



**THURBER** ENGINEERING LTD.

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
KASABONIKA LAKE MODULAR BRIDGE  
DISTRICT OF KENORA, KASABONIKA LAKE FIRST NATION, ONTARIO  
LATITUDE: 53.5263°, LONGITUDE: -88.6213°  
W.P. 6579-16-00, SITE No. 41N-0244/BO**

**GEOCRES Number: 53H-01**

**Report**

**to**

**HATCH**

Date: November 13, 2019  
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**PART 1: FACTUAL INFORMATION**

**1. INTRODUCTION**

This report presents the factual data obtained from a foundation investigation carried out by Thurber Engineering Ltd. (Thurber) for the proposed Kasabonika Lake Modular Bridge replacement in Kasabonika Lake First Nation, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the bridge site and, based on the data obtained, to provide a borehole location plan, stratigraphic profile, records of boreholes, laboratory test results, and a written description of the subsurface conditions.

Thurber was retained by the Ministry of Transportation (MTO), Northwest Region, to carry out this foundation investigation under the MTO Agreement Number 6017-E-0022, Assignment #15.

**2. SITE DESCRIPTION**

The site is located in Kasabonika Lake First Nation, approximately 1 km east of the Kasabonika Airport. The existing bridge connects the island community of Kasabonika Lake First Nation to the mainland. A survey drawing provided by MTO refers to the road that the bridge is located on as "Main Road". Main Road runs in an approximately southwest to northeast direction at the bridge.

The Ontario Structure Inspection Manual (OSIM) report prepared by MTO on June 6, 2018 indicates that the existing structure is a single span bailey panel modular bridge built in 1983. The inspection report indicates that the bridge deck is approximately 27.6 m long and 5.45 m wide. The ground surface elevation at the existing bridge deck is approximately Elevation 186.8 m. The existing bridge is in overall poor condition, with potholes at the abutments and decaying deck boards. The wearing surface and some of the deck boards have been replaced since the 2018 OSIM report. The existing bridge abutments are supported on timber cribs on a causeway placed



in the lake. The southwest approach embankment to the bridge is approximately 30 m long to the mainland and the fill is approximately 3.5 m high at the bridge. The northeast approach embankment is approximately 50 m long to the island and the fill is approximately 3 m high at the bridge. Photographs provided by MTO (see Photos C1 and C2 in Appendix C) show that the causeway beyond the bridge has previously been overtopped by high lake water levels. Photographs from 2009 (see Photos C3 and C4 in Appendix C) show that severe erosion of the approach embankments, possibly due to this flooding, has previously occurred at the bridge abutments, leading to exposure and undermining of the timber cribs. The embankment erosion was subsequently repaired at an unknown time.

The water level of Kasabonika Lake was measured at Elevation 184.0 m at the bridge on August 21, 2016, as shown on survey drawings provided by MTO, and at approximate Elevation 184.4 m in June 2019, as measured by Hatch. The previous flooding that overtopped the east approach embankment causeway indicates that the lake water level has previously been observed at greater than approximate Elevation 186 m. The lake channel is approximately 10 m wide and 0.5 to 1 m deep, which varies based on the water level.

The lands surrounding the bridge site predominantly consist of heavily forested areas with lakes, swamps, rivers, and creeks. Photographs of the bridge and surrounding area are presented in Appendix C.

Based on published geological information, the bridge lies within an area of tonalite to granodiorite bedrock. Based on local geological maps, the bedrock in the area is overlain by undifferentiated sand to silt till.

### **3. INVESTIGATION PROCEDURES**

The field investigation for the bridge replacement project was carried out from June 5 to 10, 2019 and consisted of drilling and sampling nine (9) boreholes, labeled 19-01 to 19-05B, to depths of approximately 2.3 m to 9.4 m (Elevation 184.6 m to 176.7 m). Boreholes 19-01, 19-01B and 19-01B(2) were drilled at the west abutment, while boreholes 19-02 and 19-02B were drilled at the east abutment of the bridge. Boreholes 19-04, 19-05, 19-05B were drilled along the causeway at the east approach to the bridge, while Borehole 19-03 was drilled at the west bridge approach. All boreholes were drilled on the existing road shoulders. Most of the boreholes encountered refusal on boulders or possibly frozen soil, and therefore multiple boreholes were attempted in order to retrieve information below the boulder layer. The additional attempts for Boreholes 19-01, 19-02 and 19-05 were drilled on the opposite road shoulder and are labelled Boreholes 19-01B, 19-02B and 19-05B respectively. A third attempt for Borehole 19-01 was conducted



adjacent to Borehole 19-01B and is labelled 19-01B(2).

In addition to the boreholes, three test pits were also excavated and are labelled TP-01 to TP-03. The test pits were all terminated at a depth of 2.1 m (Elevation 184.9 m to 183.9 m). TP-01 was excavated on the west approach while TP-02 and TP-03 were excavated along the east approach. Ten hand probes (HP1 to HP10) were also conducted near the base of the causeway embankments.

The approximate locations of the boreholes, test pits and hand probes from the investigation are shown on the Borehole Locations and Soil Strata Drawing included in Appendix D.

Utility clearances were obtained prior to the start of drilling. The ground surface elevations for the boreholes were estimated from the cross sections and topographic drawings provided to Thurber by MTO. The coordinate system MTM NAD 83, Zone 15 was used for the boreholes.

A limited access Simco drill rig (Photo C5 in Appendix C) was used to advance Boreholes 19-01 to 19-05B using solid stem augers and BW casing. The drill rig was transported to the site by plane from Pickle Lake, Ontario (Photo C6 in Appendix C). The soil samples were obtained in the boreholes at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). At Boreholes 19-01, 19-01B, 19-02, 19-03, 19-04 and 19-05, BQ coring methods were used to advance the boreholes past large boulders. A backhoe supplied and operated by the Kasabonika Lake First Nation was used to excavate the test pits (Photo C7 in Appendix C). Grab samples of the excavated soil were obtained from the test pits. Photos of the test pits (Photos A1 to A3) are included in Appendix A following the borehole logs for Test Pits TP-01 to TP-03.

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 samples for transport to Thurber's laboratory for further examination and testing.

Completion details of the boreholes are summarized in Table 3.1.

**Table 3.1 – Borehole Completion Details**

<b>Borehole Number</b>	<b>Borehole Depth / Base Elevation (m)</b>	<b>Completion Details</b>
19-01	4.3 / 182.6	Hole open to 2.0 m. Backfilled from 2.0 m to 0.15 m with Bentonite

Borehole Number	Borehole Depth / Base Elevation (m)	Completion Details
		holeplug and cuttings. Sand and gravel from 0.15 m to surface.
19-01B	4.2 / 182.7	Backfilled with Bentonite holeplug and cuttings to 0.15 m. Sand and Gravel to surface
19-01B(2)	3.5 / 183.5	Hole open to 1.8 m. Backfilled with Bentonite holeplug and cuttings from 1.8 m to 0.15 m. Sand and Gravel to surface.
19-02	3.7 / 182.8 DCPT 3.7 to 8.1 / 182.8 to 178.4	Hole open to 1.8 m. Backfilled from 1.8 m to 0.9 m with bentonite holeplug and cuttings. Sand and gravel from 0.9 m to surface.
19-02B	2.3 / 183.9	Backfilled with Sand and Gravel to surface.
19-03	2.5 / 184.6	Hole open to 0.9 m. Backfilled with Bentonite holeplug to 0.15 m. Sand and gravel to surface.
19-04	3.3 / 182.8	Hole open to 1.5 m. Backfilled with Sand and gravel to surface.
19-05	2.4 / 183.7	Backfilled with Bentonite holeplug to 0.15 m. Sand and Gravel to surface.
19-05B	9.4 / 176.7	Hole open to 1.7 m. Backfilled with Bentonite holeplug and sand to 0.15 m. Sand and gravel to surface.

#### 4. LABORATORY TESTING

All recovered soil samples were subjected to visual identification (VI) and to natural moisture content determination. Selected samples were also subjected to grain size distribution analyses (sieve and/or hydrometer), where appropriate. The results of this laboratory testing program are shown on the Record of Borehole sheets included in Appendix A and 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, samples of the fill and native soil from Boreholes 19-01 and 19-05B were collected respectively. The samples were then submitted to SGS Canada Inc., a CALA accredited analytical laboratory in Lakefield, Ontario, for analytical testing of corrosivity parameters and sulphate content. The results of the analytical testing from



the investigation are summarized in Section 6 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 on the Record of Borehole sheets and on the Borehole Locations and Soil Strata Drawing included in Appendix D. 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 conditions may vary between and beyond the borehole locations.

In general, the subsurface conditions encountered consisted of granular and embankment fill, underlain by deposits of large boulders, overlying native deposits of sand, gravel and sandy silt. Descriptions of the individual strata are presented below.

### **5.1 Granular Fill**

Granular fill ranging from silty sand to sand and gravel and gravelly sand with some silt was encountered at the ground surface in all boreholes, test pits, and HP10. The granular fill also contained trace clay and occasional cobbles and extended to depths ranging from 1.4 m and 2.3 m (Elevation 185.7 m to 183.8 m). Potentially frozen fill was encountered within this material at depths between 0.8 m and 3.0 m. Borehole 19-02B and Test Pits TP-01 to TP-03 were terminated within the granular fill at depths from 2.1 to 2.3 m (Elevation 184.9 to 183.9 m) due to refusal to advance through boulders and possible frozen soil.

SPT 'N' values in the granular fill ranged from 9 to greater than 100 blows per 0.3 m of penetration, indicating a loose to very dense relative density. The 100 blow values may represent the presence of a cobble, boulder or frozen soil. The measured moisture content in the fill ranged from 3 percent to 26 percent.

The results of grain size analyses conducted on selected samples of the granular fill are illustrated on Figures B1 to B3 of Appendix B. The results are summarized as follows:

Soil Particle	Silty Sand Fill Percentage	Sand and Gravel to Gravelly Sand Percentage
Gravel	3 to 30	41 to 76
Sand	32 to 62	21 to 40
Silt and Clay	23 to 25	3 to 19
Silt	26 to 43	-
Clay	4 to 13	-

## 5.2 Clayey Silt Fill

A layer of clayey silt fill containing some sand, trace gravel and occasional cobbles and boulders was encountered below the silty sand fill in Boreholes 19-01 and 19-03. The layer was 0.4 to 0.5 m thick and extended to depths of 1.9 to 2.1 m (Elevation 185.2 to 184.8 m). This fill layer appeared to be frozen in both boreholes.

SPT 'N' values measured in the clayey silt fill ranged from 33 to 100 blows for 0.3 m penetration. The results of the SPTs indicate the layer to be hard/dense to very dense in consistency. The measured moisture content in the clayey silt fill ranged from 19 to 21 percent.

## 5.3 Gravelly Sand to Sand Fill

A layer of gravelly sand to sand with some gravel fill containing cobbles and boulders was encountered below the clayey silt fill or silty sand fill in Boreholes 19-01 and 19-02. This layer had a thickness ranging from approximately 1.2 to 2.2 m and extended to depths from 3.4 to 4.3 m (Elevation 183.1 to 182.6 m). Borehole 19-01 was terminated at a depth of 4.3 m (Elevation 182.6 m) within this fill layer due to refusal to advance through boulders. The fill was partially frozen in Borehole 19-02.

SPT 'N' values measured in the gravelly sand to sand fill ranged from 49 to greater than 100 blows for 0.3 m of penetration, which indicate that the fill is dense to very dense. The 100 blow values may represent the presence of cobbles, boulders or frozen fill. The measured moisture content in the fill ranged from 11 to 21 percent.

## 5.4 Boulders

A layer of boulders was contacted within the fill or near the top of the native soil in every borehole and test pit, excluding Borehole 19-05B. The boulder layer was encountered at 2.1 to 3.5 m depth



(Elevation 184.9 to 183.5 m) and extended to 3.4 to 3.7 m depth (Elevation 183.6 to 183.2 m) in some boreholes. A number of boreholes (19-02B, 19-03, 19-04, 19-05, and test pits TP-01 to TP-03) met refusal on the boulders at depths from 2.1 to 3.5 m (Elevation 184.9 to 183.5 m). The boulders primarily consisted of granodiorite rock and the layer ranged in thickness from approximately 0.2 m to 1.1 m, where penetrated.

## 5.5 Silty Sand

A deposit of native sand with some silt to silty sand was encountered below the fill in Borehole 19-05B. The deposit also contained trace clay, trace to some gravel and occasional cobbles. The upper part of this layer appeared to be frozen. The silty sand layer was 6.3 m thick and extended to a depth of 8.5 m (Elevation 177.7 m).

SPT 'N' values measured in the silty sand deposit ranged from 9 to 41 blows for 0.3 m of penetration, which indicate that the deposit is dense to loose. The measured moisture content in the silty sand ranged from 9 to 35 percent.

The results of a grain size analysis conducted on a sample of the silty sand are illustrated on Figure B4 of Appendix B. The results are summarized as follows:

Soil Particle	Silty Sand Percentage
Gravel	0
Sand	75
Silt	22
Clay	3

## 5.6 Sand and Gravel to Gravel

Beneath the fill, boulders or native silty sand, a deposit of native sand and gravel to gravel was encountered in Boreholes 19-01B, 19-01B(2), 19-02, 19-03, 19-04 and 19-05B. Hand probes HP1 to HP9, which were conducted at the base of the existing embankment, generally encountered gravelly sand near the existing water level. This deposit also contained trace to some silt, trace clay and occasional cobbles and boulders. The layer thickness where penetrated ranged from 0.4 to 0.9 m. Boreholes 19-01B, 19-01B(2), 19-03 and 19-04 were terminated upon refusal on boulders within this deposit at depths from 2.5 to 4.2 m (Elevation 184.6 to 182.7 m). Dynamic Cone Penetration Tests (DCPTs) were driven from the bottom of Boreholes 19-01B and 19-02 and met refusal at depths of 4.1 m and 8.1 m, respectively (Elevation 182.8 and 178.4 m).



Borehole 19-05B was terminated at a depth of 9.4 m (Elevation 176.7 m) within the sandy gravel deposit and did not encounter refusal.

SPT 'N' values measured in the sand and gravel to gravel layer ranged from 23 to greater than 100 blows per 0.3 m of penetration indicating a compact to very dense consistency. Values of 100 blows or greater may represent the presence of cobbles or boulders. The moisture content within the deposit ranged from 3 to 18 percent.

The results of grain size analyses conducted on samples of the sand and gravel to gravel deposit are illustrated on Figure B5 of Appendix B. The results are summarized as follows:

Soil Particle	Sand and Gravel to Gravel Percentage
Gravel	37 to 80
Sand	19 to 55
Silt and Clay	1 to 12

## 5.7 Groundwater Conditions

Groundwater conditions were observed during drilling operations and groundwater levels were measured in the open boreholes upon completion of drilling. The measured water levels in the open boreholes may reflect the presence of residual water in the boreholes that was added for drilling and therefore may be higher than the stabilized groundwater level. A summary of the water level measurements is provided in Table 5.1 below:

**Table 5.1 - Groundwater Measurements**

Borehole	Date	Water Level (m)		Remark
		Depth	Elevation	
19-01	June 5, 2019	1.7	185.2	Open Borehole
19-01B(2)	June 6, 2019	1.5	185.4	Open Borehole
19-02	June 6, 2019	1.4	185.1	Open Borehole
19-03	June 10, 2019	0.5	186.6	Open Borehole
19-04	June 10, 2019	0.9	185.2	Open Borehole
19-05B	June 9, 2019	1.5	184.7	Open Borehole

The groundwater level should be anticipated to reflect the local lake water level. The water level of Kasabonika Lake near the bridge was measured at Elevation 184.0 m in August 2016, as shown on drawings provided by MTO, and at approximate Elevation 184.4 m in June 2019 by

Hatch. The previous flooding that overtopped the east approach embankment in 2004 indicates that the lake water level has previously been observed at greater than approximate Elevation 186 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. CORROSIVITY AND SULPHATE TEST RESULTS

Samples of the silty sand fill and native sand 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)	Test Results	
		19-01 SS#2A/B	19-05B SS#3
		Silty Sand Fill	Sand
Sulphide	%	<0.02	<0.02
Chloride	µg/g	7	2.7
Sulphate	µg/g	2.2	2.1
pH	no unit	7.49	7.52
Conductivity	µS/cm	155	115
Resistivity (calculated)	ohms.cm	6500	8700
Redox Potential	mV	303	121

## 7. ENGINEERED FILL BORROW MATERIAL

Two samples of locally available engineered granular fill were provided by MTO for gradation testing. Both samples, labelled Sample #1 and Sample #2 were collected by MTO from a stockpile of crushed rock at the MTO Kasabonika airport. The gradation test results for both samples are shown on Figures B6 to B9 in Appendix B, and have been compared to the gradation ranges for OPSS Granular A, Granular B Type II and Granular M. The results show that both samples meet the OPSS criteria for these engineered granular fill materials.



## 8. MISCELLANEOUS

Thurber obtained subsurface utility clearances prior to drilling. The northing and easting coordinates and ground surface elevations were estimated based on field measurements relative to the topographic plans provided by MTO.

RPM Drilling of Thunder Bay, Ontario supplied and operated the drilling, sampling and in-situ testing equipment for the drilling investigation. Kasabonika Lake First Nation supplied and operated the backhoe for the test pit excavations. The field investigation was supervised on a full-time basis by Mr. Liam Steers, EIT of Thurber. The overall supervision of the field program was conducted by Mr. Mark Farrant, P.Eng, of Thurber.

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

Interpretation of the field data and preparation of this report was carried out by Mr. Liam Steers, EIT and Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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**PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS**

**9. GENERAL**

This report provides an interpretation of the geotechnical data in the factual report, and presents foundation design recommendations for the proposed Kasabonika Lake Modular Bridge replacement, located in Kasabonika Lake First Nation, 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.

The bridge site is located on Main Road, which is approximately 1 km east of the Kasabonika airport, and connects the island community of Kasabonika Lake First Nation to the mainland. Main Road runs in an approximately southwest to northeast direction at the bridge.

The Ontario Structure Inspection Manual (OSIM) report prepared by MTO on June 6, 2018 indicates that the existing structure is a single span bailey panel modular bridge built in 1983. The inspection report indicates that the bridge deck is approximately 27.6 m long and 5.45 m wide. The ground surface elevation at the existing bridge deck is approximately Elevation 186.8 m. The existing bridge is in overall poor condition, with potholes at the abutments and decaying deck boards. The wearing surface and some of the deck boards have been replaced since the 2018 OSIM report. The existing bridge abutments are supported on timber cribs on a causeway placed in the lake. The southwest approach embankment to the bridge is approximately 30 m long to the



mainland and the fill is approximately 3.5 m high at the bridge. The northeast approach embankment is approximately 50 m long to the island and the fill is approximately 3 m high at the bridge.

