
1217.2 / 39.0	END OF BOREHOLE									



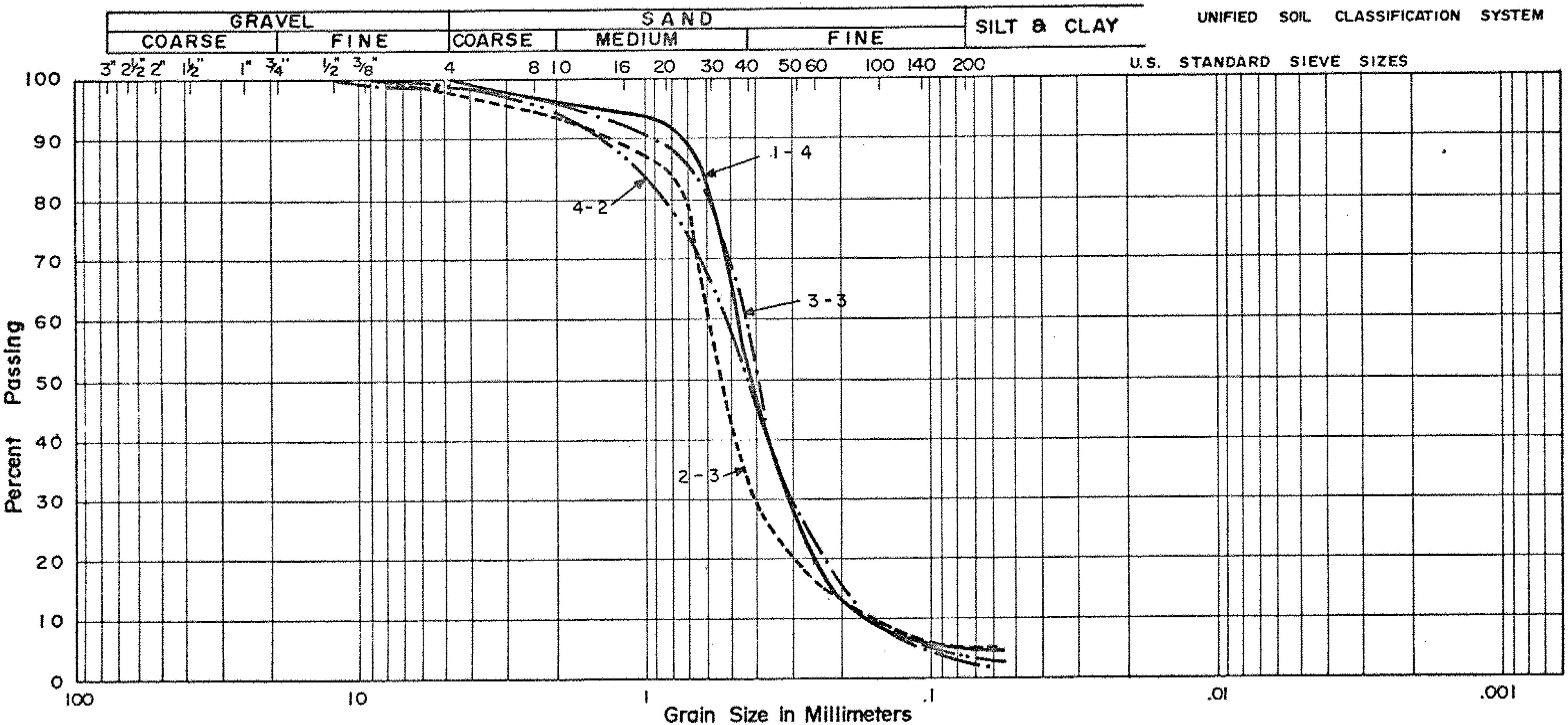
20 / 15 ◇ 5 / 10 % STRAIN AT FAILURE

OFFICE REPORT ON SOIL EXPLORATION

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE Nº 76-11-10



PROJECT: OPIKINIMIKA RIVER BRIDGE

LOCATION: HWY. 560.

