



# Part A - Foundation Investigation Report

**HIGHWAY 17 WIDENING  
AREA 1 (STA. 10+400 – 10+600), AREA 2 (STA. 11+050 – 11+160)  
AREA 3 (STA. 11+525 – 11+600), AREA 4 (STA. 12+350 – 12+480)  
TOWNSHIP OF DAMBROSSIO  
AREA 7 (STA. 16+700 – 16+825)  
TOWNSHIP OF LALIBERT  
DISTRICT OF ALGOMA  
BETWEEN WHITE RIVER AND WAWA, ONTARIO**

AGREEMENT NO. 5017-E-0043  
WORK ITEM: #5  
GWP 5031-18-00

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Enclosure 1	Site Plan, Borehole Location Plan, and Soil Strata
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Appendix D	Rock Core Photographs, Rock Core Description, and Uniaxial Compressive Strength Test Results



## PART A - FOUNDATION INVESTIGATION REPORT

Highway 17 Widening  
Area 1 (Sta. 10+400 – 10+600), Area 2 (Sta. 11+050 – 11+160)  
Area 3 (Sta. 11+525 – 11+600), Area 4 (Sta. 12+350 – 12+480), Township of Dambrossio  
Area 7 (Sta. 16+700 – 16+825), Township of Lalibert,  
District of Algoma, Between White River and Wawa, Ontario  
Agreement No 5017-E-0043, Work Item: #5  
G.W.P 5031-18-00

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### 1. Introduction

The Ministry of Transportation of Ontario Northeast Region (Ministry or MTO), plans to temporarily and permanently widen Highway 17 in Northern Ontario, and retained GHD Limited (GHD) to conduct foundation investigations at Ministry selected five (5) high fill areas. The five (5) high fill areas (Area 1, Area 2, Area 3, Area 4 and Area 7) involve local creek and lake crossings, and are located between the Towns of White River and Wawa, in the Townships of Dambrossio and Lalibert, District of Algoma, Ontario. Drawing 1 in Enclosure 1, present a site plan showing the location of these areas.

The purpose of the foundation investigations was to describe the subsurface and groundwater conditions based on borehole information and laboratory test results, and provide geotechnical recommendations for the design of embankments for temporarily and permanent road widening.

The work was conducted under a retainer agreement (Agreement No. 5017-E-0043), Work Item # 5. GHD submitted the proposal for this assignment based on the work item order received from the Ministry. The original request from the Ministry included seven (7) areas along Highway 17. However, Area 5 and Area 6 located between Area 4 and Area 7 were later removed from the scope by the Ministry. Authorization to proceed with the foundation investigation for the rest of the five areas, was obtained from Mr. Mark Winmill (Ministry's Project Manager) in an email dated August 23, 2019.

This project didn't include an environmental assessment, and the information contained herein must in no way be construed as an opinion of the environmental conditions of the project sites.

### 2. Site Conditions

Area 1 is located in the Township of Dambrossio, approximately 45 km north of the Town of Wawa. It represents a road embankment that stretches from Sta. 10+400 to Sta. 10+600. A permanent road widening of up to 5 m on the south side of Highway 17 was originally planned in this area. A creek flows through a corrugated steel pipe (CSP) culvert of about 1.5 m wide located at Sta. 10+422. Another CSP culvert aligned in south-north direction also exists at around Sta. 10+500. The general direction of flow in the region is from north to south, but the creeks in this area drain towards a local pond north of the highway. According to the survey data obtained from the Ministry in an email dated July 18, 2019, the existing embankment has a thickness of up to 5.5 m. The embankment fill consists of blasted rock derived from the rock cuts present on the north and south sides of the highway.





Area 2 is situated about 600 m south of Area 1, and involves a road embankment located in the Township of Dambrossio, between Sta. 11+050 and Sta. 11+600. A permanent road widening of up to 5 m on the south side of Highway 17 was originally planned in this area. Based on the survey data from the Ministry, the height of the existing embankment was reported to be 7.5 m. The creek at the middle of the road embankment, flows from northeast to southwest through a CSP culvert of about 1.5 m in width, and empty into a local lake called Lonely Lake. Bedrock outcrops were observed near the creek on the west side of the highway. Bedrock exposures are also present at the west and east ends of the embankment. However, much of the area on the west side was swampy and muddy.

Area 3 is located 500 m south of Area 2 and covers the road section from Sta. 11+525 to Sta. 11+600 in the Township of Dambrossio. The original plan indicate that the road widening in this area will be on the south side of Highway 17 and may reach a width of 5 m. According to the survey information obtained from the Ministry, the existing road embankment consists of up to 5.5 m thick blasted rock fill. A CSP culvert associated with this area is aligned in northeast to southwest direction. This culvert is about 1.5 m wide and is located in the middle of the embankment (at around Sta. 11+560). During the fieldwork, standing water was observed on the west side of the road embankment. Bedrock outcrops were observed on the northwest, southwest and southeast sides of the highway.

Area 4 refers to a lake crossing located in the Township of Dambrossio, between Sta. 12+350 and Sta. 12+480, approximately 1.7 km south of Area 3, or 2.5 km north of the intersection between Highway 17 and Highway 519. In this area, the road embankment was built by placing blasted rocks over a local lake called Desolation Lake. The thickness of the road embankment is about 5.3 m. A CSP culvert exists on the east side of the lake at Sta. 12+412, conveying water from north to south. The original plan in this area involved a road widening on the north side of the highway. Bedrock exposures exist on the west and east sides of the lake. The lake level during the fieldwork in early October was at El. 450. 8 m, and the water depth was 0.8 m at borehole locations.

Area 7 is located roughly 35 km north of the Town of Wawa, in the Township of Lalibert, between Sta. 16+700 and Sta. 16+825. In this area, permanent road widening of up to 5 m on the north side of Highway 17 was originally planned. Based on the Ministry's survey data, the road embankment is up to 14 m high and consists of blasted rocks. A creek was observed at the eastern end of the embankment flowing from southwest to northeast through a CSP culvert of about 2 m in diameter.

Highway 17 is a well-travelled route of the Trans-Canada Highway in Northern Ontario. Throughout the region, the highway passes through rugged topography with numerous road cuts and high fill embankments. Between White River and Wawa, the highway consists of two (2) travel lanes and about 2.5 m wide gravel shoulders. In Area 1, Area 2, Area 3 and Area 7, the vertical geometry of the highway is relatively flat with minor sags and crests. Local relief in these areas is less than 3 m. In Area 4, the highway makes a curve around the middle of Desolation Lake and is characterized by a higher relief. In all areas, the highway has posted speed limit of 90km/hr.

Apart from Highway 17, access to and from the region is serviced by secondary highways such as Highway 519, and local fishing and logging roads. In addition, infrequent flights to major surrounding cities can be obtained from a small airport located in the southern part of Wawa.

The land north and south of the project areas, beyond the limits of Highway 17, consists of a natural woodland and diverse landscapes marked by rocky uplands and depressions. A significant portion of the region including the project areas is occupied by a number of north-south trending lakes, ponds,



swamps and wetlands. The percentage of rock outcrops is very significant as numerous rock cuts were observed along the highway. Vegetation is characterized mainly by deciduous forest consisting of white birch and spruce trees. Shrubs as well as tall grasses are also common near road embankments and on wet areas. The climate is characterized by a long cold winter and a warm summer. A freezing rain and a light snow fall has occurred during the fieldwork in early October.

Mining and mineral exploration has been a common activity throughout the region, and existing reports indicated that the area around Desolation Lake (Area 4) was once explored for gold and iron ores. However, no known quarries were observed in this area during the fieldwork.

Photo 1 to Photo 18 in Appendix A show the general site conditions and field activities.

## **3. Investigation Procedures**

### **3.1 Field Investigation**

The field program consisted of advancing a total of eighteen (18) boreholes and five (5) auger holes in all areas, and was conducted between September 03, 2019 and October 03, 2019. Prior to the commencement of drilling, MTO road occupancy permit were obtained and borehole locations were cleared of utilities. Access was prepared in all areas to open up the lands for foundation investigation. The access preparation involved the cutting of trees and removal of blast rocks as well as the placement of gravel on muddy and swampy grounds. Attempts were carried out to drill boreholes at or a little away from the toes of existing embankments. However, some boreholes were repositioned as necessary in consideration of surface features, the presence of communication and hydro lines, standing water and extremely wet grounds, and steep natural slopes. Boreholes through the road embankment were completed at the center of the right or left lane of the highway.