Photographs in Appendix C show that the causeway beyond the bridge has previously been overtopped by high lake water levels. Severe erosion of the approach embankments, possibly due to this flooding, has also previously occurred and exposed and undermined the timber crib bridge foundations.

The Terms of Reference for this project indicates that the existing structure is to be replaced with a new modular bridge. Based on subsequent discussions with Hatch and MTO, it is anticipated that the replacement bridge will be along the same alignment as the existing bridge, have a longer span than the existing bridge, may include a grade raise of 300 to 600 mm to raise the vertical profile to accommodate the flooding conditions, may incorporate widening to include an additional lane, and will require increased erosion protection measures to protect the foundations. There are no detour routes available at the site and construction staging is not feasible for the bridge replacement, so a full road closure is anticipated during construction.

In general, the foundation soil stratigraphy at the site consists of granular and embankment fill, underlain by deposits of large boulders, overlying native deposits of sand, gravel and sandy silt. The short-term water level in the boreholes ranged from 184.7 m to 186.6 m. The water level of Kasabonika Lake was previously measured at Elevations from 184.0 to 184.4 m at the bridge and observed at greater than approximate Elevation 186 m during flooding conditions.

Recommendations for the design and installation of a modular bridge are presented below.

## **10. STRUCTURE FOUNDATIONS**

Based on the subsurface conditions at this site, consideration was given to supporting the modular bridge on the following foundation types:

- Spread footings placed on engineered fill pads on the existing embankment fill;
- Spread footings placed on native sand and gravel to sandy gravel; and
- Steel H-piles driven to refusal or bedrock.

A comparison of the technical advantages and disadvantages of the alternative foundation options is presented in Appendix E.



Footings founded on the native sand and gravel to sandy gravel would require deeper and wider excavation, through cohesionless soils and large boulders and below the groundwater level. Significant dewatering efforts would be required to construct the footings in the dry and the excavation equipment may encounter difficulty dislodging boulders and excavating into potentially frozen soil if construction takes place before the summer season. Therefore, recommendations for footings on native soil were not developed further.

Due to the presence of large boulders at the base of the embankment fill, it is expected that driving steel H-piles would encounter considerable difficulty. The piles may meet refusal on the boulders at too shallow a depth and therefore not be long enough to develop sufficient lateral stability. It is also anticipated that piling equipment would be very costly to mobilize to the northern, remote site location. Therefore, recommendations for driven steel H-piles were not developed further.

Recommendations for spread footings on engineered fill pads, constructed on the existing embankment fill, are provided in the following sections.

## **10.1 Engineered Fill Pads on Existing Embankment Fill**

### **10.1.1 Founding Level**

The use of concrete spread footings placed on 1 m thick granular engineered fill pads is considered feasible from a geotechnical perspective and recommended at this site to support the replacement modular bridge.

The base of the footings should be embedded a minimum of 1 m below the final road grade level, with the base of the 1 m thick engineered fill pads at a minimum of 2 m below the final grade level. Therefore, accounting for a grade raise of approximately 300 to 600 mm, the base of the fill pads are anticipated to be placed at approximate Elevation 185 m at each abutment.

### **10.1.2 Engineered Fill Pad Construction**

The engineered fill pads should consist of OPSS Granular A or Granular B Type II placed in 150 mm lifts and compacted to 100% of its Standard Proctor Maximum Dry Density (SPMDD) at  $\pm 2\%$  of Optimum Moisture Content (OMC). The minimum depth of excavation should accommodate the concrete foundation slab and the thickness of engineered fill pad below the slab. The approximately 1.5 to 2 m deep excavations are anticipated to stay above the existing boulders where the boreholes met refusal to advance, and about 0.5 to 1 m above the lake level, provided construction is conducted during a dry, low lake level season.



The dimensions of the base of the excavation should be determined by assuming a granular pad 1.0 m wider than the spread footing at the level of the footing base and projecting outward and downward at 1H:1V.

If the engineered fill pads are located close to the lake channel (if the existing timber footings are not left in place), the forward slope of the foundation pads should be embedded at least 1.0 m below a 2H:1V face of the forward slope, with the edge of footing at a minimum of 2 m behind the crest of the forward slope. Since erosion at the existing abutments was a critical issue at this site, provision of properly designed erosion protection works will be critical to ensure adequate performance of the foundations/engineered fill pads and protect the surface of the forward slopes that will be in contact with the lake water.

It will be beneficial to place/locate the new footings some distance behind the existing timber cribs to take advantage of the potential slope stabilizing effect of the existing timber foundations. However, if the footprints of the engineered pads overlap the footprints of the existing timber cribs, then the existing timber should be removed, to a depth no deeper than the level of the lake.

### 10.1.3 Geotechnical Resistances

The following geotechnical resistances are recommended for design of 1.5 and 2.0 m wide spread footings, for both single-lane or two-lane bridges, placed on minimum 1 m thick engineered fill pads on the existing fill, with the underside at or below approximate Elevation 185 m:

Structure	Footing Length	Footing Width	Factored ULS	SLS (up to 25 mm settlement)
Single-lane bridge	6.6 m	1.5 m	225 kPa	165 kPa
		2.0 m	210 kPa	155 kPa
Two-lane bridge	10.4 m	1.5 m	225 kPa	150 kPa
		2.0 m	210 kPa	140 kPa

The setback distance of the footing behind the crest of forward slope should be a minimum of 2 m.

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) 2014, Section 6.9.



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

The geotechnical resistance quoted above is for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance should be calculated as indicated in the CHBDC 2014 Clause 6.10.3 and Clause 6.10.4.

The lateral resistance of the concrete footings founded on engineered fill may be computed using an unfactored friction coefficient of 0.6. This is an “ultimate” value and requires a degree of sliding movement to occur to fully mobilize the resistance.

## **10.2 Frost Cover**

The depth of frost penetration at this site is approximately 3.0 m, as per OPSD 3090.100. Typically, the base of all footings must be provided with a minimum of 3.0 m of earth cover as protection against frost action.

However, concrete spread footings founded on granular engineered fill pads, provided they consist of non-frost susceptible, free draining engineered fill, above the lake water level do not need to be placed below the depth of frost, and should be provided with a minimum embedment of 1.0 m.

## **11. EXCAVATION AND GROUNDWATER CONTROL**

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the existing fill and native cohesionless soils above the water level may be classified as Type 3 soil. The fill and native cohesionless soils below the water level may be classified as Type 4 soils.

The excavation and backfilling for foundations must be carried out in accordance with OPSS 902. The majority of the excavations are expected to be carried out through the existing silty sand fill with gravel and cobbles above the water level. It must be noted however that obstructions including large boulders in the existing fill will likely be encountered during excavation. Suggested wording for an NSSP on obstructions is included in Appendix F. Any excavations below the groundwater or lake water level will require dewatering to lower the water level below the base of the excavation to permit construction in the dry and facilitate compaction of the backfill materials. The footing excavations should be kept above the lake level and should be conducted during a dry, low lake level season.



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.

The design of the dewatering system, if utilized, is the responsibility of the Contractor. The Contract Documents must alert the Contractor to this responsibility and to design the system in accordance with SP FOUN0003 which amends OPSS 902. SP FOUN0003 has been included in Appendix F.

In accordance with SP FOUN0003, the dewatering system is to be designed in accordance with OPSS.PROV 517. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be "N/A".

Dewatering must remain operational and effective until the foundations are constructed. Suggesting wording for an NSSP in this regard is included in Appendix F.

## 12. LATERAL EARTH PRESSURES

Backfill placed behind the new abutments should be placed in accordance with OPSS 902. All backfill should consist of free-draining, non-frost susceptible granular materials such as Granular A or B Type II or Type III conforming to the requirements of OPSS.PROV 1010. Reference should be made to the backfill arrangements stipulated in OPSD 3101.150, as appropriate. Compaction equipment to be used adjacent to the walls should be restricted in accordance with OPSS.PROV 501.

Earth pressures acting on the structure may be assumed to be distributed triangularly and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

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

Where:

- $p_h$  = horizontal pressure on the wall at depth  $h$  (kPa)
- $K$  = coefficient of lateral earth pressure (see Table 12.1)
- $\gamma$  = unit weight of retained soil (see Table 12.1)
- $h$  = depth below top of fill where pressure is computed (m)
- $q$  = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are given in Table 12.1.

**Table 12.1 – Coefficients of Lateral Earth Pressure (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 $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	Horizontal Backfill	Sloping Backfill	Horizontal Backfill	Sloping Backfill
Active $K_A$ (Unrestrained Wall)	0.27	0.38*	0.31	0.46*
At-rest $K_0$ (Restrained Wall)	0.43	-	0.47	-
Passive $K_P$	3.7	-	3.3	-

\* For abutment walls, if required

The use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) is preferred as it results in lower earth pressures acting on the wall.

In accordance with Clause 6.12.3 of the CHBDC 2014, a compaction surcharge should be added. The magnitude of the surcharge should be 12 kPa at the top of fill which linearly decreases to 0 kPa at a depth of 1.7 m (for Granular B Type I) or at a depth of 2.0 m (for Granular A or B Type II).

### 13. SEISMIC CONSIDERATIONS

Based on the presence of compact to very dense native sands and gravels with boulders, this site is considered to be a Seismic Site Class D in accordance with Table 4.1, Clause 4.4.3.2 of CHBDC 2014. The peak ground acceleration, PGA, for a 2,475-year return period seismic event at this site is 0.032 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 13.1 may be used:



**Table 13.1 – 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 $\phi = 32^\circ$ , $\gamma = 21.2 \text{ kN/m}^3$	Existing Silty Sand or Clayey Silt Fill $\phi = 31^\circ$ , $\gamma = 21 \text{ kN/m}^3$	Gravelly Sand w/ Cobbles & Boulders $\phi = 35^\circ$ , $\gamma = 22 \text{ kN/m}^3$
Active ( $K_{AE}$ )*	0.29	0.32	0.34	0.29
At Rest ( $K_{OE}$ )**	0.48	0.53	0.54	0.48
Passive ( $K_{PE}$ )	3.6	3.2	3.1	3.5

\* 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 and granular foundation soils, liquefaction is not considered to be a concern at this site.

#### **14. APPROACH EMBANKMENTS AND FORWARD SLOPES**

The existing causeway embankment height is up to approximately 3.5 m at the west approach and up to approximately 3 m at the east approach. A grade raise of approximately 300 to 600 mm is proposed for both approach embankments at this site in order raise the new bridge and to mitigate the potential for the bridge and embankments to be overtopped due to flooding conditions. Due to the cohesionless nature of the foundation soils, settlement induced by the placement of the additional fill will be fairly rapid and will be essentially complete at the end of the approach embankment construction. The settlement induced by the placement of the additional fill is expected to be about 20 to 25 mm.

Placement of the embankment grade raise should be carried out in accordance with OPSS.PROV 206. The embankment material for the grade raise may consist of imported Granular A, Granular B Type II, or Granular B Type III material. As indicated in Section 7, the granular material stockpiled at the MTO Kasabonika Airport meets the gradation requirements of OPSS Granular A, Granular B Type II and Granular M, and therefore may be used as engineered fill for the embankment or granular fill pads below the replacement bridge footings. If this or other materials are not locally available in sufficient quantities due to the remote site location, consideration may be given to using alternate locally available fill materials meeting the gradation specifications for Granular B Type I or SSM to construct the embankment grade raise. As shown on Figures B3(B) and B5(B) in Appendix B, the existing sand and gravel to gravelly sand fill used to construct the current embankment, as well as the native sand to sand and gravel encountered in the boreholes



at this site generally meet the gradation requirements of SSM (shown in red). Accordingly, it is anticipated that local borrow sources that meet the gradation requirements of SSM may be used for the embankment grade raise. This material however is not recommended for the granular fill pads below the bridge footings.

In general, surface vegetation, peat, topsoil, organic deposits, disturbed material or otherwise loose/soft soils should be stripped from the areas within the embankment footprint where fill is to be placed, particularly at the toes of the existing slopes where the widened embankment will expand into the existing lakebed. Inspection and approval of the subgrade by qualified geotechnical personnel should be conducted.

The embankment reconstruction and 300 to 600 mm grade raise should be completed at approximately the same slope inclination as the existing embankment and no steeper than 2H:1V. Stability analyses were conducted for the side slopes of the embankments under these conditions. The stability analysis figures are included in Appendix G. If using OPSS Granular A, Granular B Type II or Granular B Type III material to construct the grade raise, the Factor of Safety against slope failure is 1.5 at the west abutment (Figure 1) and 1.3 at the east abutment (Figure 2). If using local fill meeting the gradation requirements of OPSS SSM to construct the grade raise, Factor of Safety against slope failure is 1.3 at both abutments (Figures 3 and 4). A Factor of Safety of 1.3 is acceptable for the side slopes of this granular fill embankment.

The stability of the forward slopes in front of the replacement bridge abutments was also analysed. The survey drawing showed the existing forward slopes to be inclined at approximately 2H:1V at the existing west abutment and approximately 1.3H:1V at the upper part of the fill at the existing east abutment. Figures 5 and 6 show that the existing forward slope at the west abutment under a 600 mm grade raise is expected to be stable, with a Factor of Safety of 1.5 whether the grade raise is constructed of Granular A, Granular B Type II or Granular B Type III (Figure 5), or local fill meeting the gradation requirements of OPSS SSM (Figure 6). At the east abutment, Figures 7 and 8 show a Factor of Safety of 1.3 for the existing 1.3H:1V slope under a 600 mm grade raise constructed of either fill material option. It is recommended that the east forward slope be reconstructed at no steeper than 2H:1V under the 600 mm grade raise to remain stable. Figures 9 and 10 illustrate this condition, with a Factor of Safety of 1.5 for either fill material option.

The stability of the embankment side slopes and forward slopes will rely on proper steps being taken to prevent future severe erosion due to flooding conditions. Erosion protection measures are discussed in Section 15.

## **15. SCOUR AND EROSION PROTECTION**

Based on the previous severe erosion of the approach embankments leading to exposure and undermining of the existing timber crib foundations, it will be critical to provide robust erosion protection at the bridge abutments. Design of the erosion protection measures should consider hydrologic and hydraulic factors and should be carried out by specialists experienced in this field.

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

Consideration may also be given to leaving the existing timber crib abutments in place in front of the new abutments as an additional erosion protection measure.

## **16. CORROSION & SULPHATE ATTACK POTENTIAL**

The results of the corrosivity and sulphate analytical tests conducted on the silty sand fill and native sand indicate the following:

- The potential for sulphate attack on concrete foundations from the surrounding soil is considered to be negligible due to the low concentration of sulphate in the samples tested.
- The potential for corrosion on metal structural elements is considered to be mild.

## **17. CONSTRUCTION CONCERNS**

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

- Seasonal fluctuations of the groundwater and lake level are to be expected. In particular, the lake water level has a history of overtopping the existing embankment and is expected to be at a higher elevation after the spring snowmelt or after periods of heavy rainfall, which will impact the construction. The foundation construction should be kept above the lake level and conducted during a dry, low lake level season.
- Cobbles, boulders or other buried obstructions are expected to be encountered during excavation in the existing embankment fill may impede excavation progress. Suggested wording for an NSSP on obstructions is included in Appendix F.

## 18. CLOSURE

Engineering analysis and preparation of this report was carried out by Mr. Mark Farrant, P.Eng. The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

Thurber Engineering Ltd.



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Geotechnical Engineer



Keli Shi, P.Eng.  
Geotechnical Engineer, Associate



P.K. Chatterji, P.Eng., Ph.D.  
Review Principal, Designated MTO Contact



## **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 <sup>(1)</sup> '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.

# 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			

# RECORD OF BOREHOLE No 19-01

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 480.3 E 396 214.3 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing/BQ Coring COMPILED BY BH  
DATUM Geodetic DATE 2019.06.05 - 2019.06.05 LATITUDE 53.526266 LONGITUDE -88.621400 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
186.9	GROUND SURFACE											
0.0	Silty <b>SAND</b> , some gravel, trace clay, occasional cobbles Loose to Dense Brown Moist (FILL)		1	GS								
			1	SS	9							
185.2												
1.7	Clayey <b>SILT</b> , some sand, trace gravel, some cobbles and boulders Dense Brown Moist (FILL, POSSIBLY FROZEN)		2	SS	33							
184.8												
2.1			3	SS	50/ 0.025							
	Gravelly <b>SAND</b> , with cobbles and boulders Dense Brown Wet (FILL)											
183.7												
3.2												
183.2	BOULDER											
3.7			4	SS	49							
182.6												
4.3	END OF BOREHOLE AT 4.3m UPON REFUSAL TO ADVANCE CASING THROUGH BOULDERS. BOREHOLE OPEN TO 2.0m AND WATER LEVEL AT 1.7m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.15m, THEN SAND AND GRAVEL TO SURFACE.											



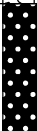
+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity  
20  
15  
10  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 19-01B

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 475.2 E 396 217.1 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing/BQ Coring COMPILED BY BH  
DATUM Geodetic DATE 2019.06.06 - 2019.06.06 LATITUDE 53.526220 LONGITUDE -88.621359 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa				WATER CONTENT (%)					
186.9	GROUND SURFACE							20	40	60	80	100					
0.0	Silty <b>SAND</b> , some gravel, trace clay, occasional cobbles Compact to Dense Brown Moist (FILL)		1	GS													17 60 23 (SI+CL)
			1	SS	21												
			2	SS	48												
184.6																	
2.3	<b>GRANODIORITE BOULDER</b>																
183.6	Sandy <b>GRAVEL</b> , trace silt, occasional cobbles Compact Brown Wet		3	SS	27												76 23 1 (SI+CL)
182.7																	
4.2	END OF BOREHOLE AT 4.2m UPON REFUSAL TO ADVANCE CASING THROUGH BOULDERS. BOREHOLE BACKFILLED WITH HOLEPLUG AND SAND TO 0.15m, THEN SAND AND GRAVEL TO SURFACE.																

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

RECORD OF BOREHOLE No 19-01B(2)

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular Bridge MTM NAD83 ZONE 15: N 5 933 474.4 E 396 216.0 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE BW Casing/ Dynamic Core Penetration Test COMPILED BY BH  
DATUM Geodetic DATE 2019.06.06 - 2019.06.06 LATITUDE 53.526213 LONGITUDE -88.621377 CHECKED BY MEF




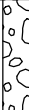

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
186.9	GROUND SURFACE																
0.0	No sample until 2.7m.																
184.2																	
2.7	<b>GRAVEL and COBBLES</b> Compact Grey Wet		1	SS	25												
183.5																	
3.5	END OF BOREHOLE AT 3.5m UPON CASING AND DCPT REFUSAL. BOREHOLE OPEN TO 1.8m AND WATER LEVEL AT 1.5m UPON COMPLETION OF DRILLING.																