BOREHOLE Nº: 1 2 3 4

SAMPLE Nº: 4 3 3 2

DEPTH:

ELEVATION:

COEFFICIENT OF UNIFORMITY: 2·5 – 3·25

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

Medium to Fine

SAND

PLASTIC PROPERTIES

LIQUID LIMIT % = N.P.

PLASTIC LIMIT % =

PLASTICITY INDEX % =

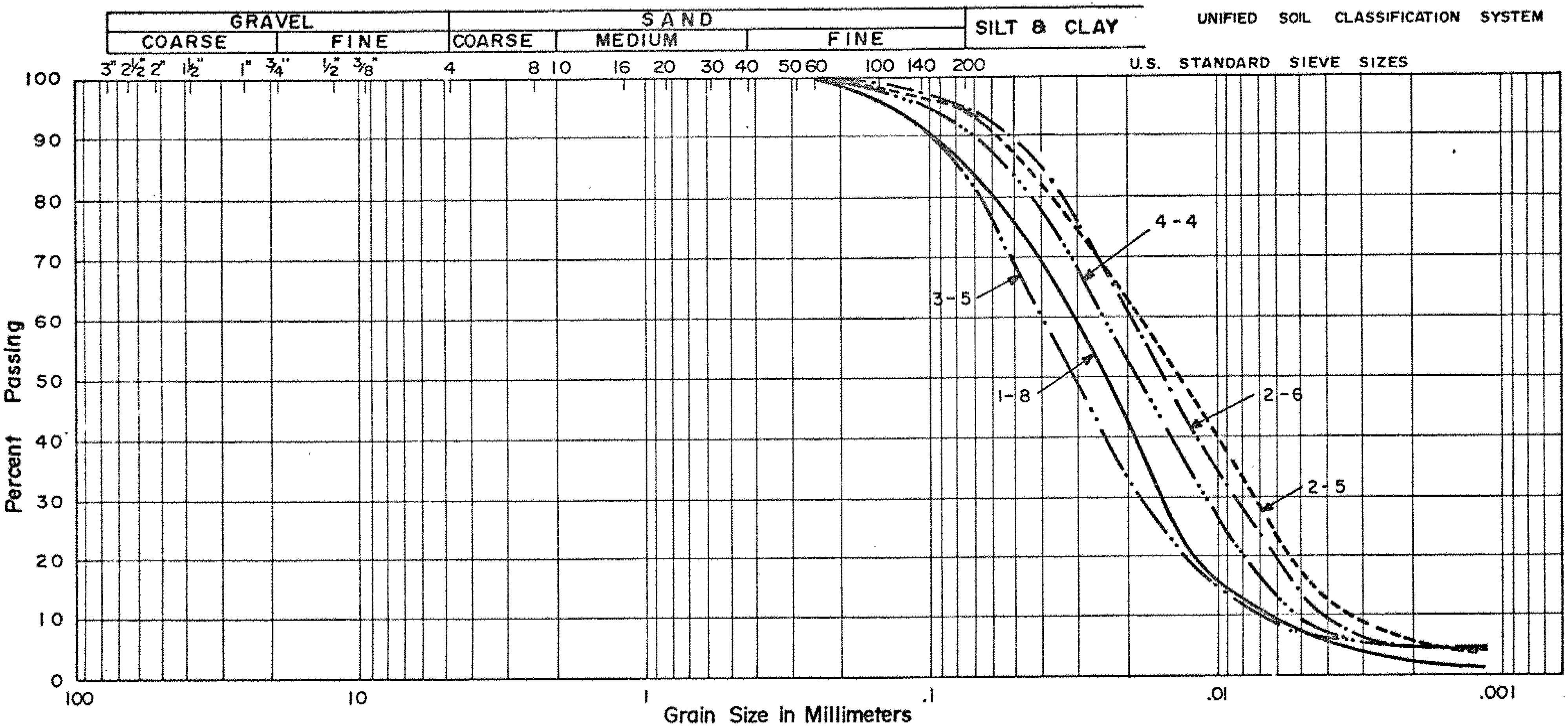
MOISTURE CONTENT % =

ENCLOSURE Nº 8

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE Nº 76-11-10



PROJECT: OPIKINIMIKA RIVER BRIDGE

LOCATION: HWY. 560

BOREHOLE Nº: 1 2 2 3 4

SAMPLE Nº: 8 5 6 5 4

DEPTH:

ELEVATION:

COEFFICIENT OF UNIFORMITY:

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SILT

with a trace to some fine sand.

PLASTIC PROPERTIES

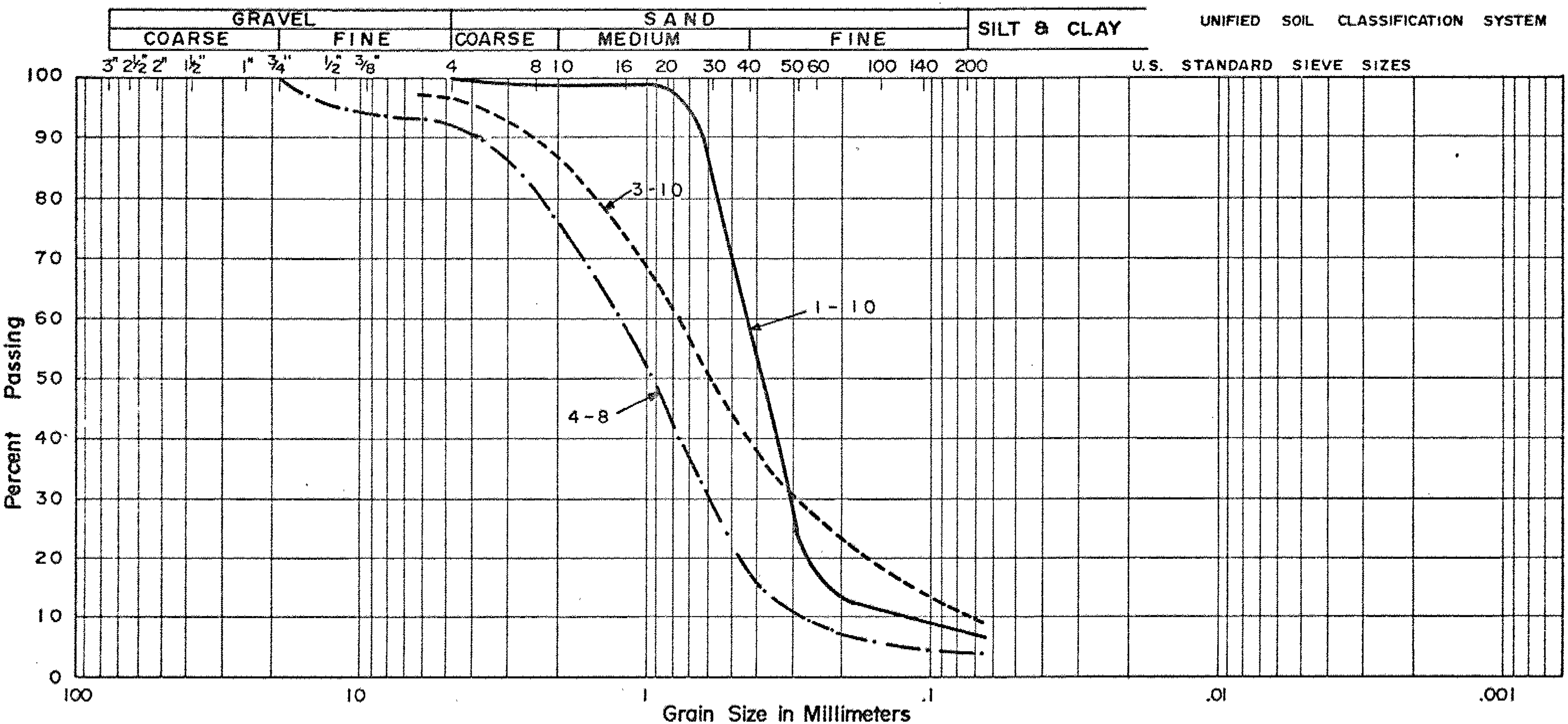
LIQUID LIMIT	% =	N.P.
PLASTIC LIMIT	% =	–
PLASTICITY INDEX	% =	–
MOISTURE CONTENT	% =	19.6 – 25.8