A summary of the field investigation program for each area investigated, including elevations, depths and remarks is given in Table 3.1. The logs of all boreholes are provided in Appendix B.

In Area 1, the foundation investigation involved drilling four (4) boreholes (BH-19-1-01, BH-19-1-02, BH-19-1-03, and BH-19-1-04), along the west toe of the existing embankment. The boreholes were drilled to the depth of 3.7 m to 6.8 m. To confirm the presence and depth of the bedrock, rock coring was conducted in two (BH-19-1-02 and BH-19-1-04) of these boreholes. In addition, two (2) boreholes (BH-19-1-05 and BH-19-1-06) were advanced through the left lane of the exiting road embankment. Boreholes through the embankment were drilled to the depth of 2.8 m to 5.9 m, with rock coring carried out in BH-19-1-05. Drawing 2 in Enclosure 1 presents the borehole location plan for Area 1.

In Area 2, the foundation investigation consisted of three (3) boreholes (BH-19-2-01, BH-19-2-02, and BH-19-2-03) advanced along the west toe of the existing embankment. The boreholes were drilled to the depth of 3.7 m to 5.3 m. Rock coring was initially required in one of the boreholes. However, because of the presence of shallow bedrock, rock coring was conducted in two of the boreholes (BH-19-2-01 and BH-19-2-02). No boreholes were required through the embankment. Drawing 3 in Enclosure 1 provides the location of the three (3) boreholes in the area.

The foundation investigation in Area 3 involved drilling three (3) boreholes (BH-19-3-01, BH-19-3-02, and BH-19-3-03) along the west toe of the existing embankment. The boreholes were drilled to the depth in the range of 2.5 m to 5.7 m, with rock coring conducted in BH-19-3-02. In addition, two (2)



boreholes (BH-19-3-04 and BH-19-3-05) were drilled through the existing embankment to the depth of 5.9 m to 9.1 m. Drawing 4 in Enclosure 1 presents the borehole location plan for Area 3.

**Table 3.1 – Field Investigation Program**

Location	Sta. No	Borehole/Hand Augerhole No.	Drilling Location	Elevation <sup>1</sup> (m)	Depth <sup>2</sup> (m)	Remark
Area 1	10+400 – 10+600	BH-19-1-01	Off road	435.3	3.7	Terminated on Probable Bedrock
		BH-19-1-02		436.2	8.3	Terminated in Bedrock after Coring
		BH-19-1-03		437.2	7.9	Terminated due to Auger Refusal
		BH-19-1-04		437.7	6.8	Terminated in Bedrock after Coring
		BH-19-1-05	Embankment	441.3	5.9	Terminated in Bedrock after Coring
		BH-19-1-06		443.5	2.8	Terminated on Probable Bedrock
Area 2	11+050 – 11+160	BH-19-2-01	Off road	447.3	3.7	Terminated in Bedrock after Coring
		BH-19-2-02		446.3	5.0	Terminated in Bedrock after Coring
		BH-19-2-03		446.6	5.3	Terminated on Probable Bedrock
Area 3	11+525 – 11+600	BH-19-3-01	Off road	460.2	5.0	Terminated on Probable Bedrock
		BH-19-3-02		459.6	5.7	Terminated in Bedrock after Coring
		BH-19-3-03		460.1	2.5	Terminated on Probable Bedrock
		BH-19-3-04	Embankment	464.3	9.1	Terminated in Bedrock after Coring
		BH-19-3-05		464.6	5.9	Terminated in Probable Bedrock
Area 4	12+350 – 12+480	BH-19-4-01	In the Lake	451.3	1.8	Terminated on Probable Bedrock
		BH-19-4-02		451.3	10.8	Terminated in Bedrock after Coring
		BH-19-4-03	Off road	452.1	2.5	Terminated on Probable Bedrock
		BH-19-4-04	Embankment	455.6	13.1	Terminated due to Auger Refusal
Area 7	16+700 – 16+825	HA-19-7-01	Off road	424.0	0.8	Terminated due to Auger Refusal on Probable Bedrock
		HA-19-7-02		421.5	0.7	
		HA-19-7-03		420.5	1.9	
		HA-19-7-04		421.6	0.9	
		HA-19-7-05		420.6	0.7	

**Note** 1: Surface or Drilling Platform Elevation; 2: Depth Below Grade (m) or Drilling Platform



In Area 4, three (3) boreholes (BH-19-4-01, BH-19-4-02, and BH-19-4-03) were advanced along the east toe of the embankment, to a depth of 1.8 m to 10.8 m. Two (2) of these boreholes (BH-19-4-01 and BH-19-4-02) were completed in the lake, with rock coring conducted in BH-19-4-02. In addition, the field program involved the completion of one (1) borehole (BH-19-4-04) at the embankment to a depth of 13.1 m. Drawing 5 in Enclosure 1 presents the location of the boreholes in Area 4.

In Area 7, a total of five (5) hand augerholes (HA-19-7-01, HA-19-7-02, HA-19-7-03, HA-19-04, and HA-19-7-05) were completed along the east toe of the existing embankment, with the purpose of confirming the bedrock surface. The depth of these hand augerholes ranged from 0.8 m to 1.9 m. Drawing 6 in Enclosure 1 present the location plan for the hand augerholes.

Drilling started in Area 1 using an Acker Soil Sentry track-mounted drilling rig equipped with hollow stem augers. Rock coring was carried out using swivel-type double tube core barrels. The drilling equipment was owned and operated by a specialist drilling contractor known as Tetry Environmental Drilling (Tetry) of Timmins, Ontario. In the time between September 03, 2019 and September 13, 2019, Tetry completed four (4) boreholes in Area 1, and was later replaced by Marathon Underground Constructors Corp. (Marathon) of Greely, Ontario. The remaining boreholes in Area 1 and all boreholes in Area 2, Area 3 and Area 4 were completed by Marathon using CME 55 track mounted drilling rig equipped with hollow stem augers and capable of rock coring.

In Area 4, drilling in the lake was conducted by Fordia Explo Limited Access portable rig mounted on a boat. The rig is designed for shallow depth geotechnical investigation in areas where access is limited, and can be used for auger, rotary, or percussive drilling and rock coring. The boat was placed in the lake with the support of an excavator and tied to trees to obtain balance against current. A sediment curtain (silt fence) was used to prevent the release of silt and drill cuttings into the lake.

All access preparation, track and barge-mounted drilling, soil and rock sampling, and backfilling of boreholes was conducted under the full time supervision of a GHD field technician.

During drilling, representative soils samples were obtained at selected intervals from all boreholes, using a 50 mm outer-diameter (OD) split-barrel sampler advanced in accordance with the Standard Penetration Test (SPT) procedures described in the ASTM D1586. The drill rigs were equipped with 63.5 kg cathead automatic hammer calibrated to fall freely through 760 mm. The results of the SPTs are reported as "N" values on borehole logs. In addition to soils samples, NQ size (47.6 mm) rock cores were obtained from boreholes completed in Area 1, Area 2, Area 3 and Area 4.

Soil samples obtained from boreholes were inspected in the field immediately upon retrieval for type, texture, and color. All samples were sealed in plastic jars and transported to the GHD laboratory in Whitby and Waterloo for further visual examination and geotechnical laboratory tests.

Rock cores were described based on color, hardness, degree of fracturing, weathering, core recovery (REC), rock quality designation (RQD) and were placed in core boxes for additional description and laboratory testing. The core boxes were labeled with project name, area or location of drilling, borehole number, core run lengths and depth, date of coring, and name of drilling contractor.

The groundwater condition at borehole locations were observed and recorded during drilling by visual examination of soil samples, sampler and drill rods. Upon completion of drilling, groundwater levels were measured in open boreholes. In addition, a total of four (4) monitoring wells were installed in Area 1 (BH-19-1-01), Area 2 (BH-19-2-03), Area 3 (BH-19-3-03) and Area 4 (BH-19-4-03) to conduct



short term static water level measurements. The monitoring wells were 50 mm PVC standpipes with 1.5 m screen, and were backfilled in the upper part with sand and bentonite.

Upon completion of drilling, all boreholes drilled on land were backfilled with a mixture of auger cuttings, and sealed at the top with bentonite in accordance with the MTO guidelines and Ministry of Environment, Conservation and Parks (MOECP) O.Reg. 903 for borehole abandonment. The boreholes in the lake were grouted with cement and sealed with bentonite to a depth of about 1 m.