# RECORD OF BOREHOLE No 19-02

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular Bridge MTM NAD83 ZONE 15: N 5 933 495.3 E 396 245.6 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/ BW Casing/ Dynamic Cone Penetration Test COMPILED BY BH  
DATUM Geodetic DATE 2019.06.06 - 2019.06.06 LATITUDE 53.526395 LONGITUDE -88.620925 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
186.5	GROUND SURFACE							20 40 60 80 100		W <sub>p</sub> W      W <sub>L</sub>				
0.0	Silty <b>SAND</b> , some gravel, trace clay, occasional cobbles Compact to Dense Brown Moist (FILL)		1	GS										
			1	SS	14									
			2	SS	38									
184.3														
2.2	<b>SAND</b> , some gravel, some cobbles and boulders		3	SS	100/									
183.9	Very Dense Brown Wet (FILL, POSSIBLY FROZEN)				0.150									
2.6	BOULDER													
183.1														
3.4	<b>SAND</b> and <b>GRAVEL</b> , some silt, trace clay, occasional boulders		4	SS	104									
182.8	Very Dense Brown Wet													
3.7	End of sampling and start DCPT													
178.4	END OF BOREHOLE AT 8.1m.													
8.1	BOREHOLE OPEN TO 1.8m AND WATER LEVEL AT 1.4m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.9m, THEN SAND TO SURFACE.													


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

RECORD OF BOREHOLE No 19-02B

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular Bridge MTM NAD83 ZONE 15: N 5 933 499.0 E 396 241.3 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing COMPILED BY BH  
DATUM Geodetic DATE 2019.06.08 - 2019.06.08 LATITUDE 53.526429 LONGITUDE -88.620988 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
186.2	GROUND SURFACE							20 40 60 80 100						
0.0	Silty <b>SAND</b> , some gravel, trace clay, occasional cobble Loose to Very Dense Brown Moist (FILL)		1	GS			186							
			1	SS	9		185							
	(POSSIBLY FROZEN)													
			2	SS	86									
183.9							184							
2.3	END OF BOREHOLE AT 2.3m. AUGER AND CASING REFUSAL AT 2.3m ON BOULDERS. BOREHOLE BACKFILLED WITH SAND AND GRAVEL TO SURFACE.													

# RECORD OF BOREHOLE No 19-03

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 466.5 E 396 203.4 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing COMPILED BY BH  
DATUM Geodetic DATE 2019.06.10 - 2019.06.10 LATITUDE 53.526145 LONGITUDE -88.621569 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT						UNIT WEIGHT  γ  kN/m <sup>3</sup>	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								
187.1	GROUND SURFACE						20 40 60 80 100									
0.0	Silty <b>SAND</b> , some gravel to gravelly, trace clay, occasional cobbles Very Dense Brown Moist (FILL) (POSSIBLY FROZEN)		1	GS		187										
			1	SS	78											
185.7							186									
1.4	Clayey <b>SILT</b> , some sand, trace gravel, occasional cobbles Brown (FILL, POSSIBLY FROZEN)		2	SS	100											
185.2																
1.9	Gravelly <b>SAND</b> Very Dense Brown Wet					185										
2.3			3	SS	100/											
184.8																
2.5	<b>GRANODIORITE BOULDER</b>  END OF BOREHOLE AT 2.5m. CASING REFUSAL AT 2.3m. CORE BARREL REFUSAL AT 2.5m. BOREHOLE OPEN TO 0.9m AND WATER LEVEL AT 0.5m UPON COMPLETION OF DRILLING . BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.15m, THEN SAND AND GRAVEL TO SURFACE.				<0.025											



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

# RECORD OF BOREHOLE No 19-04

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 510.9 E 396 254.2 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing COMPILED BY BH  
DATUM Geodetic DATE 2019.06.10 - 2019.06.10 LATITUDE 53.526534 LONGITUDE -88.620790 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  <b>γ</b>  kN/m <sup>3</sup>	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 <sub>P</sub> w      w <sub>L</sub>																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
186.1	GROUND SURFACE						20 40 60 80 100																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
0.0	<b>SAND</b> and <b>GRAVEL</b> , some silt, trace clay, occasional cobbles Brown Moist (FILL)		1	GS			186																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							</

# RECORD OF BOREHOLE No 19-05

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 515.9 E 396 276.0 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing COMPILED BY BH  
DATUM Geodetic DATE 2019.06.08 - 2019.06.08 LATITUDE 53.526575 LONGITUDE -88.620459 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  w <sub>p</sub>	NATURAL MOISTURE CONTENT  w	LIQUID LIMIT  w <sub>L</sub>	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
								20 40 60 80 100									
186.1	GROUND SURFACE																
0.0	Gravelly <b>SAND</b> , trace to some silt, occasional cobbles Compact Brown Moist to Wet (FILL)		1	GS													
184.7			1	SS	22												
1.4																	
184.0	Silty <b>SAND</b> , gravelly, trace clay Very Dense Brown Wet (FILL, POSSIBLY FROZEN)		2	SS	117											30 32 30 8	
2.1																	
183.7	BOULDER																
2.4	END OF BOREHOLE AT 2.4m. CASING REFUSAL AT 2.4m. ON BOULDERS. BOREHOLE BACKFILLED WITH HOLEPLUG TO 0.15m, THEN SAND AND GRAVEL TO SURFACE.																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 19-05B

1 OF 2

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 523.0 E 396 270.9 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing COMPILED BY BH  
DATUM Geodetic DATE 2019.06.09 - 2019.06.09 LATITUDE 53.526640 LONGITUDE -88.620535 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
186.2	GROUND SURFACE											
0.0	Gravelly <b>SAND</b> , some silt, some organics, trace clay Brown Moist (FILL)  Very Dense (FILL, POSSIBLY FROZEN)		1	GS			186					
			1	SS	100/							
					0.100							
184.8							185					
1.4	<b>SAND</b> and <b>SILT</b> , some clay, trace gravel Very Dense Brown Wet (FILL, POSSIBLY FROZEN)		2	SS	60							3 41 43 13
184.0							184					
2.2	<b>SAND</b> , some silt, occasional cobbles Dense Brown Wet (POSSIBLY FROZEN)		3	SS	41							
183.2							183					0 75 22 3
3.0	<b>SAND</b> , silty, trace clay, trace to some gravel Compact to Loose Brown Wet		4	SS	28							
							182					
			5	SS	18							
							181					
							180					
	no recovery		6	SS	16							
							179					
							178					
	granite cobble		7	SS	9							
177.7												
8.5	Sandy <b>GRAVEL</b> , trace silt Dense Grey Wet		8	SS	42		177					80 19 1 (SI+CL)
176.7												
9.4	END OF BOREHOLE AT 9.4m. BOREHOLE OPEN TO 1.7m AND WATER LEVEL AT 1.5m UPON											

Continued Next Page

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

# RECORD OF BOREHOLE No 19-05B

2 OF 2

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 523.0 E 396 270.9 ORIGINATED BY LS  
 DIST Kenora HWY Main Road BOREHOLE TYPE Solid Stem/BW Casing COMPILED BY BH  
 DATUM Geodetic DATE 2019.06.09 - 2019.06.09 LATITUDE 53.526640 LONGITUDE -88.620535 CHECKED BY MEF

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
	Continued From Previous Page																
	COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE TO 1.5m, THEN SAND AND GRAVEL TO SURFACE.																

# RECORD OF BOREHOLE No TP-01

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 470.7 E 396 200.3 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Test Pit COMPILED BY BH  
DATUM Geodetic DATE 2019.06.08 - 2019.06.08 LATITUDE 53.526182 LONGITUDE -88.621614 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE										WATER CONTENT (%)
187.1	GROUND SURFACE							20	40	60	80	100						
0.0	Sandy <b>GRAVEL</b> , trace silt		1	GS													76 21 3 (SI+CL)	
186.7	Brown		2	GS														
0.3	(FILL)		3	GS														
			4	GS														
			5	GS														
			6	GS														
			7	GS														
184.9																		
2.1	END OF TEST PIT AT 2.1m DUE TO REFUSAL ON BOULDERS AND POSSIBLY FROZEN SOIL. BACKFILLED WITH CUTTINGS TO SURFACE.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10



(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No TP-02

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 506.8 E 396 246.8 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Test Pit COMPILED BY BH  
DATUM Geodetic DATE 2019.06.08 - 2019.06.08 LATITUDE 53.526499 LONGITUDE -88.620903 CHECKED BY MEF

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 <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
186.0	GROUND SURFACE							20	40	60	80	100		W <sub>p</sub>	W	W <sub>L</sub>	GR SA SI CL	
0.0	Gravelly <b>SAND</b> , some silt Brown Moist (FILL)		1	GS		185								○			14 52 27 7	
			2	GS											○			
			3	GS											○			
	layer of organics		4	GS											○			
184.8																		
1.2	Silty <b>SAND</b> , some gravel, trace clay, occasional cobbles and boulders Brown Wet (FILL)		5	GS		184								○				
			6	GS											○			
			7	GS											○			
183.9														○				
2.1	END OF TEST PIT AT 2.1m DUE TO REFUSAL ON BOULDERS AND POSSIBLY FROZEN SOIL. BACKFILLED WITH CUTTINGS TO SURFACE.																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No TP-03

1 OF 1

METRIC

W.P. 6579-16-00 LOCATION Kasabonika Lake Modular BridgeMTM NAD83 ZONE 15: N 5 933 510.1 E 396 268.9 ORIGINATED BY LS  
DIST Kenora HWY Main Road BOREHOLE TYPE Test Pit COMPILED BY BH  
DATUM Geodetic DATE 2019.06.08 - 2019.06.08 LATITUDE 53.526524 LONGITUDE -88.620568 CHECKED BY MEF

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
186.2	GROUND SURFACE							20	40	60	80	100							
0.0	Gravelly <b>SAND</b> , some silt, occasional cobbles Brown Moist (FILL)  <b>SAND</b> and <b>SILT</b> , trace to some gravel, trace to some clay, occasional cobbles Brown Moist (FILL)		1	GS			186												
185.6			2	GS															
0.6			3	GS															
			4	GS			185												
			5	GS															
			6	GS															
			7	GS															
184.1																			
2.1	END OF TEST PIT AT 2.1m DUE TO REFUSAL ON BOULDERS AND POSSIBLY FROZEN SOIL. BACKFILLED WITH CUTTINGS TO SURFACE.																		



**Photo A1: Test Pit TP-01 (Date taken: June 8, 2019).**



**Photo A2: Test Pit TP-02 (Date taken: June 8, 2019).**

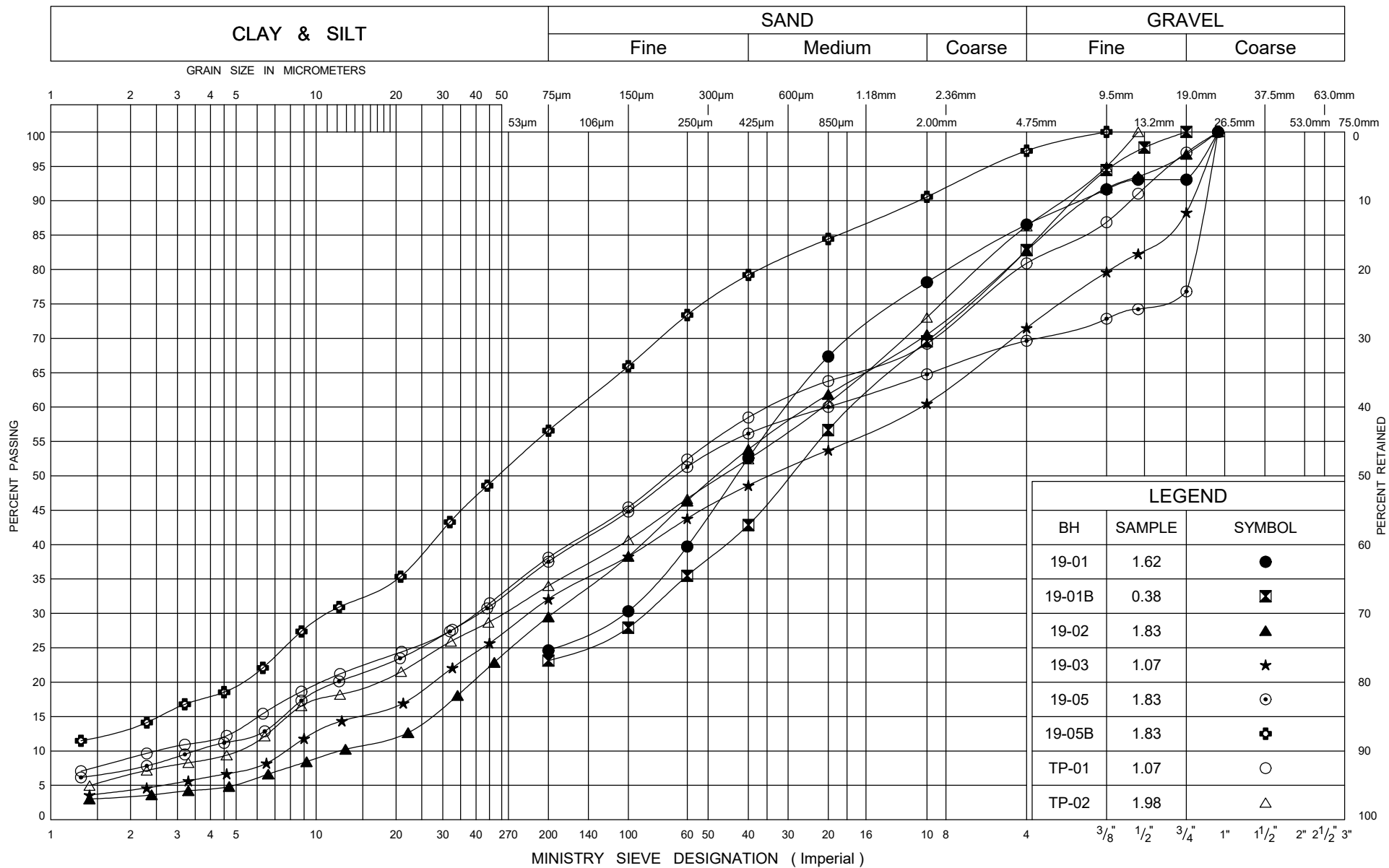


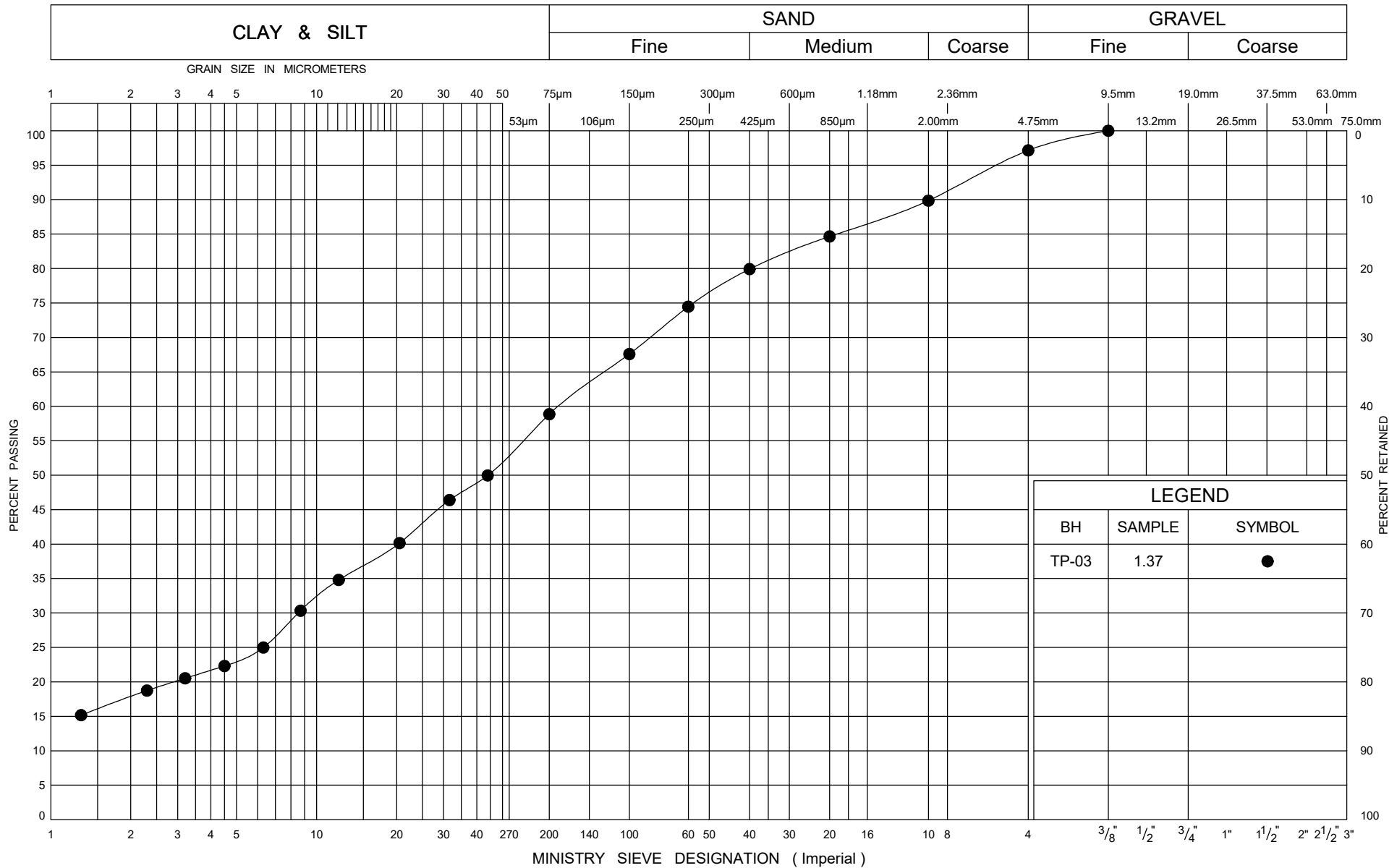
**Photo A3: Test Pit TP-03 (Date taken: June 8, 2019).**