ENCLOSURE Nº 9

DOMINION SOIL INVESTIGATION LIMITED

GRAIN SIZE DISTRIBUTION

OUR REFERENCE Nº 76-11-10



PROJECT: OPIKINIMIKA RIVER BRIDGE

LOCATION: HWY. 560

BOREHOLE Nº: 1 3 4

SAMPLE Nº: 10 10 8

DEPTH:

ELEVATION:

COEFFICIENT OF UNIFORMITY: 3 - 10

COEFFICIENT OF CURVATURE:

Classification of Sample and Group Symbol:

SAND

poorly to well graded, trace of silt

PLASTIC PROPERTIES

LIQUID LIMIT % = N.P.

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

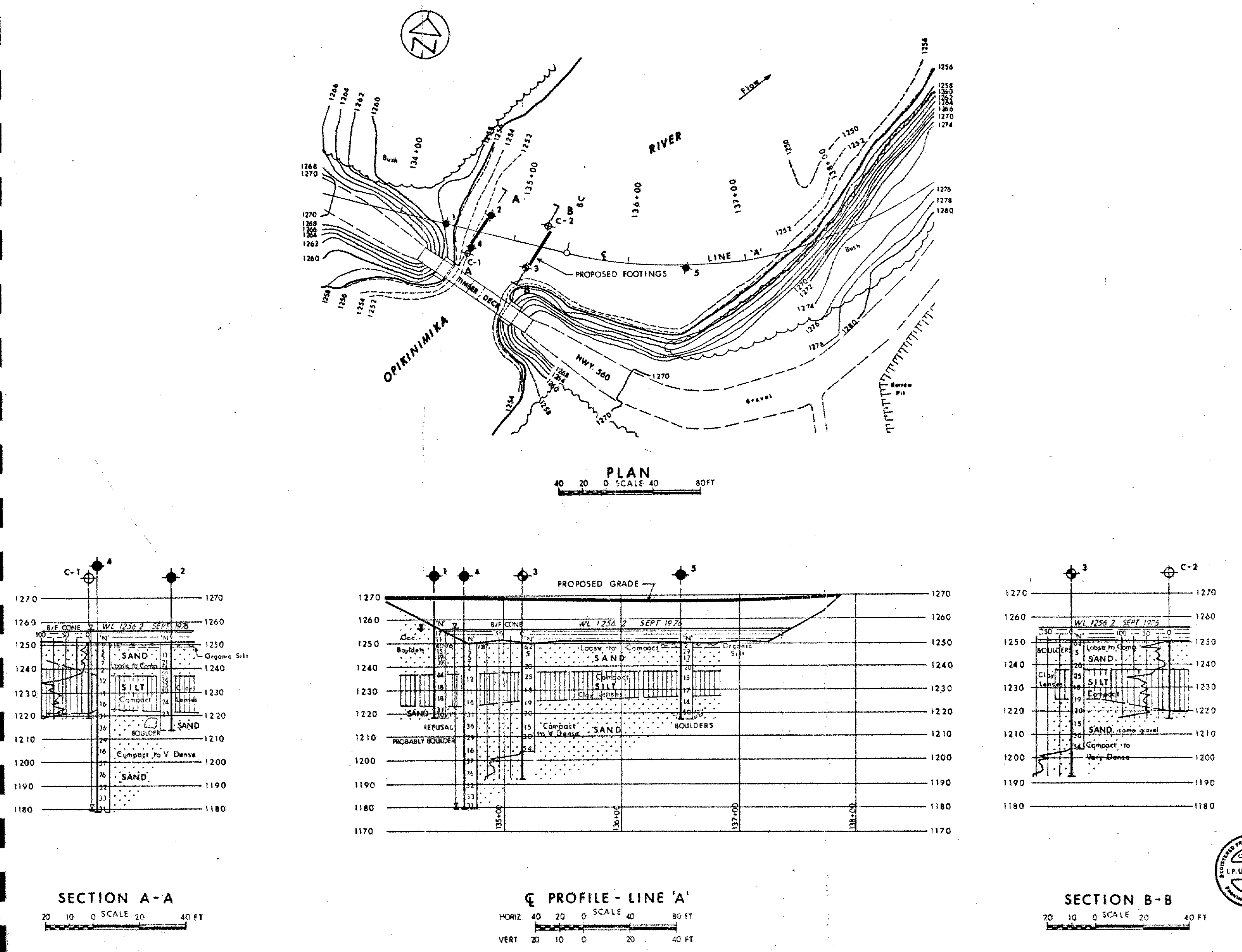
ENCLOSURE Nº 10

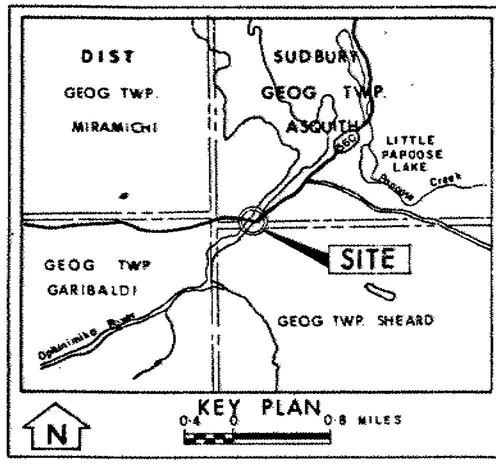
CONT No
WP No 42-76-01

OPIKINIMIKA RIVER

BORE HOLE LOCATIONS & SOIL STRATA

SHEET





LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- 'N' Blows/ft (Std Pen Test 350ft lbs energy)
- CONE Blows/ft (60° Cone, 350ft lbs energy)
- WL at time of investigation NOV & DEC 1976
- Head — ARTESIAN WATER
- Encountered

No	ELEVATION	STATION	OFFSET
1	1257.1	134+40	℄
2	1256.2	134+76	16' LT.
3	1256.2	135+15	20' RT.
4	1256.2	134+66	14' RT.
5	1256.2	136+50	3' RT
C-1	1256.0	134+65	17' RT
C-2	1256.2	135+25	19' LT

-NOTE-

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

REGISTERED PROFESSIONAL ENGINEER — CIVIL — L. P. LIESZKOWSZKY — PROVINCE OF ONTARIO

REVISIONS | DATE | BY | DESCRIPTION

HWY No 560 | DIST 14
SUBM'D | CHECKED | DATE DEC 1976 | SITE 46-21
DRAWN | CHECKED | APPROVED | DWG 46-21-2

76-11-10

Appendix F

List of Specifications and Suggested Text for Selected NSSP

1. List of OPSS Documents Referenced in this Report

- OPSS.PROV 501
- OPSS.PROV 539
- OPSS 804
- OPSS.PROV 902
- OPSS. PROV 903
- OPSS.PROV 1010

2. Suggested text for NSSP on "Installation of Roadway Protection System"

Cobbles and boulders are present within the existing embankment fill and underlying native soils at this site. These cobbles and boulders may impede the installation of the roadway protection system. At some locations, the installation may not be able to penetrate the obstructions and reach the design depth. The Contractor shall be prepared to remove, drill through and/or penetrate these obstructions and extend the protection system to the design depth.