Surveying of the as-drilled borehole locations was conducted by Callon Dietz Inc. (Callon Dietz) of Sudbury, Ontario under contract to GHD. In the lake in Area 4, surveying of boreholes was carried out during drilling, once the boat was tied and stabilized. Callon Dietz provided coordinates in MTM NAD 83 Northing and Easting. The coordinates shown on borehole logs and any part of this report correspond to these northings and eastings. All elevations given in this report are geodetic.

### **3.2 Laboratory Program**

Geotechnical laboratory testing was performed at GHD's laboratory located in Whitby, Ontario. The laboratory program consisted of moisture content, Atterberg Limits and grain size analyses. For this assignment, moisture content tests were carried out on all samples collected from all boreholes. Atterberg Limits tests were conducted on two (2) samples, and gradation analyses (sieve and hydrometer) were performed on thirty two (32) representative soil samples.

Table 3.2 provides a summary of the laboratory program carried out for this project.

All routine laboratory tests were conducted in accordance with MTO procedures, which follow American Society for Testing Materials (ASTM) standards. The results of the moisture content, Atterberg Limits tests and gradation analyses are provided on the corresponding borehole logs provided in Appendix B. The results of the Atterberg Limits tests and gradation analyses are also presented graphically on plasticity charts and gradation curves given in Appendix C.

In addition to routine soil laboratory tests, a total of three (3) unconfined compressive strength (UCS) tests were conducted on rock cores collected from boreholes drilled in Area 1, Area 3 and Area 4. The UCS test results are provided on corresponding borehole logs and also given in Appendix D.



**Table 3.2 - Laboratory Analysis Program**

Location	Borehole No.	Sample No.	Depth <sup>1</sup> (m)	Type of Laboratory Test			
Area 1	BH-19-1-01	SS3	1.5 - 2.1			Hydrometer	
	BH -19-1-01	SS4	2.3 – 3.1		Sieve		
	BH-19-1-02	SS6	4.5 – 5.0			Hydrometer	
	BH -19-1-03	SS8	5.4 - 5.9		Sieve		
	BH -19-1-03	SS9	6.1 - 6.7		Sieve		
	BH -19-1-03	SS10	7.7 - 7.9		Sieve		
	BH -19-1-04	SS4	2.3 - 2.9		Sieve		
	BH -19-1-04	SS5	3 - 3.7		Sieve		
	BH-19-1-05	SS1	0.2 - 0.8			Hydrometer	
	BH -19-1-06	SS1	0.2 – 0.8			Hydrometer	
	BH-19-1-06	SS2	0.8 - 1.4			Hydrometer	
Area 2	BH -19-2-01	SS1	0 - 0.3		Sieve		
	BH-19-2-02	SS1	0 – 0.6		Sieve		
		SS2	0.6 - 1.1			Hydrometer	
		Rock Core	4.4 – 4.6				UCS
	BH-19-2-03	SS4	3 - 3.7	Atterberg Limit		Hydrometer	
		SS5	3.8 - 4.4			Hydrometer	
Area 3	BH-19-3-01	SS5	3.1 – 3.6	Atterberg Limit			
	BH-19-3-01	SS6	3.8 - 4.4			Hydrometer	
	BH-19-3-02	SS3	1.5 - 2.1			Hydrometer	
	BH-19-3-03	SS2	0.8 - 1.4			Hydrometer	
	BH -19-3-03	SS4	2.3 - 2.5		Sieve		
	BH -19-3-04	SS2	3.8 - 4.4		Sieve		
	BH-19-3-04	SS3	4.6 - 5.2		Sieve		
	BH-19-3-04	Rock Core	5.9 – 6.2				UCS
	BH-19-3-05	SS1	0.2 - 0.8			Hydrometer	
	BH -19-3-05	SS2	0.8 - 1.2		Sieve		
Area 4	BH-19-4-02	SS6	6.6 - 7.2			Hydrometer	
		Rock Core	7.6 – 7.8				UCS
	BH-19-4-03	SS3	1.5 - 2.1			Hydrometer	
		SS4	2.3 - 2.5			Hydrometer	
	BH-19-4-04	SS1	0.2 - 0.8			Hydrometer	
	BH-19-4-04	SS3	7.6 – 8.2		Sieve		
	BH-19-4-04	SS4	9.1 – 9.7		Sieve		
Area 7	BH-19-7-03	SS1	1.1 - 1.4			Hydrometer	
	BH-19-7-05	SS1	0.4 - 0.7			Hydrometer	

Note 1: Depth Below Grade (m) or Drilling Platform





## **4. Regional Physiography and Geology**

Based on publicly available geological reports and maps, the project areas lie in the Superior Province of the Canadian Shield. The Superior Province is divided into various regionally extensive sub-provinces. The project areas are located in the Wawa sub-province. The physiography is represented by the Wawa-Abitibi Terrane. Topography in the region is generally rugged and hilly, and is strongly controlled by the nature of the underlying bedrock. Topographic highs correspond to bedrock outcrops resistant to weathering and erosion. Weak rocks and recent materials gave rise to lower elevations.

The bedrock geology is composed predominantly of irregularly distributed Archean greenstone belts (Michipicoten, Gamitagama, and Mishibishu) surrounded by granitic bodies of various compositions and sizes, with smaller mafic intrusive rocks locally present. The Michipicoten greenstone belt is a structurally and stratigraphically complex assemblage of volcanic, sedimentary and intrusive rocks, metamorphosed to greenschist facies and localized amphibolite facies. Relative to smaller greenstone belts, the grade of metamorphism in the Michipicoten greenstone belt was low.

Most parts of the project areas are rocky and consisted of gently dipping rock outcrops. The rocks are characterized by well-developed white and dark bands of minerals, foliations, and discontinuous quartz veins. Northwest and northeast trending Faults are common in the region. In addition, the metasedimentary and metavolcanic rocks are locally intruded by a series of diabase dykes.

Any existing overburden in the region consists of a thin layer of discontinuous glaciolacustrine deposits and recent organic, alluvial and fluvial materials. Glaciofluvial outwash deposits are confined in topographically low areas along bedrock valleys. In all project areas, the main overburden materials encountered above the bedrocks, were mainly peat and sand and gravel deposits.

## **5. Subsurface Conditions**

Details of the subsurface conditions encountered at the project areas are graphically presented on individual soil strata profiles provided on Drawings 2 to 5 in Enclosure 1, and on the logs in Appendix B. The profiles represent a transition from one soil type to another along the lines of cross sections, and should not be inferred to represent an exact plane of geological or stratigraphic change, as the subsurface and groundwater conditions may vary between and beyond the borehole locations.

The following sections provide descriptions of the major soil strata, and subsurface and groundwater conditions encountered at Area 1, Area 2, Area 3, Area 4 and Area 7.

### **5.1 Area 1**

The subsurface investigation in Area 1 involved drilling four (4) boreholes (BH-19-1-01, BH-19-1-02, BH-19-2-03 and BH-19-2-04) close to the toe of the road embankment. An additional two (2) boreholes (BH-19-1-05 and BH-19-1-06) were also completed through the embankment. In summary, the stratigraphy along the toe of the embankment consisted of 0.2 m to 5.3 m thick peat, underlain by layers of silty sand, sand and gravel, and sandy gravel materials. The thickness of the granular materials beneath the peat ranged from 0.7 m to 2.8 m. Following the granular materials, a greenstone bedrock was encountered. At the road embankment, an asphalt layer was underlain by granular fill of



sand and gravel. The fill was underlain by 1.4 m to 2.1 m thick rock fill consisting blasted and smaller size rocks. A bedrock was encountered beneath the rock fill. The following sections provide the descriptions of the soil, rock and groundwater conditions encountered in Area 1.

### **5.1.1 Peat**

A layer of peat was encountered in BH-19-1-01, BH-19-1-02, BH-19-1-03 and BH-19-1-04. Peat is normally formed from the remains of grasses, sedges and bog mosses. The peat was dark brown in color, amorphous and spongy, and wet. In BH-19-1-02, sandy fractions were visible in retrieved samples and the peat was described as amorphous to sandy peat. The thickness of the peat ranged from 0.6 m in BH-19-1-02 to 5.3 m in BH-19-1-03, suggesting the presence of a thicker organic deposit in the southeastern part of the road embankment, extending to El. 431.9 m.

The moisture content of samples of the peat ranged from 170% to 724%. High moisture content values were obtained in samples taken from the lower portion of BH-19-1-03.