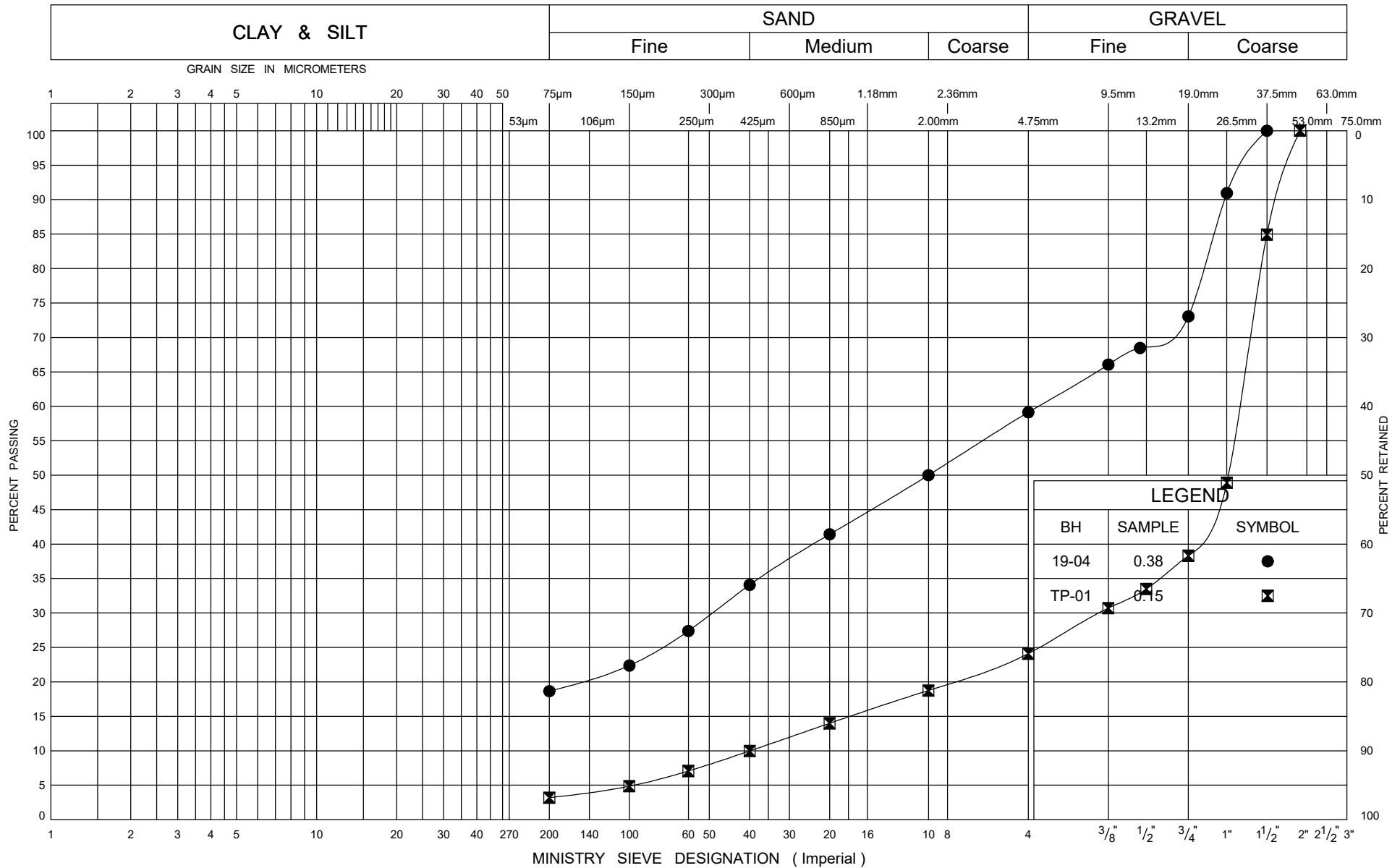


## **Appendix B**

### **Geotechnical and Analytical Laboratory Test Results**







Ministry of  
Transportation

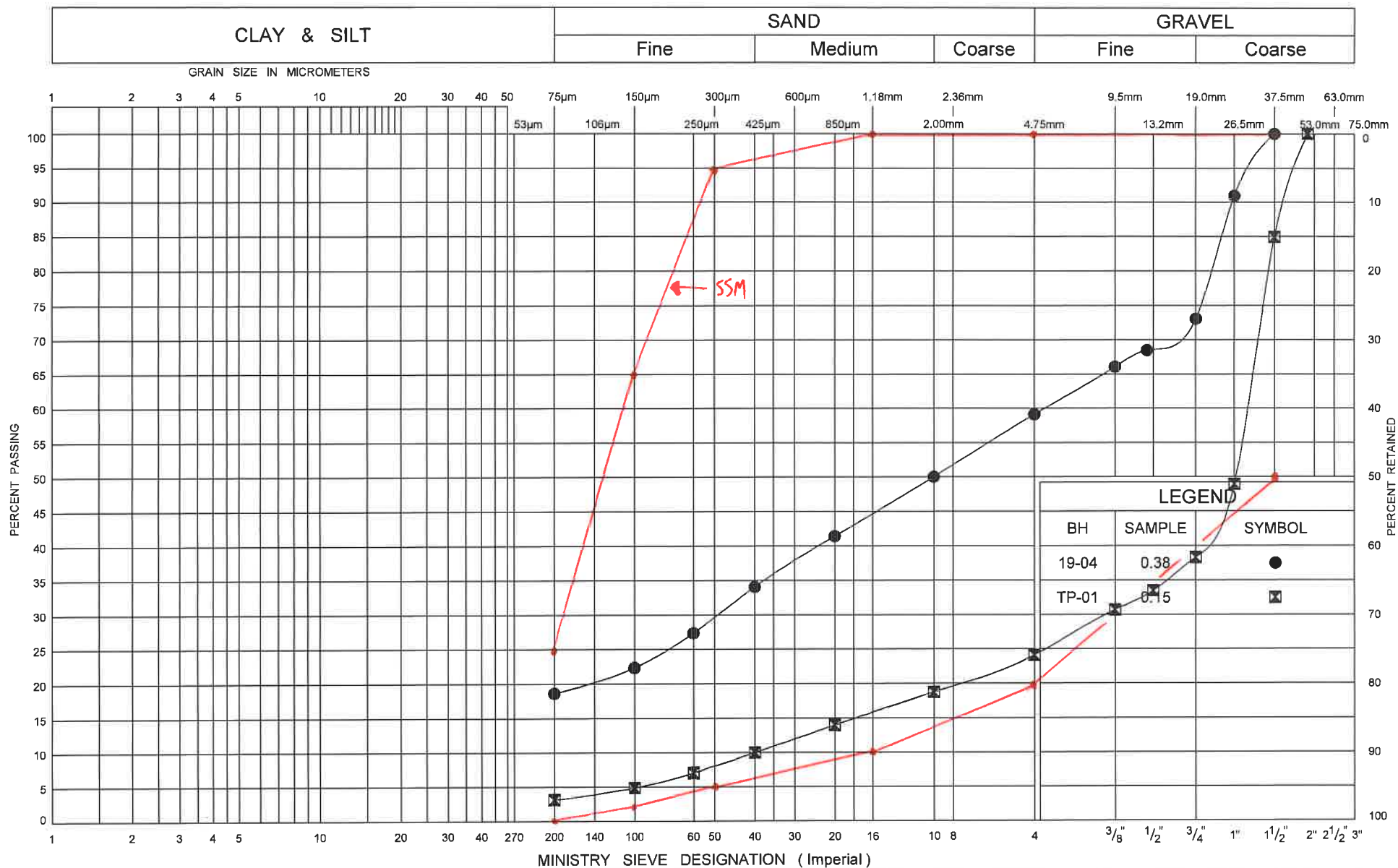
## GRAIN SIZE DISTRIBUTION

### SAND AND GRAVEL to Gravelly SAND Fill

FIG No B3

W P 6579-16-00

Kasabonika Lake Modular Bridge



Ministry of  
Transportation

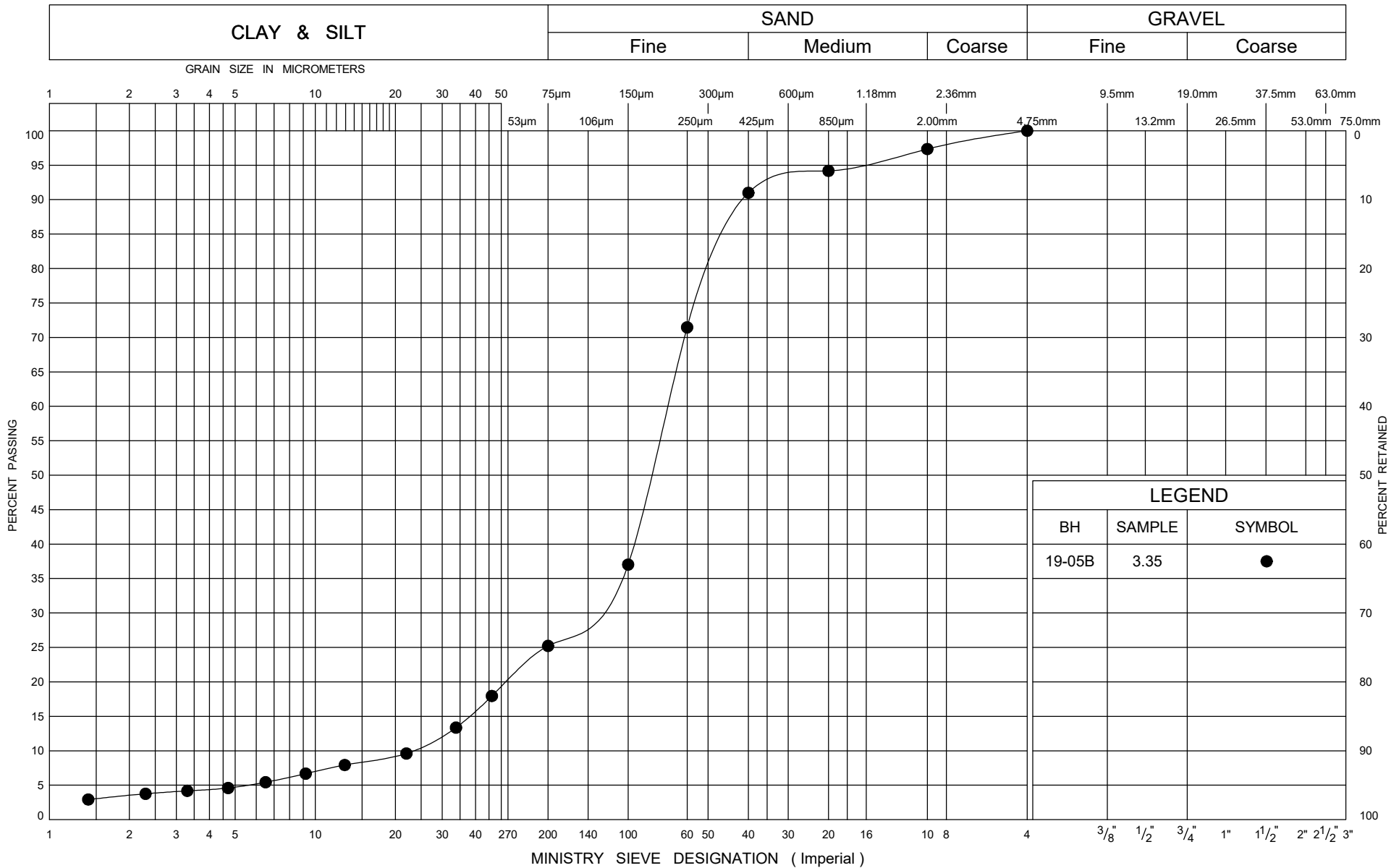
## GRAIN SIZE DISTRIBUTION

### SAND AND GRAVEL to Gravelly SAND Fill

FIG No B3 (B)

W P 6579-16-00

Kasabonika Lake Modular Bridge



Ministry of  
Transportation

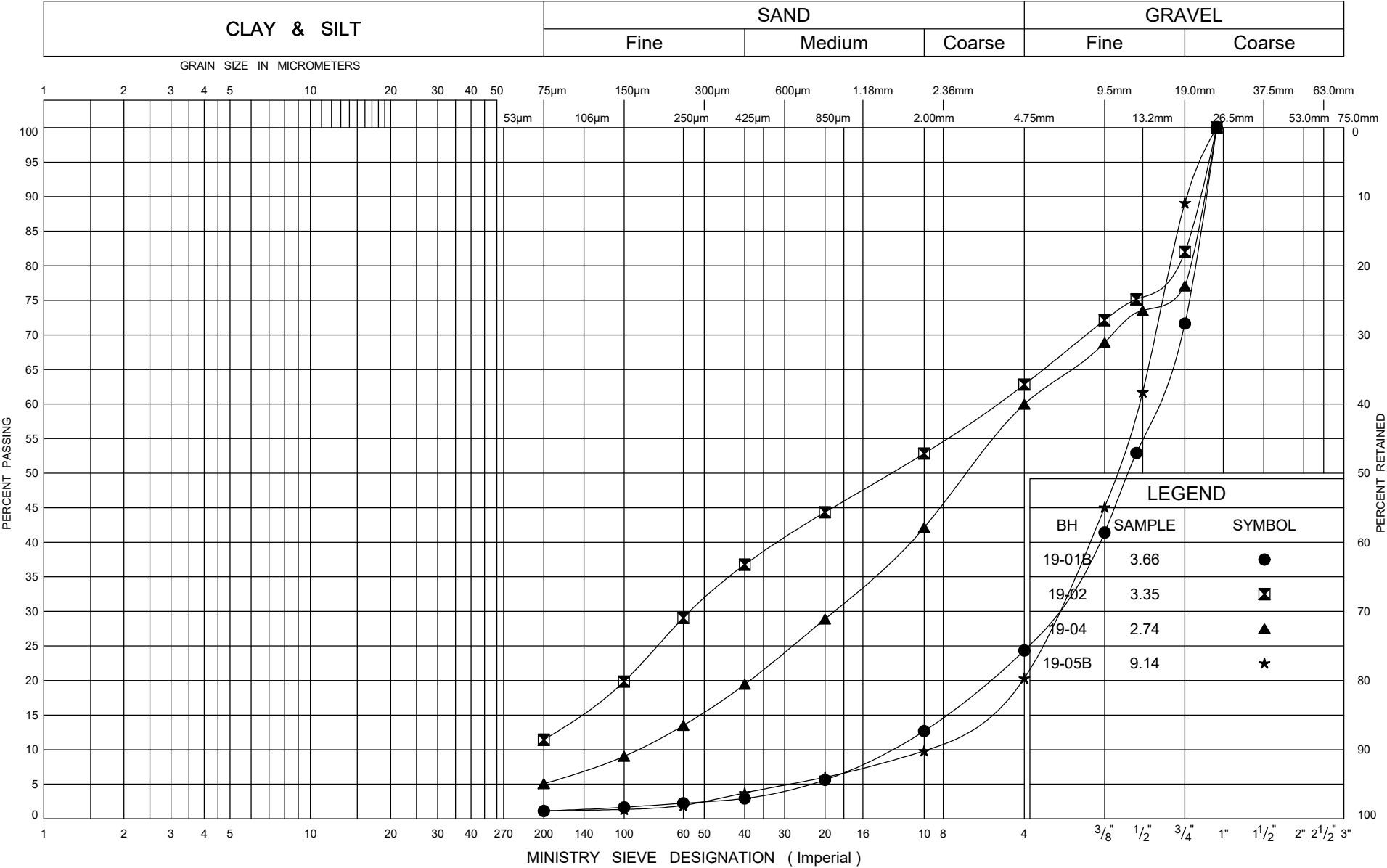
## GRAIN SIZE DISTRIBUTION

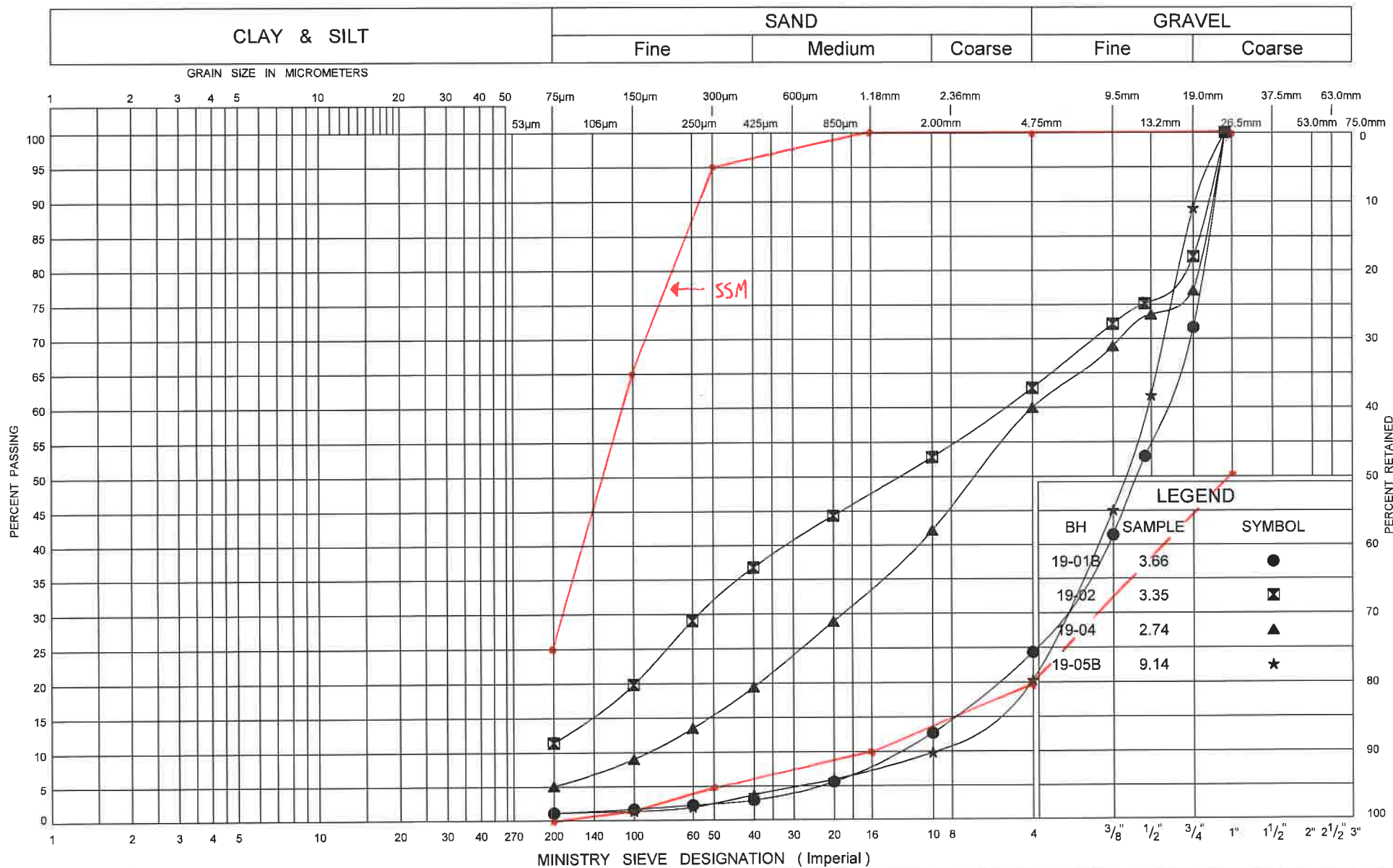
Silty SAND

FIG No B4

W P 6579-16-00

Kasabonika Lake Modular Bridge





**GRAIN SIZE DISTRIBUTION**  
SAND AND GRAVEL to GRAVEL

FIG No B5 (B)