### **5.1.2 Silty Sand**

A silty sand layer with varying amounts of silt was encountered below the peat in BH-19-1-01. The silty sand contained some gravel, cobbles and organic matter, was dark brown in color and wet. The thickness of this silty sand was 0.7 m, extending to El. 433.9 m.

The SPT "N"-value within this layer was 34 blows/300 mm, suggesting the presence of "dense" soil.

The moisture content of the silty sand deposit was 25%.

### **5.1.3 Sand with Gravel /Sand and Gravel/ Sandy Gravel**

A layer of sand with gravel was encountered in BH-19-1-01 at a depth of 0.2 m, and extended to the full depth of investigation of 3.7 m (El. 431.6 m). In BH-19-1-02 and BH-19-1-03, the layer was encountered beneath the peat, and was described to be sand and gravel. The gravel proportion increased further in BH-19-1-04 and the layer was described as sandy gravel. In all boreholes, the layer consisted of trace silt, trace clay and cobbles, and was brown to grey in color and wet. The thickness of this layer ranged from 1.4 m in BH-19-1-04 to 3.8 m in BH-19-1-02.

The SPT "N"-values in the sand with gravel /sand and gravel/ sandy gravel layer ranged from 15 blows/300 mm to greater than 100 blows/300 mm, indicating a "compact" to "very dense" state of relative density. In BH-19-1-02, drilling in the upper part of the sand and gravel layer was found to be difficult because of the presence of a higher proportion of gravel and cobbles.

The moisture content tests carried out on samples yielded values ranging from 5% to 35%. High values of moisture content were obtained from samples taken in the upper part of BH-19-1-03.

The sieve analyses of samples taken from BH-19-1-01, BH-19-1-03, and BH-19-1-04 indicated a composition of 23% - 88% gravel, 12% - 68% sand, and 0% - 9% fines (silt and clay). Hydrometer analysis of a sample from BH-19-1-01 resulted in 30% of gravel, 57% of sand, 11% of silt, and 2% of clay. The grain size distribution curves are provided on Fig. No. GSA-1-1 in Appendix C.



#### **5.1.4 Sand with Silt**

A sand with silt deposit consisting of trace gravel and trace clay was encountered in BH-19-1-02 beneath the sand and gravel layer. This deposit was grey in color, wet and had a thickness of 0.6 m.

The SPT “N”-value within the sand with silt deposit was documented to be more than 100 blows/300 mm, and the deposit was described to be “very dense”.

The moisture content of a sample of the silty sand was 17%.

A grainsize analysis of a sample of the silty sand resulted in a composition of 9% gravel, 66% sand, 23% silt and 2% clay. The grain size distribution curve is given on Fig. No. GSA-1-2 in Appendix C.

#### **5.1.5 Asphalt**

A layer of asphalt was encountered in BH-19-1-05 and BH-19-1-06 drilled through the embankment of Highway 17. The asphalt thickness at borehole locations ranged from 200 mm to 230 mm.

#### **5.1.6 Fill**

A fill material was encountered beneath the asphalt layer. The fill consisted of sand with gravel to sand and gravel, with trace silt and trace clay. Cobbles and a higher proportion of gravel were also encountered in the upper part of the fill. The fill was brown in color and was dry to moist at the time of drilling. The thickness of the granular fill ranged from 0.6 m to 1.2 m, extending to El. 440.5 m.

The SPT “N” values within the fill were in the range of 18 blows/300 mm to 37 blows/300 mm, indicating a “compact” to “dense” in-situ state of relative density. Because of the higher proportion of gravel, the SPT “N” values in the upper part of the fill were higher than in the lower part.

Moisture content tests conducted on samples of the fill gave values from 4% to 13%. The high moisture content values correspond to the lower part of the fill with an increased amount of silt.

The grainsize analyses of representative samples from BH-19-1-05 and BH-19-1-06 resulted in a composition of 28% - 48% gravel, 48% - 61% sand, 7% - 10% silt, and 1% - 2% clay. The grain size distribution curves are given on Fig. No. GSA-1-3 in Appendix C.

#### **5.1.7 Rock Fill**

A rock fill was encountered beneath the granular fill in BH-19-1-05 and BH-19-1-06. Because of difficult drilling conditions and auger grinding, the casing was inserted through the rock fill without sampling and in-situ testing. Generally, field observations indicated that the embankment fill consisted of all sizes of rocks including blasted rocks obtained from the surrounding outcrops. The thickness of the rock fill ranged from 1.4 m in BH-19-1-06 to 2.1 m in BH-19-1-05, extending to El. 438.3 m.

No samples were retrieved from the rock fill for laboratory testing.

#### **5.1.8 Bedrock**

Rock outcrops are present both on the southwest and southeast ends of the road embankment. The presence of a bedrock was confirmed through diamond coring in BH-19-1-02 and BH-19-1-04. The bedrock was encountered at a depth of 5.0 m (El. 431.2 m) in BH-19-1-02 and 3.7 m (El. 438.3 m) in



BH-19-1-04, and coring was carried out to a depth of 8.3 m (El. 427.9 m) and 6.8 m (El. 430.9 m), respectively. A bedrock was also encountered in BH-19-1-05 advanced through the road embankment. The depth of the bedrock in this borehole was 2.9 m (El. 438.3 m), and rock coring was carried out for a total length of 3 m, or up to the depth of 5.9 m (El. 435.3 m).

The bedrock encountered in all three boreholes was described to be Greenstone. It was dark green to black in color, fine to medium grained, weakly to moderately foliated, and consisted of quartz and plagioclase crystals in a fine matrix of dark minerals. The rock cores were slightly weathered and moderately to well fractured, and were medium to hard (based on geological hammer and knife test).

Measured Core Recovery (REC) was 88% to 100% in BH-19-1-02, 100% in BH-19-1-04, and 99% to 100% in BH-19-1-05. The corresponding Rock Quality Designation (RQD) ranged from 51% to 85% in BH-19-1-02, 88% to 96% in BH-19-1-04, and 72% to 73% in BH-19-1-05. Based on the RQD values, the rock mass quality was described to be “fair” to “excellent”.

Photo 19 to Photo 21 given in Appendix D, show the rock cores from BH-19-1-02, BH-19-1-04 and BH-19-1-05. The corresponding rock core descriptions are provided in Table D1 in Appendix D.

#### **5.1.9 Groundwater**

Groundwater was encountered in BH-19-1-02, BH-19-1-03 and BH-19-1-04 during drilling. The depth of the groundwater level in these boreholes upon completion of drilling varied from 0.15 m to 0.38 m. The level of groundwater was also measured in a well installed in BH-19-1-01 on October 2, 2019, 27 days after the completion of the borehole. The results indicated a static water level of 1.5 m.

It should be noted that the depth of the groundwater level and its gradient of flow in the area may be influenced by the placement of the road embankment, the surrounding landscape, the rock outcrops, underlying geology, and the water levels in creeks, local lakes and marshy grounds, and may fluctuate because of seasonal changes, periods of precipitation, and temperature. As such, the groundwater level may differ at any time throughout the year and during construction.

Groundwater data is presented on individual borehole logs provided in Appendix B.

### **5.2 Area 2**

The subsurface investigation in Area 2 involved three (3) boreholes (BH-19-2-01, BH-19-2-02, and BH-19-2-03) completed close to the toe of the road embankment. Based on the borehole information, the subsurface in the southwestern part of the road embankment consisted of sand with gravel, and gravelly sand materials with traces of organic topsoil. In the southeastern part of the embankment, a peat was encountered beneath the ground surface followed by layers of silt and silty sand materials. The granular materials are underlain by a greenstone bedrock. The following sections provide the descriptions of soils, rocks and groundwater conditions encountered in Area 2.

#### **5.2.1 Peat**

A layer of peat was encountered at the top of the subsurface in BH-19-2-03 drilled in the southeastern part of the embankment. The peat was dark brown in color and wet. In the top part, undecomposed large pieces of wood as well as trace sand and gravel were observed. In the lower part, the peat became amorphous and spongy and was extremely wet. The thickness of the peat was 3 m.



The moisture content of samples of the peat ranged from 47% to 617%. High moisture content values were obtained in samples taken from the lower portion of BH-19-2-03.

### **5.2.2 Gravelly Sand / Sand with Gravel**

A layer of gravelly sand and sand with gravel was encountered immediately beneath the ground surface in BH-19-2-01 and BH-19-2-02. The gravelly sand consisted of some topsoil, trace organic matter, and trace to some fines. In the lower portion of BH-19-2-02, the proportion of gravel increased, and the layer was described as sand and gravel. The gravelly sand was dark brown to brown in color and wet. Its thickness ranged from 0.3 m in BH-19-2-01 to 1.4 m in BH-19-2-02.