W P 6579-16-00

Kasabonika Lake Modular Bridge



Ministry of  
Transportation

Ontario

**Client:** Ministry of Transportation

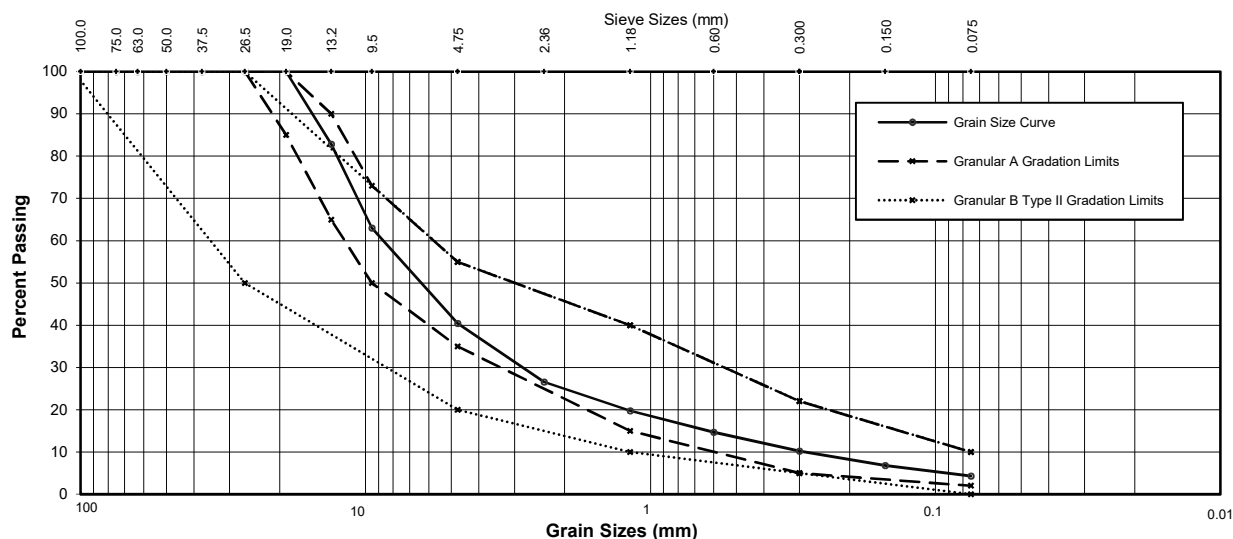
**Project No.:** 25489

**Project:** Kasabonika Lake Bridge

**Date:** 30-Sep-19

**Sample Source:** Stockpile at Kasabonika Airport  
**Material Type:** Granular A or Granular B Type II  
**Specification:** OPSS 1010  
**Sample Description:** 19 mm Crusher Run Rock - Sample #1

**Date Tested:** 13-Sep-19  
**Sampled by:** MTO  
**Date Sampled:** 22-Aug-19  
**Test Method:** ASTM



GRAVEL				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	150	100.0		
	100	100.0		
	75	100.0		
	63	100.0		
	50	100.0		
	37.5	100.0		
	26.5	100.0		
	19	100.0		
	13.2	82.8		
	9.5	63.0		
	4.75	40.5		

SAND & FINES				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	2.36	26.6		
	1.18	19.7		
	0.6	14.7		
	0.3	10.2		
	0.15	6.8		
	0.075	4.3		

SILT AND CLAY			
Silt	-		
Clay	-		
Total Fines:	4.3%		

Gravel: 59.5%      Deleterious  
Sand: 36.2%      Material: -  
Fines: 4.3%      % Crushed: -  
Asph. Content: -

Computer File : 26111  
Series No.: 1

**Comments:** This sample meets OPSS 1010 requirements for Granular A and Granular B Type II.

Checked By: BT



Client: Ministry of Transportation

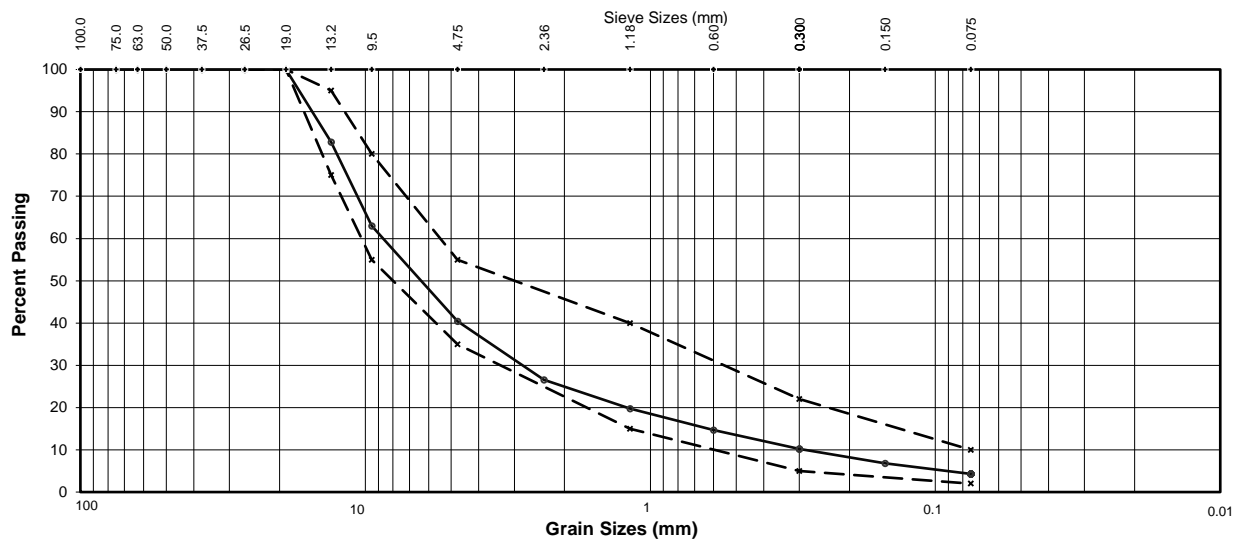
Project No.: 25489

Project: Kasabonika Lake Bridge

Date: 30-Sep-19

Sample Source: Stockpile at Kasabonika Airport  
 Material Type: Granular M  
 Specification: OPSS 1010  
 Sample Description: 19 mm Crusher Run Rock - Sample #1

Date Tested: 13-Sep-19  
 Sampled by: MTO  
 Date Sampled: 22-Aug-19  
 Test Method: ASTM



GRAVEL				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	150	100.0		
	100	100.0		
	75	100.0		
	63	100.0		
	50	100.0		
	37.5	100.0		
	26.5	100.0	100	100
	19	100.0	100	100
	13.2	82.8	95	75
	9.5	63.0	80	55
	4.75	40.5	55	35

Gravel: 59.5%      Deleterious  
 Sand: 36.2%      Material: -  
 Fines: 4.3%      % Crushed: -  
                       Asph. Content: -

SAND & FINES				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	2.36	26.6		
	1.18	19.7	40	15
	0.6	14.7		
	0.3	10.2	22	5
	0.15	6.8		
	0.075	4.3	10	2

SILT AND CLAY			
Silt	-		
Clay	-		
Total Fines:	4.3%		

Computer File : 26111

Series No.: 2

Comments: This sample meets OPSS 1010 requirements for Granular M.

Checked By: BT

**Client:** Ministry of Transportation

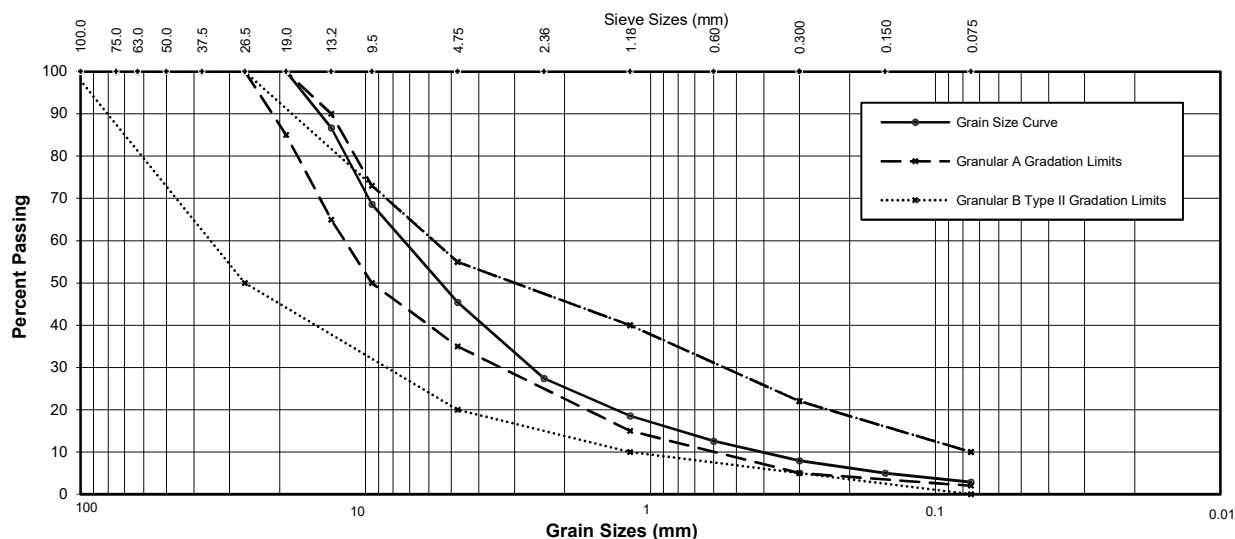
**Project No.:** 25489

**Project:** Kasabonika Lake Bridge

**Date:** 30-Sep-19

**Sample Source:** Stockpile at Kasabonika Airport  
**Material Type:** Granular A or Granular B Type II  
**Specification:** OPSS 1010  
**Sample Description:** 19 mm Crusher Run Rock - Sample #2

**Date Tested:** 13-Sep-19  
**Sampled by:** MTO  
**Date Sampled:** 22-Aug-19  
**Test Method:** ASTM



GRAVEL				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	150	100.0		
	100	100.0		
	75	100.0		
	63	100.0		
	50	100.0		
	37.5	100.0		
	26.5	100.0		
	19	100.0		
	13.2	86.7		
	9.5	68.6		
	4.75	45.4		

SAND & FINES				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	2.36	27.4		
	1.18	18.5		
	0.6	12.6		
	0.3	8.0		
	0.15	5.0		
	0.075	2.9		

SILT AND CLAY			
Silt	-		
Clay	-		
Total Fines:	2.9%		

Gravel: 54.6%      Deleterious  
Sand: 42.6%      Material: -  
Fines: 2.9%      % Crushed: -  
Asph. Content: -

Computer File : 26111  
Series No.: 2

**Comments:** This sample meets OPSS 1010 requirements for Granular A and Granular B Type II.

Checked By: BT



**THURBER ENGINEERING LTD.**

**Figure B9**

**Client:** Ministry of Transportation

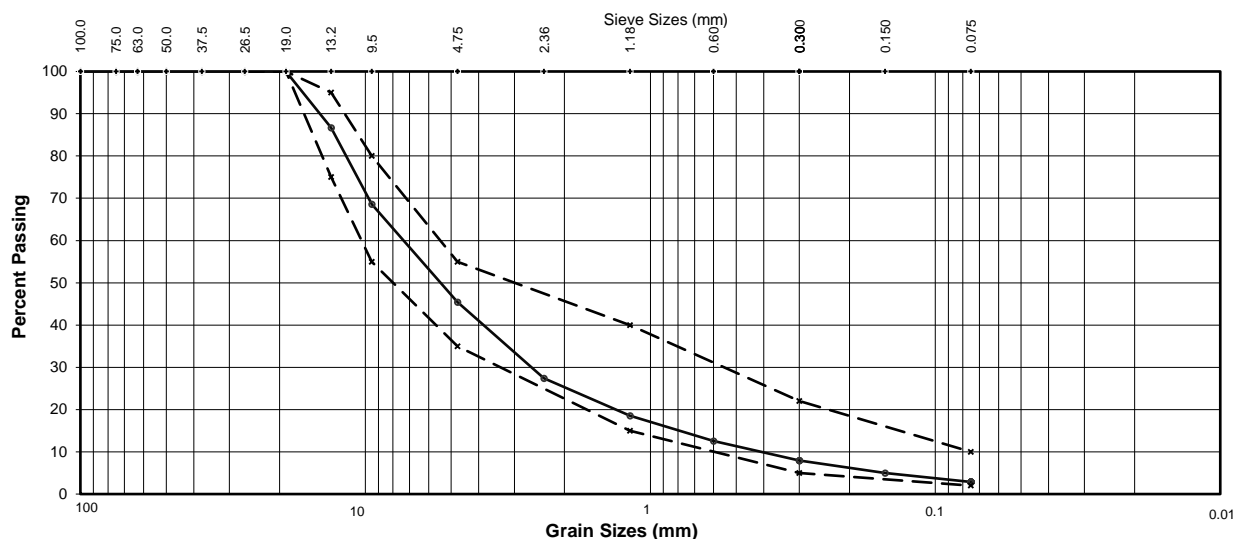
**Project No.:** 25489

**Project:** Kasabonika Lake Bridge

**Date:** 30-Sep-19

**Sample Source:** Stockpile at Kasabonika Airport  
**Material Type:** Granular M  
**Specification:** OPSS 1010  
**Sample Description:** 19 mm Crusher Run Rock - Sample #2

**Date Tested:** 13-Sep-19  
**Sampled by:** MTO  
**Date Sampled:** 22-Aug-19  
**Test Method:** ASTM



GRAVEL				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	150	100.0		
	100	100.0		
	75	100.0		
	63	100.0		
	50	100.0		
	37.5	100.0		
	26.5	100.0	100	100
	19	100.0	100	100
	13.2	86.7	95	75
	9.5	68.6	80	55
	4.75	45.4	55	35

SAND & FINES				
Sieve No.	Opening (mm)	Percent Passing	Gradation Limits	
			Max	min
	2.36	27.4	40	15
	1.18	18.5		
	0.6	12.6		
	0.3	8.0	22	5
	0.15	5.0		
	0.075	2.9	10	2

SILT AND CLAY			
Silt	-		
Clay	-		
Total Fines:	2.9%		

Gravel: 54.6%      Deleterious  
Sand: 42.6%      Material: -  
Fines: 2.9%      % Crushed: -  
Asph. Content: -

Computer File : 26111  
Series No.: 4

**Comments:** This sample meets OPSS 1010 requirements for Granular M.

Checked By: BT



## FINAL REPORT

CA14645-JUN19 R1

25489, Kasabinika Lake Bridge

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               Liam Steers

Telephone           613-276-4587

Facsimile            905-829-1166

Email                 lsteers@thurber.ca

Project               25489, Kasabinika Lake Bridge

Order Number

Samples              Soil (2)

### 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        CA14645-JUN19

Received             06/17/2019

Approved             06/21/2019

Report Number       CA14645-JUN19 R1

Date Reported        07/19/2019

### COMMENTS

Temperature of Sample upon Receipt: 20 degrees C

Cooling Agent Present:Yes

Custody Seal Present:No

Chain of Custody Number:NA

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

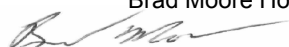




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# FINAL REPORT

CA14645-JUN19 R1

**Client:** Thurber Engineering Ltd.

**Project:** 25489, Kasabinika Lake Bridge

**Project Manager:** Liam Steers

**Samplers:** Liam Steers

## PACKAGE: - Corrosivity Index (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	19-01 SS#2A/B	19-05B SS#3
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	15/06/2019	15/06/2019

Parameter	Units	RL		Result	Result
<b>Corrosivity Index</b>					
Corrosivity Index	none	1		1	2
Soil Redox Potential	mV	-		303	121
Sulphide	%	0.02		< 0.02	< 0.02
pH	pH Units	0.05		7.49	7.52
Resistivity (calculated)	ohms.cm	-9999		6500	8700

## PACKAGE: - General Chemistry (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	19-01 SS#2A/B	19-05B SS#3
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	15/06/2019	15/06/2019

Parameter	Units	RL		Result	Result
<b>General Chemistry</b>					
Conductivity	uS/cm	2		155	115

## PACKAGE: - Metals and Inorganics (SOIL)

<b>Sample Number</b>	5	6
<b>Sample Name</b>	19-01 SS#2A/B	19-05B SS#3
<b>Sample Matrix</b>	Soil	Soil
<b>Sample Date</b>	15/06/2019	15/06/2019

Parameter	Units	RL		Result	Result
<b>Metals and Inorganics</b>					
Moisture Content	%	0.1		13.4	31.8
Sulphate	µg/g	0.4		2.2	2.1



FINAL REPORT

CA14645-JUN19 R1

Client: Thurber Engineering Ltd.