The SPT “N” values within the gravelly sand or sand with gravel was in the range of 3 blows/300 m to more than 100 blows/300 m, indicating a “loose” to “very dense” relative density.

Moisture content tests carried out on retrieved samples yielded 43% to 92%.

The sieve analyses indicated a composition of 26% - 28% gravel, 61% - 70% sand, and 4% - 11% fines. The grain size distribution curve is given on Fig. No. GSA-2-1 in Appendix C.

### **5.2.3 Silt**

A layer of silt consisting of trace gravel, trace sand, trace clay, and organic matter was encountered in BH-19-2-03 beneath the peat deposit. The silt was grey in color, wet, and had a thickness of 0.8 m, extending to the depth of 3.8 m (El. 442.8 m).

The SPT “N”-value was 1 blows/300 mm, and the deposit was described to be “very soft”.

The moisture content of a sample of the silt was reported to be 91%.

An Atterberg Limit test performed on this silt yielded negligible liquid limit, indicating that the soil is non-plastic. A hydrometer test on the same sample resulted in a composition of 1% gravel, 7% sand, 89% silt and 3% clay. The grain size distribution curve is given on Fig. No. GSA-2-2 in Appendix C.

### **5.2.4 Sand with Silt**

A sand with silt deposit was encountered underneath the silt layer in BH-19-2-03. The silty sand consisted of trace to some gravel, trace clay, and was dark brown in color and wet. The thickness of this silty sand deposit was 1.5 m, extending to the depth of 5.3 m (El. 441.2 m) in BH-19-2-03.

The SPT “N”-values ranged from 12 blows/300 mm to as high as 100 blows/300 mm, suggesting “compact” to “very dense” soil relative density.

The moisture content test of retrieved samples resulted in 18.7% to 28.4%.

The grainsize analysis of a sample taken at a depth of 4 m (El. 442.5 m) from BH-19-2-03, yielded a composition of 10% gravel, 61% sand, 27% silt, and 2% clay. The corresponding grain size distribution curve is presented on Fig. No. GSA-2-3 in Appendix C.

### **5.2.5 Bedrock**

Rock outcrops are present both on the southwest and southeast ends of the road embankment. The existence of a bedrock was confirmed through diamond coring in BH-19-2-01 and BH-19-2-02. The



bedrock was encountered at a depth of 0.3 m (El. 447.0 m) in BH-19-2-01 and 1.4 m (El. 444.8 m) in BH-19-2-02. Coring was done for a length of 3.4 m in BH-19-2-01 (to El. 443.7 m). In BH-19-2-02, rock coring extended for a length of 3.6 m or to the depth of 5 m (El. 441.3 m).

The bedrock encountered in the two boreholes was described to be Greenstone, and was the same as the type of rock exposed at road cuts and surface exposures in the area. It was dark green to black in color, fine to medium grained, weakly to moderately foliated, and consisted of quartz and plagioclase crystals in a fine matrix of dark minerals. The rock cores were slightly weathered and moderately to highly fractured, and were medium to hard (based on geological hammer and knife test).

Measured Core Recovery (REC) in BH-19-2-01 ranged from 98% to 100%. In BH-19-2-02, the REC was in the range of 93% to 100%. The Rock Quality Designation (RQD) values ranged from 67% to 81% in BH-19-2-01, and 33% to 90% in BH-19-2-02. Based on the RQD values, the quality of the rock mass near BH-19-2-01 was described to be “fair” to “excellent”, while the quality of the rock mass around BH-19-2-02 was “poor” to “good”. Especially, the core run corresponding to the upper part of the bedrock in BH-19-2-02 was highly fractured, and indicated a “very poor” rock mass quality.

A UCS test was conducted on a rock core taken at a depth of 4.4 m (El. 441.9 m) from BH-19-2-02. The results of the USC test indicated a compressive strength of 199.3 MPa.

Photo 22 and Photo 23 in Appendix D, show the rock cores from BH-19-2-01 and BH-19-2-02. The rock core descriptions (Table D2) and details of the USC test are also given in Appendix D.

### **5.2.6 Groundwater**

Groundwater was encountered in BH-19-2-02 during drilling. The depth of the groundwater level in this borehole upon completion of drilling was 0.15 m. The groundwater level was also measured in a monitoring well installed in BH-19-2-03 on October 2, 2019, about 3 days after the completion of the borehole. The results indicated a stabilized water level of 0.9 m.

It should be noted that the depth of the groundwater level and its gradient of flow in the area may be influenced by the placement of the road embankment, the surrounding landscape, the rock outcrops, underlying geology, and the water levels in creeks, local lakes and marshy grounds, and may fluctuate because of seasonal changes, periods of precipitation, and temperature. As such, the groundwater level may differ at any time throughout the year and during construction.

Groundwater data is presented on individual borehole logs provided in Appendix B.

## **5.3 Area 3**

The subsurface investigation in Area 3 involved drilling three (3) boreholes (BH-19-3-01, BH-19-3-02, and BH-19-3-03) close to the toe, and two boreholes (BH-19-3-04 and BH-19-3-05) through the road embankment. Based on the information from these boreholes, the subsurface in the southwestern part of the embankment consisted of peat, silty clay and sand. In the southeastern part, a 1.5 m silty sand with gravel was encountered beneath the ground surface followed by gravelly sand materials. At the road, the asphalt layer was underlain by a fill composed of sand and gravel (sandy gravel). Beneath the granular fill, the embankment is composed of rock fill. Both the granular materials at the toe and the rock fill at the embankment are underlain by a greenstone bedrock. The following sections provide the descriptions of soils, rocks and groundwater conditions encountered in Area 3.





### **5.3.1 Peat**

A layer of peat was encountered in BH-19-3-01 and BH-19-1-02 immediately below the ground surface. The peat was dark brown in color, amorphous and spongy, and wet. The thickness of the peat ranged from 1.4 m in BH-19-3-02 to 3 m in BH-19-3-01.

The moisture content of samples of the peat ranged from 148% to 588%. High moisture content values were obtained in samples taken from the lower portion of BH-19-3-01.

### **5.3.2 Silty Clay**

A silty clay deposit was encountered underneath the peat in BH-19-3-01. The silty clay contained organic matter, and was grey in color and wet. The thickness of this deposit was 0.7 m, extending to the depth of 3.7 m (El. 456.5 m).

The SPT "N"-value within the silty clay deposit was negligible or "Weight of the Hammer (WH)" suggesting a "very soft" soil consistency.

The moisture content of the silty clay deposit was 144%.

Atterberg Limit tests performed on a sample of the silty clay gave a liquid limit of 64 and a plastic limit of 53, resulting in a plasticity index of 11. The results of these tests are reported on the Unified Soil Classification System plasticity chart presented on Fig. No. PC-3-1 in Appendix C. Based on the results, the deposit may be classified as organic silty clay of high compressibility (OH).

### **5.3.3 Sand with Gravel**

A layer of sand with gravel was encountered in BH-19-3-01, at a depth of 3.7 m (El. 456.5 m), and extending to the full depth of investigation of 5.0 m (El. 455.7 m). The sand layer consisted of some silt and trace clay, and was grey in color and wet.

The SPT "N"-value in the upper part this deposit was 10 blows/300 mm, indicating "compact" state of relative density.

The moisture content of a retrieved sample from this deposit was 12.7%.

The grainsize analysis of the same sample gave rise a composition of 21% gravel, 62% sand, 16% silt and 1% clay. The grain size distribution curve is given on Fig. No. GSA-3-1 in Appendix C.

### **5.3.4 Silty Sand with Gravel**

A silty sand with gravel deposit was encountered underneath the peat in BH-19-3-02 and immediately below the ground surface in BH-19-3-03. The deposit consisted of trace clay and organic matter, and was dark grey in color and wet. Its thickness ranged from 0.9 m in BH-19-3-02 to 1.5 m in BH-19-3-03, extending to the depth of 2.3 m (El. 457.3 m) and 1.5 m (El. 458.6 m), respectively.

The SPT "N"-values within the silty sand ranged from 4 blows/300 mm to 18 blows/300 mm, suggesting "very loose" to "compact" soil relative density.

The moisture content of samples from the silty sand was in the range of 14.6% to 23%.



The grainsize analyses of representative samples taken from both BH-19-3-02 and BH-19-3-03, resulted in a composition of 23% - 25% gravel, 46% - 49% sand, 24% - 30% silt, and 1% - 2% clay. The corresponding grain size distribution curve is presented on Fig. No. GSA-3-2 in Appendix C.

### **5.3.5 Gravelly Sand**

A layer of gravelly sand was encountered beneath the silty sand in BH-19-3-03. The gravelly sand consisted of trace fines, and was dark brown in color and wet. Its thickness was 1 m, extending to the full depth of investigation of 2.5 m (El. 457.7 m).

The SPT “N” values within this layer ranged from 17 blows/300 m to as high as 100 blows/300 m, indicating a “compact” to “very dense” relative density.

Moisture content tests carried out on retrieved samples yielded 26% to 103%.

The sieve analysis of a representative sample yielded a composition of 36% gravel, 57% sand, and 7% fines. The grain size distribution curve is given on Fig. No. GSA-3-3 in Appendix C.

### **5.3.6 Asphalt**

A layer of asphalt was encountered in BH-19-3-04 and BH-19-3-05 drilled through the road embankment. The asphalt thickness at borehole locations was 180 mm.

### **5.3.7 Fill**

A fill material was encountered beneath the asphalt layer. The fill consisted of gravelly sand to sand and gravel, with some silt, trace clay and cobbles. It was brown to grey in color and was dry to moist. The thickness of the fill ranged from 0.8 m to 1 m, extending to El. 463.4 m.

The SPT “N” values within the fill were in the range of 21 blows/300 mm to 46 blows/300 mm, indicating a “compact” to “dense” in-situ state of relative density.

Moisture content tests conducted on samples of the fill gave values from 4% to 7%.

The grainsize analyses of samples from BH-19-3-05 resulted in a composition of 33% - 72% gravel, 24% - 53% sand, 11% silt, and 3% clay. The corresponding grain size distribution curves are presented on Fig. No. GSA-3-4 in Appendix C.

### **5.3.8 Rock Fill**

A rock fill was encountered beneath the granular fill in BH-19-3-04 and BH-19-3-05. No sampling and in-situ testing was conducted in the rock fill. Generally, field observations indicated that the rock fill consisted of all sizes of rocks including blasted rocks from the surrounding outcrops. The thickness of the rock fill ranged from 3.0 m in BH-19-3-04 to 3.1 m in BH-19-3-05, extending to El. 460.3 m.

No samples were retrieved from the rock fill for laboratory testing.

### **5.3.9 Bedrock**

Rock outcrops are present both on the southwest and southeast ends of the road embankment. The presence of bedrock was confirmed through diamond coring in BH-19-3-02 and BH-19-3-04. The



bedrock was encountered at a depth of 2.3 m (El. 457.3 m) in BH-19-3-02 and 5.8 m (El. 458.5 m) in BH-19-3-04. Coring was carried out for a length 3.4 m in BH-19-3-02 (El. 453.9 m). In BH-19-3-04, the rock coring extended for a length of 3.3 m or to the depth of 9.1 m (El. 455.2 m). A bedrock was also encountered in BH-19-3-05 at a depth of 4.3 m (El. 460.3 m), although the rock coring in this borehole was limited to 1.8 m and couldn't be used to confirm the presence of bedrock.

The bedrock encountered in all boreholes was described to be Greenstone. It was dark green to black in color, fine to medium grained, weakly to moderately foliated, and consisted of quartz and plagioclase crystals in a fine matrix of dark minerals. The rock cores were slightly weathered and moderately to highly fractured, and were medium to hard (based on geological hammer and knife test).

Measured Core Recovery (REC) was 100% both in BH-19-3-02 and BH-19-3-04, indicating less degree of weathering. The RQD values in BH-19-3-02 ranged from 83% to 100%. In BH-19-3-04, the RQD values were between 68% and 90%. Based on the RQD values, the quality of the rock mass near BH-19-3-02 was described to be "good" to "excellent", while the quality of the rock mass beneath the road embankment or around BH-19-3-04 was "fair" to "good".

A UCS test was conducted on a rock core taken at a depth of 5.9 m (El. 458.6 m) from BH-19-3-04. The results of the USC test indicated a compressive strength of 78.6 MPa.

Photo 24 and Photo 25 in Appendix D, show the rock cores from BH-19-3-02 and BH-19-3-04. The rock core descriptions (Table D3) and details of the USC test are also given in Appendix D.

#### **5.3.10 Groundwater**

Groundwater was encountered in BH-19-3-01 and BH-19-3-02 during drilling. The depth of the groundwater level in these boreholes upon completion of drilling was 0.15 m. The groundwater level was also measured in a monitoring well installed in BH-19-3-03 on October 2, 2019, about 4 days after the completion of the borehole. The results indicated a stabilized water level of 1.3 m.

It should be noted that the depth of the groundwater level and its gradient of flow in the area may be influenced by the placement of the road embankment, the surrounding landscape, the rock outcrops, underlying geology, and the water levels in creeks, local lakes and marshy grounds, and may fluctuate because of seasonal changes, periods of precipitation, and temperature. As such, the groundwater level may differ at any time throughout the year and during construction.

Groundwater data is presented on individual borehole logs provided in Appendix B.

### **5.4 Area 4**

The subsurface investigation in Area 4 involved two (2) boreholes (BH-19-4-01 and BH-19-4-02) in the lake, one (1) borehole (BH-19-4-03) close to the toe, and one (1) borehole (BH-19-3-04) at the road embankment. Based on the information from the boreholes, the subsurface in the lake consisted of a peat layer underlain by silt, sandy silt and gravelly sand deposits. In the northeast part, a 1.4 m peat was encountered followed by silty sand and sandy silt deposits. At the road, the asphalt layer was underlain by a fill composed of gravelly sand. Beneath the fill, the embankment is composed of rock fill. The lower part of the stratigraphy consisted of a greenstone bedrock. The following sections provide the descriptions of soils, rocks and groundwater conditions encountered in the area.



#### **5.4.1 Peat**

A layer of peat was encountered immediately below the lake bottom in BH-19-4-02 and the ground surface in BH-19-1-03. The peat was dark brown in color, amorphous and spongy, and wet. The thickness of the peat ranged from 4.1 m in BH-19-3-02 to 1.4 m in BH-19-3-03.

The moisture content of samples of the peat ranged from 107% to 233%. High moisture content values were obtained in samples taken from the lower portion of BH-19-4-02.

#### **5.4.2 Silty Sand to Sandy Silt**

A layer of silty sand to sandy silt consisting of trace to some gravel and trace clay was encountered in BH-19-4-03 beneath the peat deposit. The sandy silt deposit with organic matter was also encountered immediately below the lake bottom in BH-19-4-01. The silty sand to sandy silt layer was dark brown to grey in color and wet. Its thickness in BH-19-4-01 was 0.5 m, extending to the full depth of investigation of 1.8 m from the top of the drilling platform (El. 449.5 m). In BH-19-4-03, the silty sand was 1.1 m thick, extending to the depth of 2.5 m (El. 449.6 m).

The SPT “N”-values within this deposit in BH-19-4-03 ranged from 23 blows/300 mm to over 100 blows/300 mm, and the deposit was described to be “compact” to “very dense”.

The moisture contents of samples of the silty sand ranged from 12% to 16%.

The grainsize analyses of samples taken from BH-19-4-03, yielded a composition of 10% - 25% gravel, 39% sand, 34% - 43% silt, and 2% clay. The corresponding grain size distribution curve is presented on Fig. No. GSA-4-1 in Appendix C.

#### **5.4.3 Silt**

A silt deposit was encountered underneath the peat in BH-19-4-02. The silt consisted of some sand, trace clay, and organic matter, and was dark brown in color and wet. The thickness of this silt deposit was 0.8 m, extending to the depth of 7.2 m from the drilling platform (El. 444.2 m).

The SPT “N”-value within this deposit was 7 blows/300 mm, suggesting “loose” soil relative density.

The moisture content of a retrieved sample was 89%.

The grainsize analysis of the same sample gave rise a composition of 0% gravel, 11% sand, 84% silt and 5% clay. The grain size distribution curve is shown on Fig. No. GSA-4-2 in Appendix C.

#### **5.4.4 Asphalt**

A layer of asphalt was encountered in BH-19-4-04 drilled through the embankment of Highway 17. The asphalt thickness at borehole location was 200 mm.

#### **5.4.5 Fill**

A fill material consisting of gravelly sand with trace to some silt, trace clay and trace cobbles was encountered beneath the asphalt layer. The fill was brown in color and dry. The thickness of the granular fill was 1.2 m, extending to El. 454.2 m.