Project: 25489, Kasabinika Lake Bridge

Project Manager: Liam Steers

Samplers: Liam Steers

PACKAGE: - Other (ORP) (SOIL)

Sample Number	5	6
Sample Name	19-01 SS#2A/B	19-05B SS#3
Sample Matrix	Soil	Soil
Sample Date	15/06/2019	15/06/2019

Parameter	Units	RL		Result	Result
Other (ORP)					
Chloride	µg/g	0.4		7.0	2.7



# FINAL REPORT

CA14645-JUN19 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	DIO0349-JUN19	µg/g	0.4	<0.4	4	20	96	80	120	103	75	125
Sulphate	DIO0349-JUN19	µg/g	0.4	<0.4	4	20	94	80	120	97	75	125

### Carbon/Sulphur

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

Parameter	QC batch Reference	Units	RL	Method Blank	Duplicate		LCS/Spike Blank			Matrix Spike / Ref.		
					RPD	AC (%)	Spike Recovery (%)	Recovery Limits (%)		Spike Recovery (%)	Recovery Limits (%)	
								Low	High		Low	High
Sulphide	ECS0031-JUN19	%	0.02	<0.02	ND	20	105	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	EWL0291-JUN19	uS/cm	2	< 0.002	0	10	99	90	110	NA		



FINAL REPORT

CA14645-JUN19 R1

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	EWL0291-JUN19	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](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 --



SGS Environment,  
Health and Safety

# Request for Laboratory Services and CHAIN OF CUSTODY

- Lakefield: 185 Concession St., Lakefield, ON K0L 2H0 Phone: 705-652-2000 Toll Free: 877-747-7658 Fax: 705-652-6365  
- London: 657 Consortium Court, London, ON, N6E 2S8 Phone: 519-672-4500 Toll Free: 877-848-8060 Fax: 519-672-0361 Web: www.ca.sgs.com

No: \_\_\_\_\_  
Page \_\_\_\_ of \_\_\_\_

Received By: Oleg Mozhar  
Received Date: 6/19/19 (mm/dd/yy)  
Received Time: 1:30 am / pm (circle)

Laboratory Information Section - Lab use only  
Received By (signature): [Signature]  
Custody Seal Present: Y (N) (circle)  
Custody Seal Intact: Y (N) (circle)

Cooling Agent Present: N Type: Ice  
Temperature Upon Receipt (°C): 20°C, 20°C, 20°C

LAB LIMS #: CA14045  
June 19

## REPORT INFORMATION

## INVOICE INFORMATION

## PROJECT INFORMATION

Company: Thurber Engineering  
Contact: Liam Steers  
Address: 103-2010 Winston Park Dr.  
Oakville, ON, L6H6P5  
Phone: (905) 829-8665  
Fax: (905) 829-1166  
Email: lsteers@thurber.ca

☒ (same as Report Information)  
Company: \_\_\_\_\_  
Contact: \_\_\_\_\_  
Address: \_\_\_\_\_  
Phone: \_\_\_\_\_  
Email: \_\_\_\_\_

Quotation #: \_\_\_\_\_ P.O. #: \_\_\_\_\_  
Project #: 25480A Site Location/ID: Kanabika Lake Bridge  
☒ Regular TAT (5-7 days) TATs are quoted in business days (exclude statutory holidays & weekends).  
RUSH TAT (Additional Charges May Apply) ☐ 1 Day ☐ 2 Days ☐ 3-4 Days  
PLEASE CONFIRM RUSH FEASIBILITY WITH SGS REPRESENTATIVE PRIOR TO SUBMISSION  
Specify Due Date: \_\_\_\_\_ Rush Confirmation ID: \_\_\_\_\_

DRINKING WATER SAMPLES (POTABLE WATER FOR HUMAN CONSUMPTION) MUST BE SUBMITTED WITH SGS DRINKING WATER CHAIN OF CUSTODY

## ANALYSIS REQUESTED

COMMENTS:  
Field Filtered (F)  
Preserved (P)

## REGULATIONS

Regulation 153 (2011):  
☐ Table 1 ☐ Res/Park ☐ Soil Texture:  
☐ Table 2 ☐ Ind/Com ☐ Coarse  
☐ Table 3 ☐ Agri/Other ☐ Medium  
☐ Table ☐ Fine  
Other Regulations:  
☐ Reg 347/558 (3 Day min TAT)  
☐ PW/QO ☐ MMER  
☐ CCME ☐ Other:  
Municipality: \_\_\_\_\_  
Sewer By-Law:  
☐ Sanitary  
☐ Storm

RECORD OF SITE CONDITION (RSC) ☐ YES ☐ NO

SAMPLE IDENTIFICATION		DATE SAMPLED	TIME SAMPLED	# OF BOTTLES	MATRIX												
1	19-01 55#2A/B	15/06/2019		1	Soil	Corrosivity											
2	19-05 B 55#3	15/06/2019		1	Soil												
3																	
4																	
5																	
6																	
7																	
8																	
9																	
10																	

Observations/Comments/Special Instructions

Sampled By (NAME): Liam Steers Signature: [Signature] Date: 06/11/2019 (mm/dd/yy) Pink Copy - Client  
Relinquished by (NAME): Liam Steers Signature: [Signature] Date: 06/11/2019 (mm/dd/yy) Yellow & White Copy - SGS



## **Appendix C**

### **Site Photographs**



**Photo C1: Overtopping of east causeway embankment**  
(Date taken: Sept. 22, 2004; provided by MTO).



**Photo C2: Overtopping of east causeway embankment**  
(Date taken: Sept. 22, 2004; provided by MTO).



Photo C3: Erosion at west abutment foundation (Date taken: July 7, 2009; provided by MTO).



**Photo C4: Erosion at east abutment foundation (Date taken: July 7, 2009; provided by MTO).**



**Photo C5: Simco Drill Rig drilling at Borehole 19-01; north side of west abutment looking east  
(Date taken: June 5, 2019).**



**Photo C6: Unloading Simco Drill Rig from plane at Kasabonika Airport (Date taken: June 4, 2019).**



**Photo C7: Backhoe at Test Pit TP-02 on north side of east approach embankment, looking east  
(Date taken: June 8, 2019).**



**Photo C8: East bridge approach looking west (Date taken: June 4, 2019).**



**Photo C9: East bridge approach embankment looking east (Date taken: June 4, 2019).**



**Photo C10: South side of east approach embankment looking west (Date taken: June 4, 2019).**



**Photo C11: South side of east approach embankment looking east (Date taken: June 4, 2019).**



**Photo C12: North side of east approach embankment looking west (Date taken: June 4, 2019).**



**Photo C13: North side of bridge looking west showing large boulders and gabion baskets for erosion protection (Date taken: June 4, 2019).**



**Photo C14: East abutment footing looking north (Date taken: June 4, 2019).**



**Photo C15: Looking east towards west bridge abutment (Date taken: June 4, 2019).**



**Photo C16: West abutment footing looking north (Date taken: June 4, 2019).**



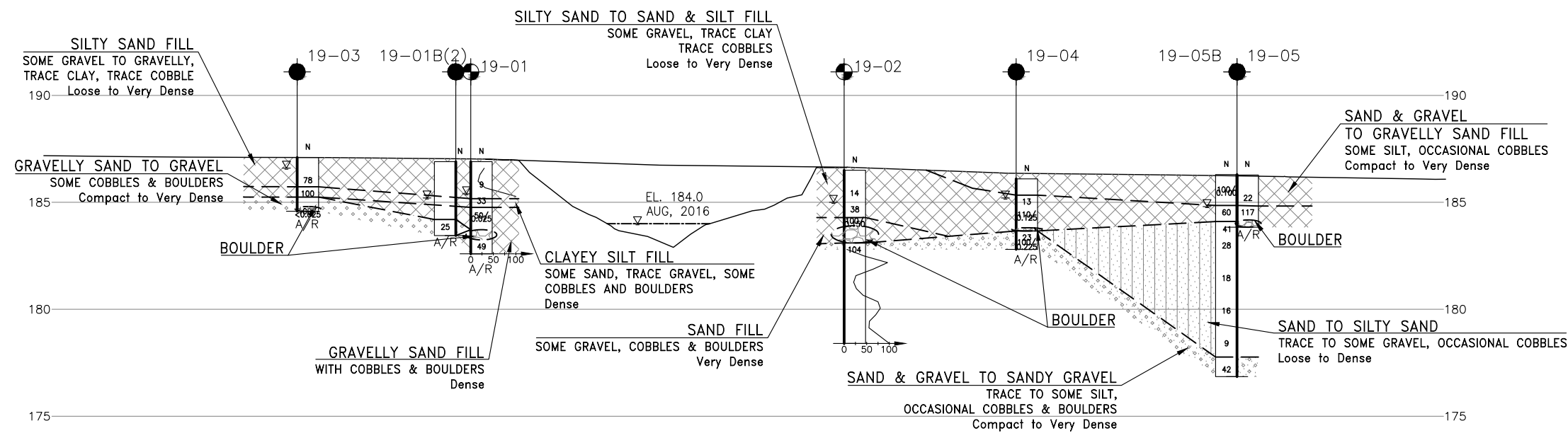
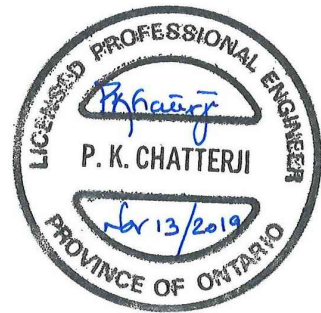
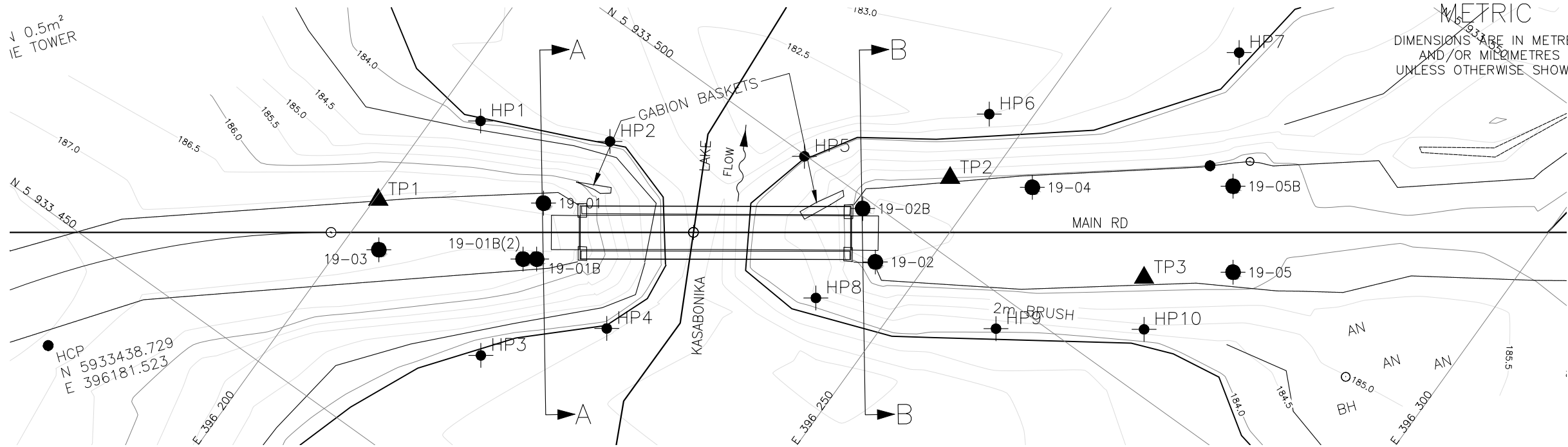
**Photo C17: West abutment and south side of bridge looking east (Date taken: June 4, 2019).**



## **Appendix D**

### **Borehole Locations and Soil Strata Drawing**

↓ 0.5m<sup>2</sup>  
IE TOWER

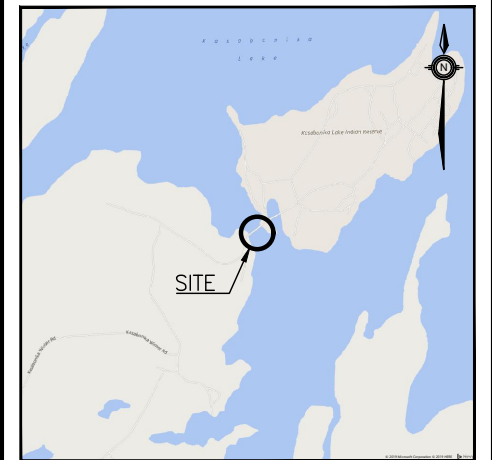


CONT No  
WP No 6579-16-00

Kasabonika Lake Bridge

BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



KEYPLAN

LEGEND

●	Borehole
●	Borehole and Cone
▲	Test Pit
+	Hand Probe
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
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
19-01	186.9	5 933 480.3	396 214.3
19-01B	186.9	5 933 475.2	396 217.1
19-01B(2)	186.9	5 933 474.4	396 216.0
19-02	186.5	5 933 495.3	396 245.6
19-02B	186.2	5 933 499.0	396 241.3
19-03	187.1	5 933 466.5	396 203.4
19-04	186.1	5 933 510.9	396 254.2
19-05	186.1	5 933 515.9	396 276.0
19-05B	186.2	5 933 523.0	396 270.9

-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 15.

GEOCRES No. 53H-01

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LS	CHK MEF	CODE
DRAWN	BH	CHK PKC	41N-0244/B0
STRUCT	DWG	1	
DATE	NOV 2019		

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

CONT No  
WP No 6579-16-00

Kasabonika Lake Bridge



SHEET

BOREHOLE LOCATIONS AND SOIL STRATA

HATCH



THURBER ENGINEERING LTD.



KEYPLAN

LEGEND

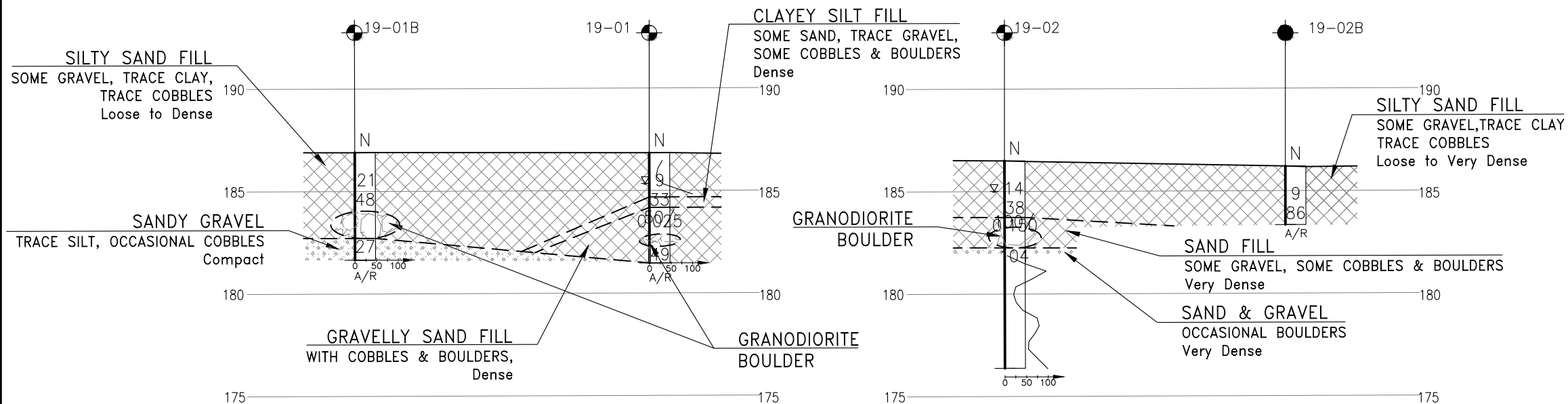
	Borehole
	Borehole and Cone
	Test Pit
	Hand Pit
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60' Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
19-01	186.9	5 933 480.3	396 214.3
19-01B	186.9	5 933 475.2	396 217.1
19-01B(2)	186.9	5 933 474.4	396 216.0
19-02	186.5	5 933 495.3	396 245.6
19-02B	186.2	5 933 499.0	396 241.3
19-03	187.1	5 933 466.5	396 203.4
19-04	186.1	5 933 510.9	396 254.2
19-05	186.1	5 933 515.9	396 276.0
19-05B	186.2	5 933 523.0	396 270.9

-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.
- 3) Coordinate system is MTM NAD 83 Zone 15.

GEOCRES No. 53H-01



SECTION A-A



H 1:100

V 1:200

SECTION B-B



H 1:100

V 1:200



REVISIONS	DATE	BY	DESCRIPTION
DESIGN	LS	CHK MEF	CODE
DRAWN	BH	CHK PKC	41N-0244/B0
STRUCT	DWG	2	



## **Appendix E**

### **Foundation Comparison**



## COMPARISON OF FOUNDATION ALTERNATIVES

Concrete Spread Footings on Native Sand and Gravel to Sandy Gravel	Spread Footings on Engineered Fill Pads on Existing Fill	Driven Steel H-Piles
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. High resistance values possible on native soil.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Deep excavation through cohesionless soil, large boulders and possibly frozen soil to construct footings on native soil.</li> <li>ii. Dewatering the cohesionless soils to below the founding level is not practical.</li> </ul>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Ease of construction.</li> <li>ii. Minimal excavation or dewatering required.</li> <li>iii. Lower cost than other footing options or pile foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Lower resistance values than constructing footings on native soil.</li> <li>ii. May require jacking up of modular bridge to mitigate future settlement.</li> <li>iii. Granular fill must be protected from scour and erosion.</li> </ul>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Minimal excavation or dewatering required.</li> <li>ii. Minimal risk of settlement.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. High cost to mobilize pile driving equipment to remote site.</li> <li>ii. Piles may refuse on boulders and be too short for sufficient lateral resistance.</li> </ul>
<b>NOT RECOMMENDED</b>	<b>RECOMMENDED</b>	<b>NOT RECOMMENDED</b>



## **Appendix F**

### **List of OPSSs and OPSDs and Suggested Wording for NSSP**



## **1. List of OPSS and OPSD Documents Relevant to this Project**

- OPSS PROV 206 (Construction Specification for Grading)
- OPSS PROV 501 (Construction Specification for Compacting)
- OPSS 517 (Construction Specification for Dewatering of Pipeline, Utility, and Associated Structure Excavation)
- OPSS PROV 804 (Construction Specification for Seed and Cover)
- OPSS 902 (Construction Specification for Excavating and Backfilling – Structures)
- Special Provision No. FOUN0003 to OPSS 902 (Dewatering Structure Excavations)
- OPSS PROV 1010 (Material Specification for Aggregates – Base, Subbase, Select Subgrade, and Backfill Material)
- OPSD 3090.100 (Foundation Frost Depths for Northern Ontario)
- OPSD 3101.150 (Walls Abutment, Backfill Minimum Granular Requirements)

## **2. Suggested Wording for NSSPs**

- **“Obstructions”**

Excavations for foundation construction will encounter obstructions such as cobbles and boulders embedded in the 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.

- **“Dewatering”**

Dewatering may be required during foundation excavation and construction to construct the engineered fill pads in the dry. Excavation below the lake and groundwater level will lead to subgrade softening. The dewatering system must be effective to maintain the water level at a minimum of 0.5 m below the final subgrade level throughout construction.



The dewatering system is to be designed in accordance with SP FOUN0003 and OPSS.PROV. 517. A preconstruction survey is not required, thus Designer Fill-In \*\* in SP FOUN0003 should be "N/A". Special Provision FOUND0003 is included below.

## **DEWATERING STRUCTURE EXCAVATIONS - Item No.**

---

Special Provision No. FOUN0003

March 8, 2018

---

### **Amendment to OPSS 902, November 2010**

OPSS 902, November 2010, Construction Specification for Excavating and Backfilling - Structures is amended as follows:

#### **902.02 REFERENCES**

Section 902.02 of OPSS 902 is amended by the addition of the following:

#### **Ontario Provincial Standard Specifications, Construction**

OPSS 517      Dewatering  
OPSS 805      Temporary Erosion and Sediment Control Measures

#### **902.03 DEFINITIONS**

Section 903.03 of OPSS 902 is amended by the addition of the following:

**Automatic Transfer Switch** means as defined in OPSS 517.

**Cofferdam** means as defined in OPSS 539.

**Cut-Off Wall** means as defined in OPSS 517.

**Design Storm Return Period** means as defined in OPSS 517.

**Dewatering System** means as defined in OPSS 517.

**Groundwater Control System** means as defined in OPSS 517.

**Plug** means as defined in OPSS 517.

**Sediment** means as defined in OPSS 517.

**Sediment Control Measure** means as defined in OPSS 517.

**Temporary Flow Passage System** means as defined in OPSS 517.

**Unwatering** means as defined in OPSS 517.

**Vegetated Discharge Area** means as defined in OPSS 517.

**Waterbody** means as defined in OPSS 517.

**Watercourse** means as defined in OPSS 517.

## **902.04 DESIGN AND SUBMISSION REQUIREMENTS**

### **902.04.01 Design Requirements**

#### **902.04.01.01 Dewatering**

Clause 902.04.01.01 of OPSS 902 is deleted in its entirety and replaced with the following:

A dewatering system shall be designed to control water and the flow of water into the excavation, prevent disturbance of the foundation, permit the placing of concrete in the dry, and complete the excavating and backfilling for structures work.