The SPT “N” value within the fill was 72 blows/300 mm, indicating a “very dense” state of compaction.



Moisture content tests conducted on a sample of the fill yielded 4.5%.

The grainsize analysis of the same sample resulted in a composition of 32% gravel, 57% sand, 10% silt, and 1% clay. The grain size distribution curve is given on Fig. No. GSA-4-3 in Appendix C.

#### **5.4.6 Rock Fill**

A rock fill was encountered beneath the granular fill in BH-19-4-01. Because of difficult drilling conditions and auger grinding, the casing was inserted through the rock fill without sampling and in-situ testing. Generally, field observations indicated that the embankment fill consisted of all sizes of rocks including blasted rocks obtained from the surrounding outcrops. The thickness of the rock fill was 5.3 m, extending to the depth of 6.7 m from the top of the asphalt layer (El. 448.9 m).

No samples were retrieved from the rock fill for laboratory testing.

#### **5.4.7 Sandy Gravel to Gravel**

A layer of sandy gravel to gravel was encountered beneath the rock fill in BH-19-4-04. The sandy gravel to gravel layer consisted of cobbles, and was dark brown in color and moist. Trace organic matter was also obtained in the upper part of this layer, immediately beneath the rock fill. Its thickness was 4.6 m, extending to the depth of 11.3 m (El. 444.3 m).

The SPT "N" values within this layer ranged from 13 blows/300 m to as high as 100 blows/300 m, indicating a "compact" to "very dense" relative density.

Moisture content values of samples ranged from negligible to 8.6%.

The sieve analyses of samples yielded 66% - 99% gravel, 1% - 30% sand, and 0% - 4% fines. The grain size distribution curves are presented on Fig. No. GSA-4-4 in Appendix C.

#### **5.4.8 Bedrock**

Rock outcrops are present both on the northwest and northeast ends of the road embankment or the lake shore. The presence of bedrock was confirmed through diamond coring in BH-19-4-02. The bedrock was encountered at a depth of 7.2 m from the drilling platform (El. 444.2 m). Rock coring in this borehole was carried out for a length 3.6 m (El. 440.5 m). A highly fractured bedrock was also encountered in BH-19-4-04 at a depth of 11.3 m (El. 444.3 m), although the rock coring in this borehole was limited to 1.8 m and could not be used to confirm the presence of a bedrock.

The bedrock encountered in BH-19-4-02 was described to be Greenstone. It was dark green to black in color, fine to medium grained, weakly to moderately foliated, and consisted of quartz and plagioclase crystals in a fine matrix of dark minerals. The rock cores were slightly weathered and moderately to highly fractured, and were medium to hard (based on geological hammer and knife test).

Measured Core Recovery (REC) in BH-19-4-02 was 100%. The corresponding RQD values were computed to be between 87% and 100%. Based on the RQD values, the quality of the rock mass in the lake near BH-19-3-02 was described to be "good" to "excellent".

A UCS test was conducted on a rock core taken at a depth of 7.6 m (El. 443.7 m) from BH-19-4-02. The results of the USC test indicated a compressive strength of 119.5 MPa.



Photo 26 in Appendix D, show the rock cores from BH-19-4-02. The corresponding rock core descriptions (Table D4) and details of the USC test are also given in Appendix D.

#### **5.4.9 Groundwater**

The lake level was at El. 450.8 both in BH-19-4-01 and BH-19-4-02. A monitoring well was installed in BH-19-4-03 to measure stabilized groundwater level. The groundwater level measured in this well on October 2, 2019, 2 days after the completion of the borehole, showed a water level at a depth of 0.8 m (El. 450.7 m), slightly lower than the elevation of the water surface in the lake.

It should be noted that the depth of the groundwater level and its gradient of flow in the area may be influenced by the placement of the road embankment, the surrounding landscape, the rock outcrops, underlying geology, and the water levels in creeks, local lakes and marshy grounds, and may fluctuate because of seasonal changes, periods of precipitation, and temperature. As such, the groundwater level may differ at any time throughout the year and during construction.

Groundwater data is presented on individual borehole logs provided in Appendix B.

### **5.5 Area 7**

The subsurface investigation in Area 7 involved completing five (5) hand auger holes (HA-19-7-01, HA-19-7-02, HA-19-7-03, HA-19-7-04, and HA-19-7-05) close to the toe of the road embankment to confirm the depth of the bedrock surface. The hand augers were advanced to a maximum depth of 1.9 m (El. 418.6 m). No coring was carried out in Area 7 to confirm the presence of bedrock. The subsurface within the depth of investigation consisted of a peat and topsoil underlain by sandy silt, and sand and gravel. All hand augers reached refusal on probable bedrock. The following sections provide the descriptions of soils and groundwater conditions in the area.

#### **5.5.1 Peat / Topsoil**

A layer of peat was encountered immediately below the ground surface. In HA-19-7-01, a topsoil was encountered below the ground surface. The peat was dark brown in color, amorphous and spongy, and wet. The thickness of the peat ranged from 0.2 m in HA-19-7-05 to 0.9 m in HA-19-7-03, extending to El. 419.6 m. The topsoil in HA-19-7-01 was 0.1 m thick. The topsoil consisted of some sand and trace gravel, and organic matter, and was dark brown in color and wet.

#### **5.5.2 Sandy Silt / Silt with Sand**

A layer of sandy silt /silt with sand/ consisting of trace to some gravel and trace clay was encountered beneath the peat or topsoil deposits. The sandy silt / silt with sand layer was brown to grey in color and moist to wet. Its thickness ranged from 0.2 m in HA-19-7-01 to 0.7 m in HA-19-04.

The moisture contents of auger (grab) samples of the sandy silt ranged from 30% to 36%.

The grainsize analyses of samples taken from HA-19-7-03 and HA-19-7-05, yielded a composition of 17% - 21% gravel, 11% - 25% sand, 54% - 64% silt, and 4% clay. The corresponding grain size distribution curve is presented on Fig. No. GSA-7-1 in Appendix C.





### **5.5.3 Sand and Gravel**

A layer of sand and gravel was encountered beneath the sandy silt. The sand and gravel layer consisted of cobbles, trace fines, and was brown to grey in color and moist to wet. It thickness ranged from 0.3 m to 0.5 m, extending to the depth of 1.9 m in HA-19-7-03 (El. 418.6 m).

### **5.5.4 Groundwater**

Groundwater was observed during the fieldwork. The depth of the groundwater level upon completion of the hand augers was observed to vary from 0.3 m to 0.5 m.

Groundwater data is presented on individual logs provided in Appendix B.



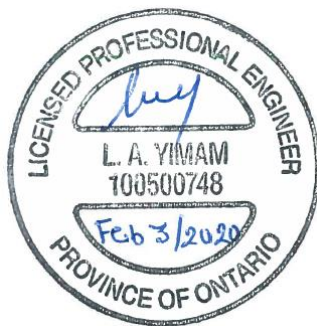

## 6. Closure

The fieldwork was supervised by Mr. Joe Lin, Mr. Jun Wang and Mr. Moe Nasir under the direction of Mr. Lul Yimam, PhD. P.Eng. The drilling equipment were supplied and operated by Tetry Environmental Drilling of Timmins, Ontario and Marathon Underground Constructors Corp. of Greely, Ontario. Routine laboratory tests of soil samples were conducted at the GHD laboratory in Whitby, Ontario. Complex laboratory tests of rock cores were carried out at GHD's MTO accredited High Complexity material testing laboratory in Waterloo, Ontario. Surveying of the as-drilled borehole locations was conducted by Callon Dietz Inc. (Callon Dietz) of Sudbury, Ontario.

This report was prepared by Mr. Lul Yimam, PhD, P.Eng., Senior Geotechnical/Foundation Engineer and MTO Key Personnel. Mr. Nyle McIlveen, P.Eng. conducted an independent review of the report.

Sincerely,

GHD



Lul Yimam, PhD., P. Eng.