When the system includes temporary flow passage system, the system shall be designed, as a minimum, for a [\* Designer Fill-In, See Notes to Designer] year design storm return period, and groundwater discharge. A longer return period shall be used when determined appropriate for the work.

The dewatering system shall be according to the design requirements specified in OPSS 517.

### **902.04.02 Submission Requirements**

Subsection 902.04.02 of OPSS 902 is deleted in its entirety and replaced with the following:

#### **902.04.02.01 Working Drawings**

Working Drawings for the dewatering system shall be according to OPSS 517.

#### **902.04.02.02 Preconstruction Survey**

When a groundwater control system by wells or a well point system will be used, a condition survey of property and structures that may be affected by the work shall be carried out. The condition survey shall include the location and condition of adjacent properties, buildings, underground structures, water wells, Utilities, and structures, within a distance of [\*\* Designer Fill-In, See Notes to Designer] metres from the groundwater control system. In addition, all water wells used as a supply of drinking water and located within this distance shall be tested for compliance with Ontario Drinking Water Quality Standards.

Water wells within the preconstruction survey distance can be located using the website <https://www.ontario.ca/environment-and-energy/map-well-records> or its successor site.

Copies of the condition survey and water quality test results shall be submitted to the Contract Administrator prior to the operation of the groundwater control system.

#### **902.04.02.03 Milestone Inspections**

Clause 902.04.02.03 of OPSS 902 is deleted in its entirety.

## **902.07 CONSTRUCTION**

Subsection 902.07.04 of OPSS 902 is deleted in its entirety and replaced with the following:

#### **902.07.04                      Dewatering Structure Excavation**

##### **902.07.04.01                      General**

The dewatering systems shall be constructed and operated according to the Working Drawings.

Activation and deactivation of a temporary flow passage system, if applicable, shall be according to OPSS 517.

The dewatering system shall be continuously operational to control buoyancy forces until such forces can be resisted by backfill and structure self-weight, to keep excavations stable, to avoid erosion impacts from the release of accumulated water, and to keep the work area in the condition required to complete the associated work as specified in the Contract Documents.

When a temporary flow passage system is to remain operational through a seasonal shutdown period, the Contractor shall be responsible for any maintenance or repair costs due to the system during the seasonal shutdown period.

Temporary erosion and sediment control measures, including controlling the discharge of water, shall be according to OPSS 805. Measures not specified in OPSS 805 shall be according to the Working Drawings. Temporary erosion and sediment control measures and cover material to protect exposed soils, as required by the Working Drawings, shall be installed as soon as is practical.

Stranded fish shall be managed as specified in the Contract Documents.

Unwatering shall be carried out as necessary.

Water suspected of being contaminated as indicated by visual or olfactory observations shall be reported to the Contract Administrator.

Dewatering and temporary flow passage systems shall be discontinued in a manner that does not disturb any structure, pipeline, or flow channel. Operation of the dewatering system shall be shut down according to the procedures specified in the Working Drawings, where applicable.

##### **902.07.04.02                      Discharge of Water**

The discharge of water shall be according to OPSS 517.

##### **902.07.04.03                      Monitoring**

Monitoring shall be according to OPSS 517.

##### **902.07.04.04                      System Amendments**

Amendments to stop any displacement, damage, soil loss or erosion due to the operation of the dewatering system shall be according to OPSS 517.

##### **902.07.04.05                      Removal**

Removal of dewatering system and temporary flow passage system components shall be according to OPSS 517.

NOTES TO DESIGNER:

Designer Fill-Ins

- \* Fill in the design storm return period according to MTO Drainage Design Standard TW-1.
- \*\* Fill in the preconstruction survey distance as recommended by the foundation engineer.

WARRANT: Include with this standard tender item only on the recommendation of a foundation engineer.

CUSTODIAN: Tony Sangiuliano, MERO - Foundation Group.



## **Appendix G**

### **Slope Stability Analysis Figures**

# KASABONIKA LAKE BRIDGE SIDE SLOPE WEST ABUTMENT 2H:1V CONDITION WITH GRADE RAISE

FIGURE 1

File Name: 25489 West Abutment Side Slope.gsz

Last Edited By: Geoff Lay

Date: 10/28/2019

Method: Morgenstern-Price

Minimum Slip Surface Depth: 1 m

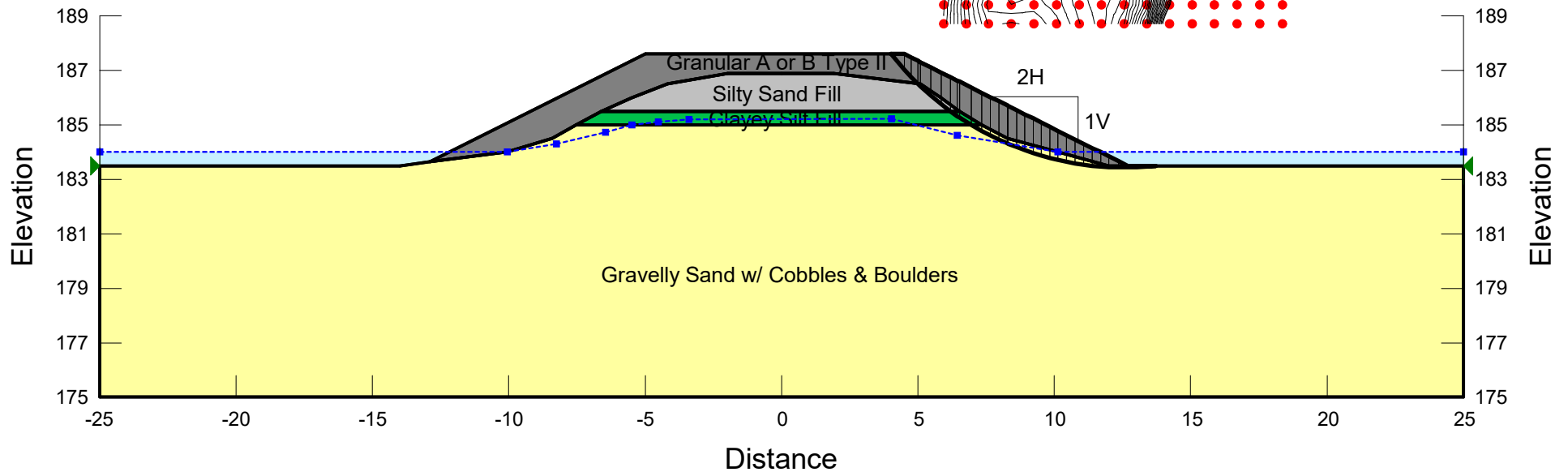
Seismic: 0

Granular A or B Type II 22 kN/m<sup>3</sup> 0 kPa 35 °

Silty Sand Fill 21 kN/m<sup>3</sup> 0 kPa 31 °

Clayey Silt Fill 21 kN/m<sup>3</sup> 0 kPa 30 °

Gravelly Sand w/ Cobbles & Boulders 22 kN/m<sup>3</sup> 0 kPa 35 °



# KASABONIKA LAKE BRIDGE SIDE SLOPE EAST ABUTMENT 2H:1V CONDITION WITH GRADE RAISE

FIGURE 2

File Name: 25489 East Abutment Side Slope.gsz

Last Edited By: Geoff Lay

Date: 10/28/2019

Method: Morgenstern-Price

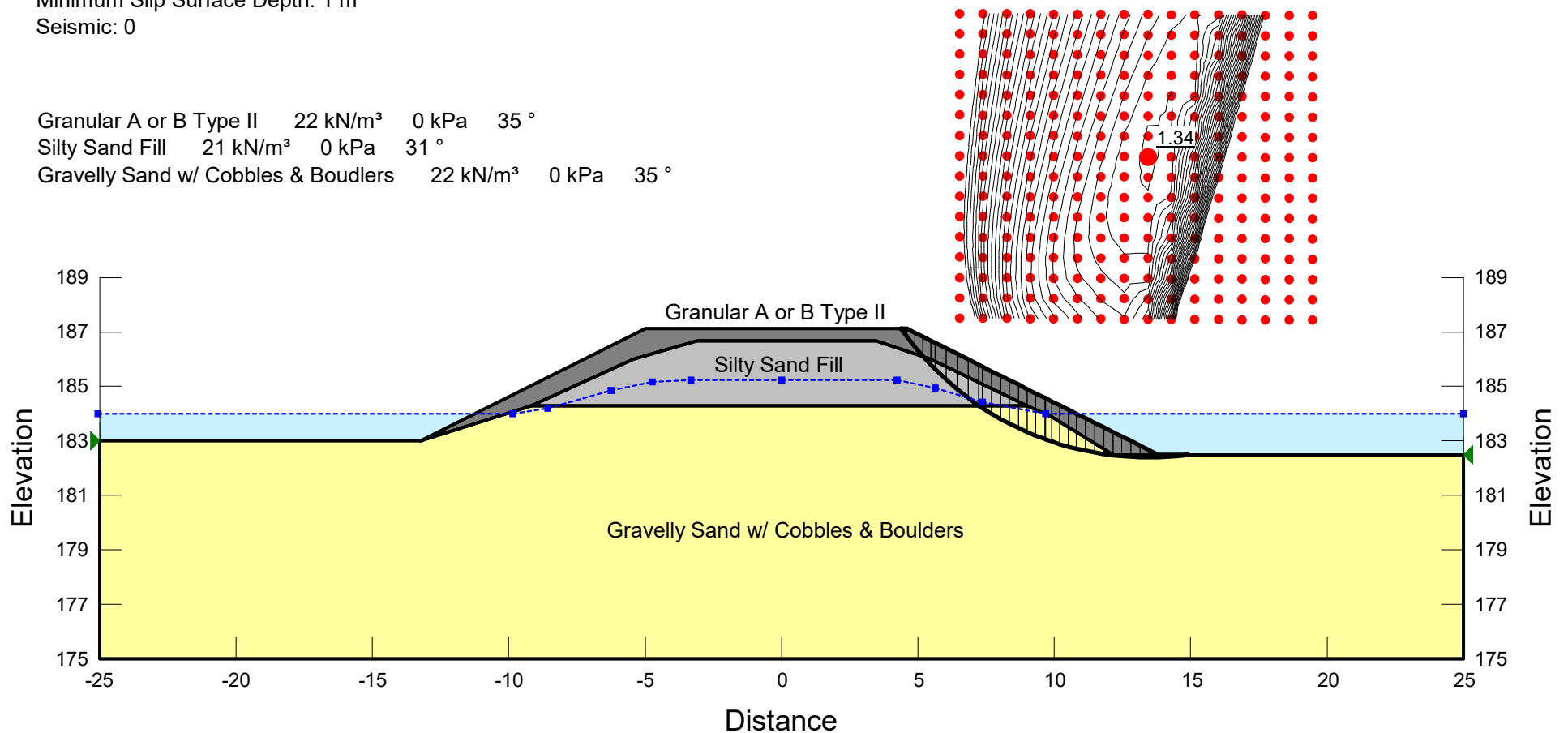
Minimum Slip Surface Depth: 1 m

Seismic: 0

Granular A or B Type II    22 kN/m<sup>3</sup>    0 kPa    35 °

Silty Sand Fill    21 kN/m<sup>3</sup>    0 kPa    31 °

Gravelly Sand w/ Cobbles & Boulders    22 kN/m<sup>3</sup>    0 kPa    35 °



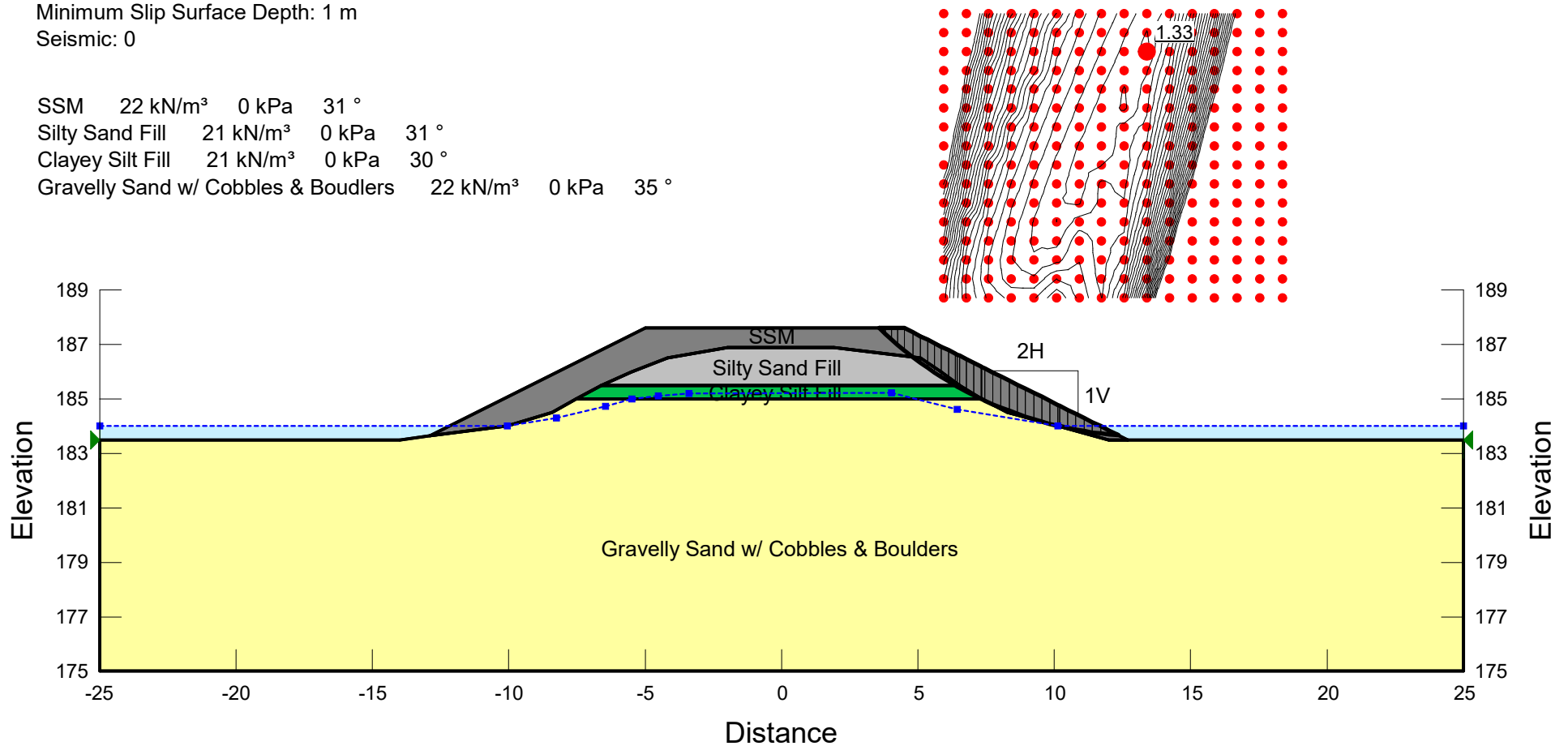
# KASABONIKA LAKE BRIDGE SIDE SLOPE WEST ABUTMENT 2H:1V CONDITION WITH GRADE RAISE

FIGURE 3

File Name: 25489 West Abutment Side Slope.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

SSM	22 kN/m <sup>3</sup>	0 kPa	31 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °



# KASABONIKA LAKE BRIDGE SIDE SLOPE EAST ABUTMENT 2H:1V CONDITION WITH GRADE RAISE

FIGURE 4

File Name: 25489 East Abutment Side Slope.gsz

Last Edited By: Geoff Lay

Date: 10/28/2019

Method: Morgenstern-Price

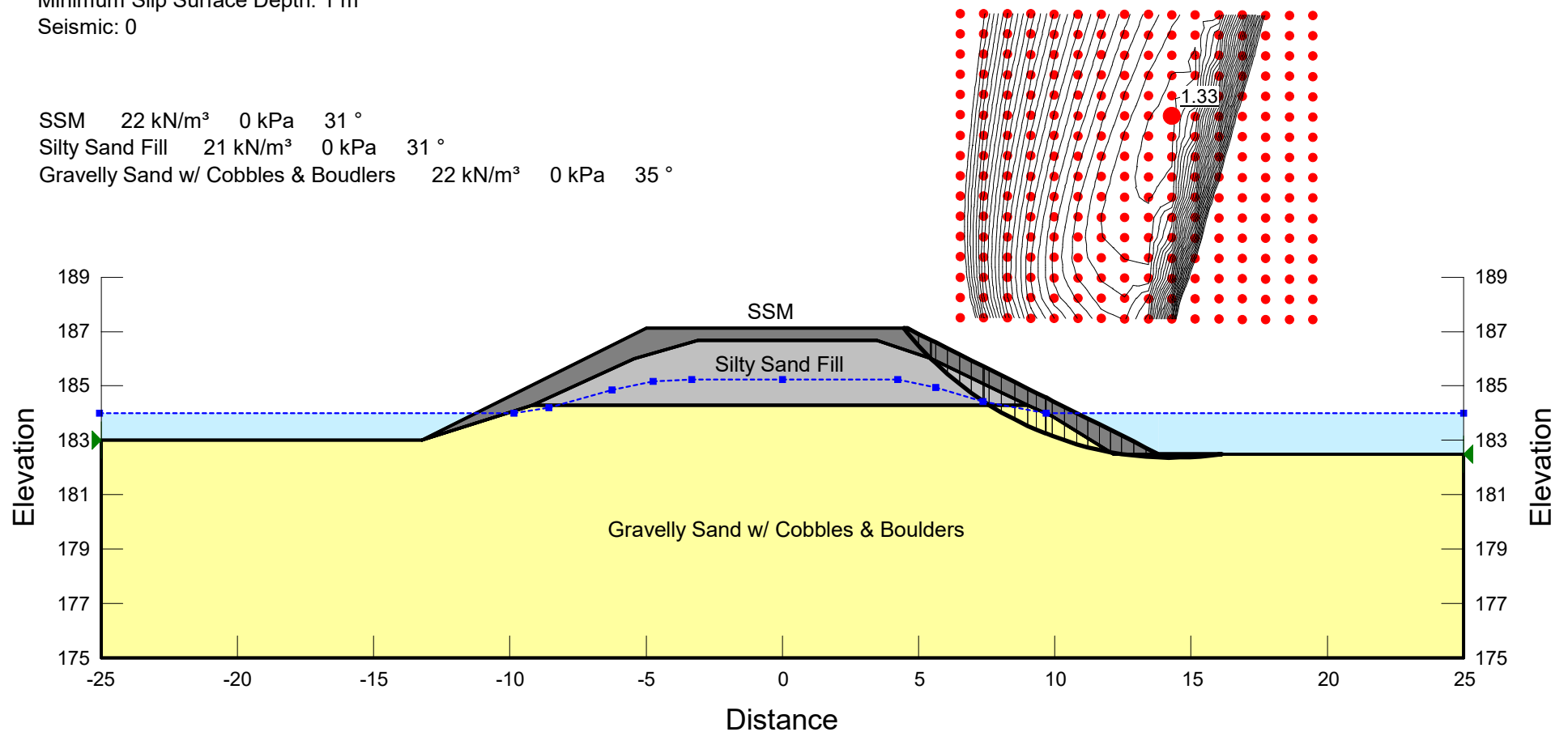
Minimum Slip Surface Depth: 1 m

Seismic: 0

SSM 22 kN/m<sup>3</sup> 0 kPa 31 °

Silty Sand Fill 21 kN/m<sup>3</sup> 0 kPa 31 °

Gravelly Sand w/ Cobbles & Boulders 22 kN/m<sup>3</sup> 0 kPa 35 °



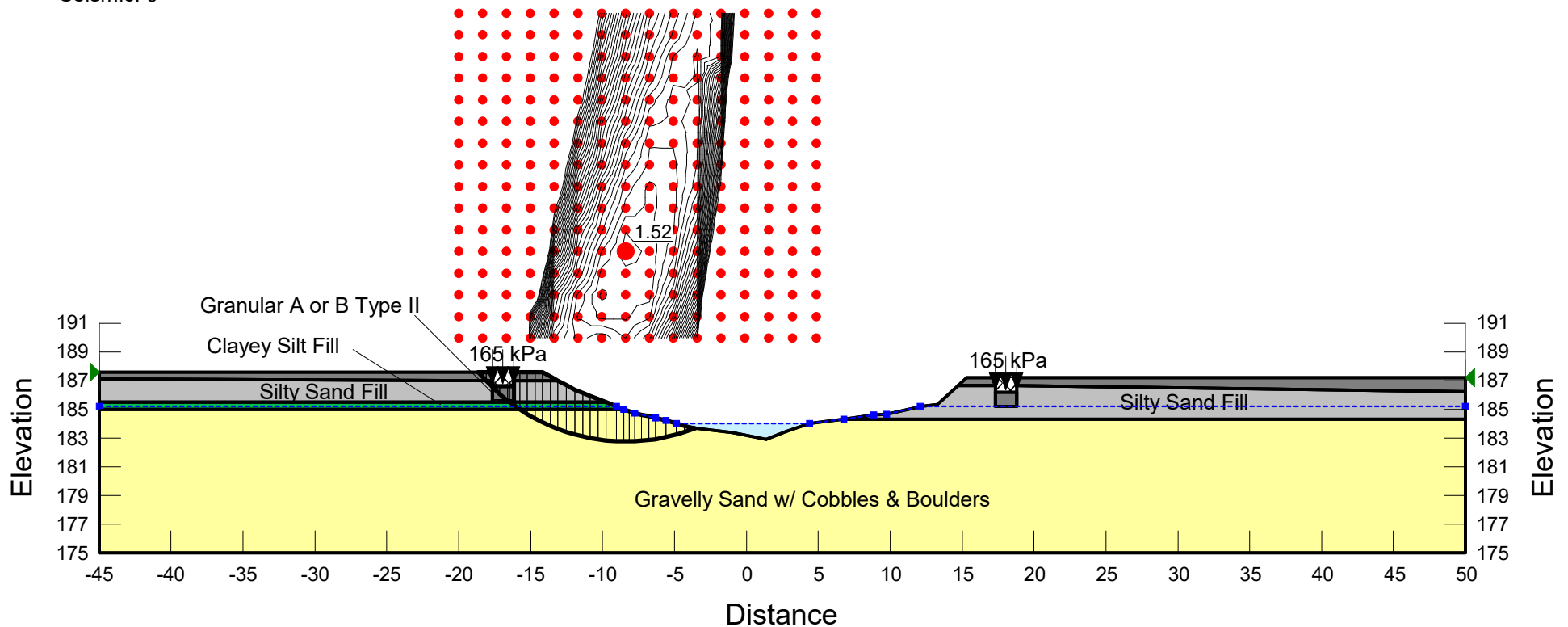
# KASABONIKA LAKE BRIDGE FORWARD SLOPE WEST ABUTMENT EXISTING CONDITION WITH GRADE RAISE

**FIGURE 5**

File Name: 25489 West Abutment Forward Slope 2H-1V.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

Granular A or B Type II	22 kN/m <sup>3</sup>	0 kPa	35 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °



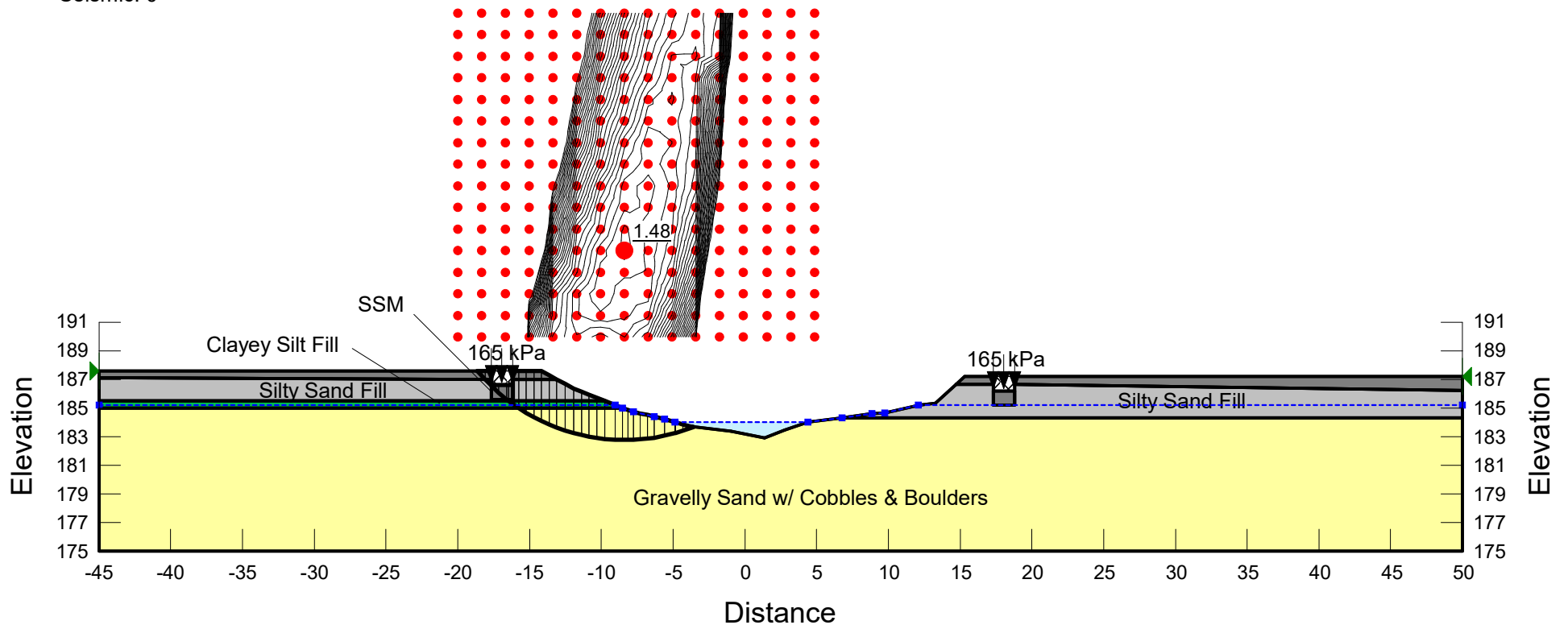
# KASABONIKA LAKE BRIDGE FORWARD SLOPE WEST ABUTMENT EXISTING CONDITION WITH GRADE RAISE

FIGURE 6

File Name: 25489 West Abutment Forward Slope 2H-1V.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

SSM	22 kN/m <sup>3</sup>	0 kPa	31 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °



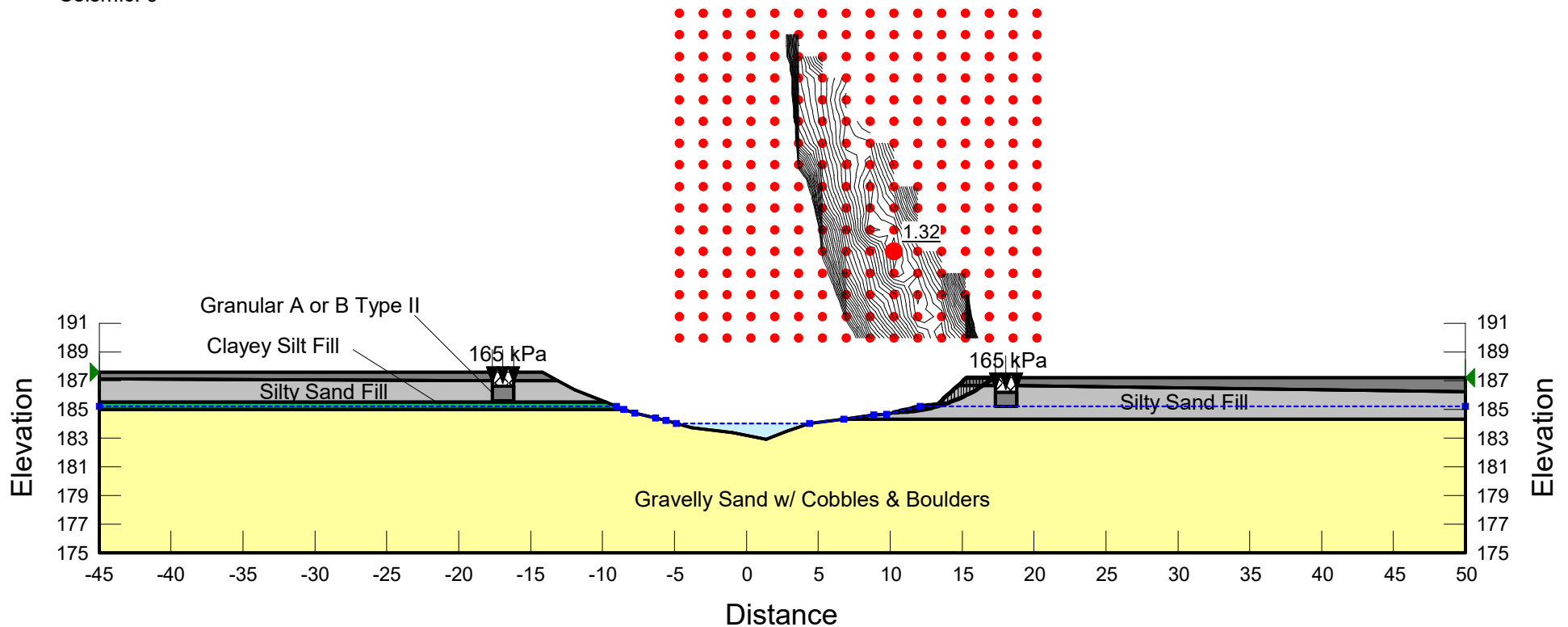
# KASABONIKA LAKE BRIDGE FORWARD SLOPE EAST ABUTMENT EXISTING CONDITION (1.3H:1V) WITH GRADE RAISE

**FIGURE 7**

File Name: 25489 East Abutment Forward Slope.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

Granular A or B Type II	22 kN/m <sup>3</sup>	0 kPa	35 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °



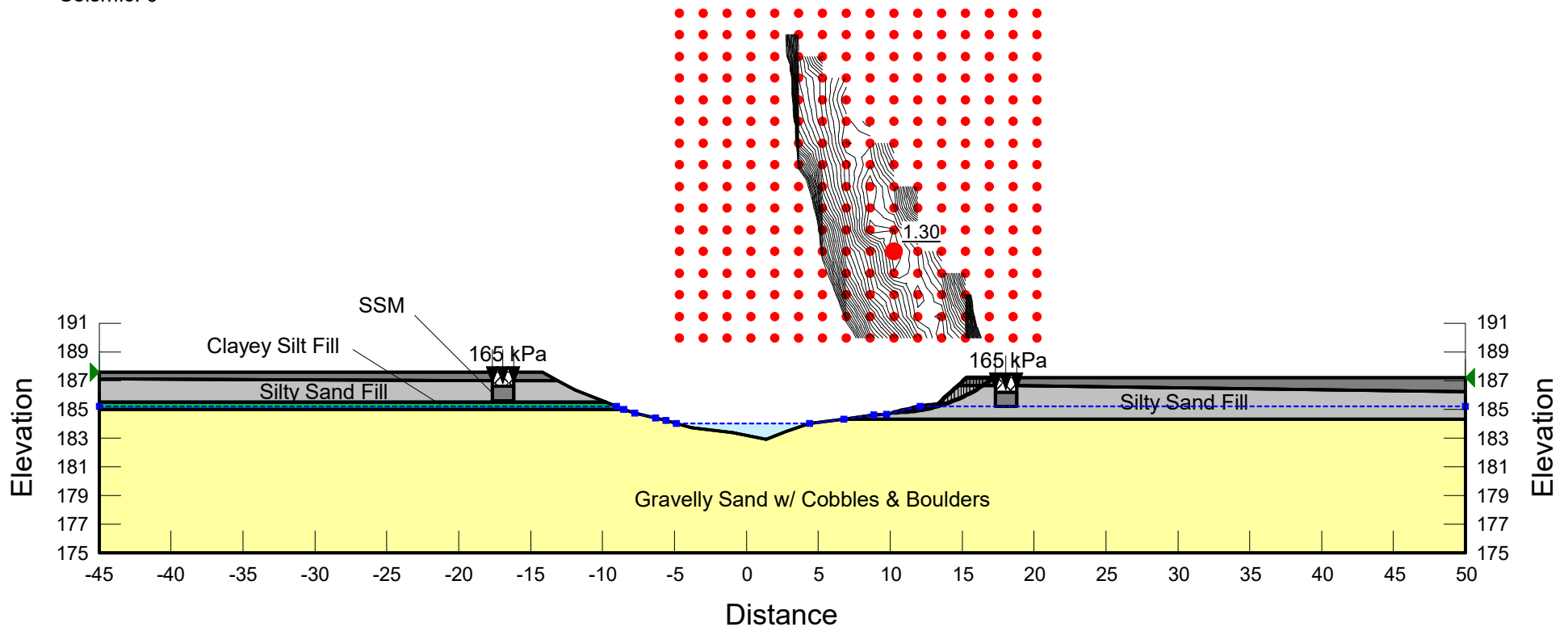
# KASABONIKA LAKE BRIDGE FORWARD SLOPE EAST ABUTMENT EXISTING CONDITION (1.3H:1V) WITH GRADE RAISE

**FIGURE 8**

File Name: 25489 East Abutment Forward Slope.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

SSM	22 kN/m <sup>3</sup>	0 kPa	31 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °



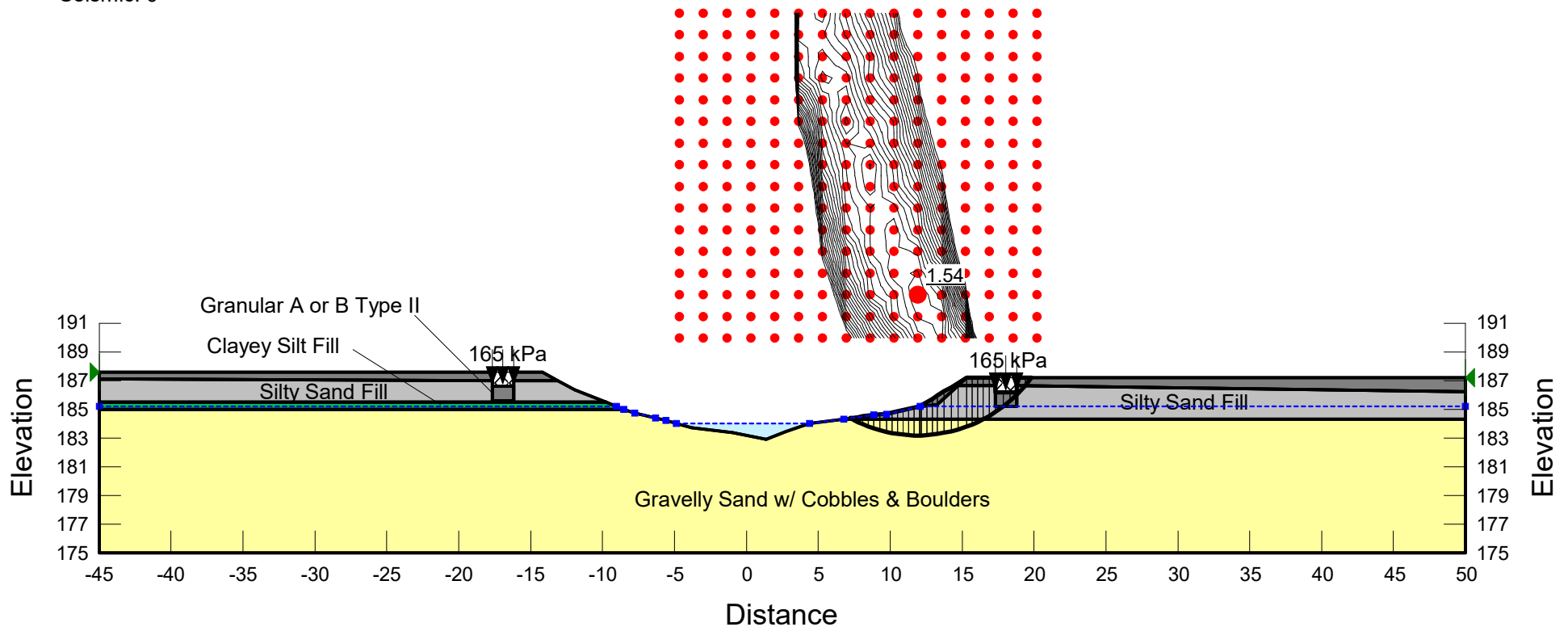
# KASABONIKA LAKE BRIDGE FORWARD SLOPE EAST ABUTMENT 2H:1V CONDITION WITH GRADE RAISE

**FIGURE 9**

File Name: 25489 East Abutment Forward Slope 2H-1V.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

Granular A or B Type II	22 kN/m <sup>3</sup>	0 kPa	35 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °



# KASABONIKA LAKE BRIDGE FORWARD SLOPE EAST ABUTMENT 2H:1V CONDITION WITH GRADE RAISE

FIGURE 10

File Name: 25489 East Abutment Forward Slope 2H-1V.gsz  
Last Edited By: Geoff Lay  
Date: 10/28/2019

Method: Morgenstern-Price  
Minimum Slip Surface Depth: 1 m  
Seismic: 0

SSM	22 kN/m <sup>3</sup>	0 kPa	31 °
Silty Sand Fill	21 kN/m <sup>3</sup>	0 kPa	31 °
Clayey Silt Fill	21 kN/m <sup>3</sup>	0 kPa	30 °
Gravelly Sand w/ Cobbles & Boulders	22 kN/m <sup>3</sup>	0 kPa	35 °