Project Manager and Senior Geotechnical/Foundation Engineer  
MTO Key Personnel



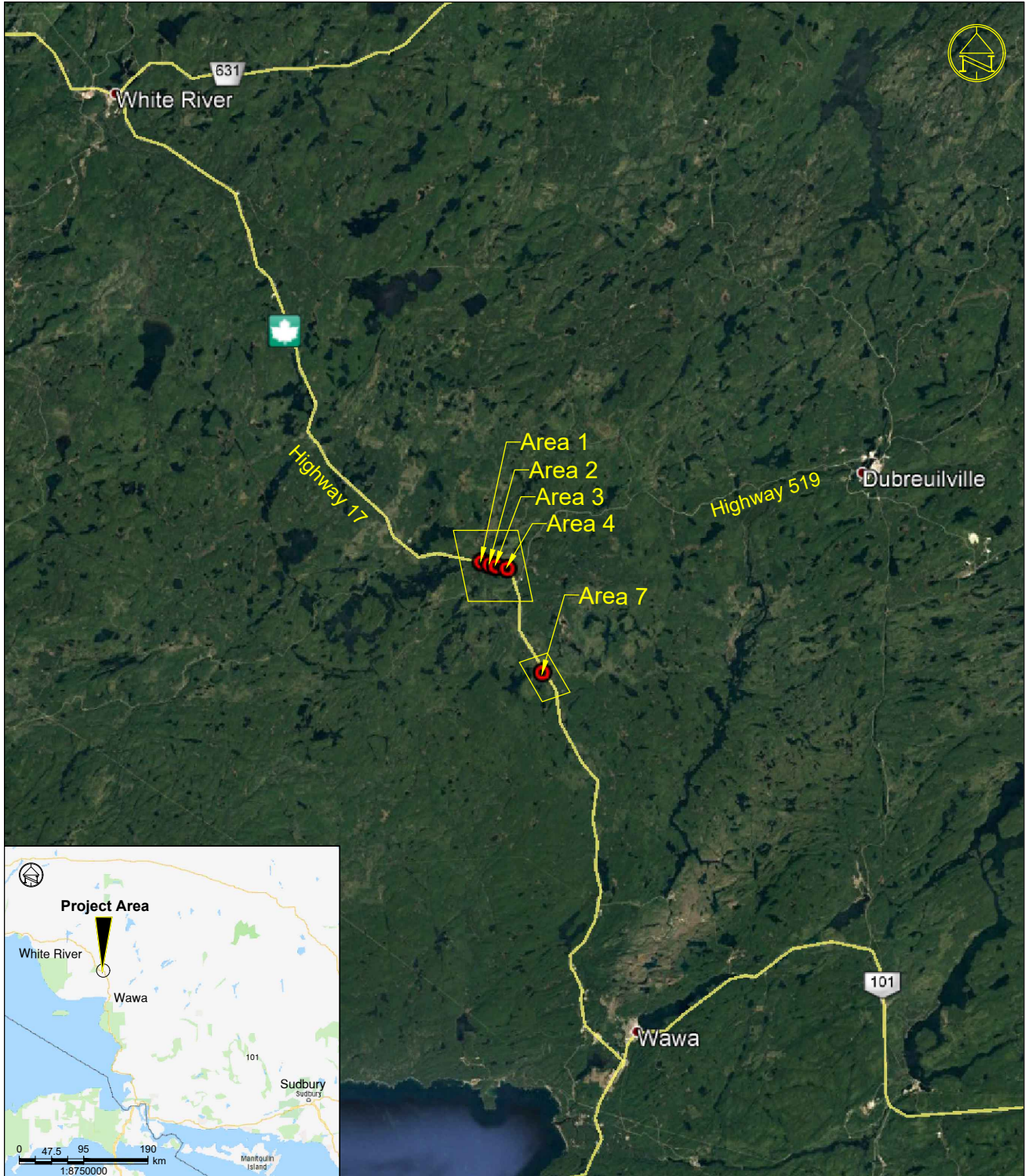
Nyle McIlveen, P.Eng.

Principal



# **Enclosure 1**

## **Site Plan, Borehole Location Plan, and Soil Strata**



LEGEND:  Project Area

REFERENCE: Google Earth Pro 7.3.2.5776

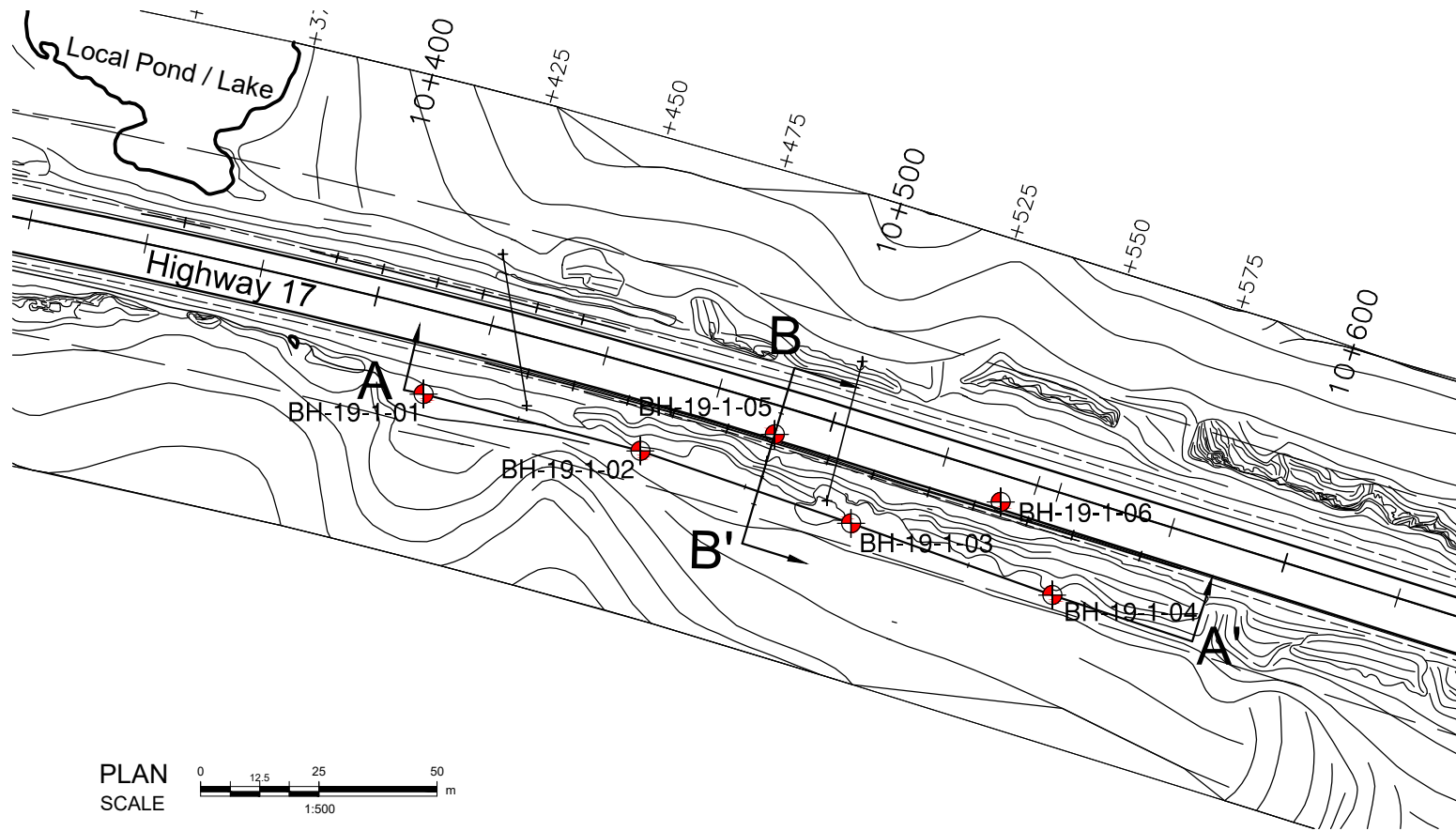
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GWP:	5031-18-00	Hwy No.: 17
Township:	Dambrossio & Lalibert	
District:	Algoma	
Drawn:	AW	Project No.: 11185012 (500)
Checked:	LY	Date: 2020.01.17
Reviewed:	LY	Revision:
Approved:	NM	Drawing: 1



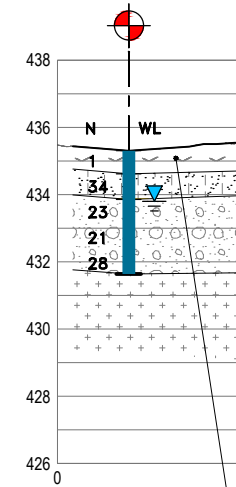
## Site Plan

Foundation Investigation and Design  
Hwy 17 Widening, Between White River and Wawa





BH-19-1-01  
Sta. 10+415, 17.6 Rt of CL



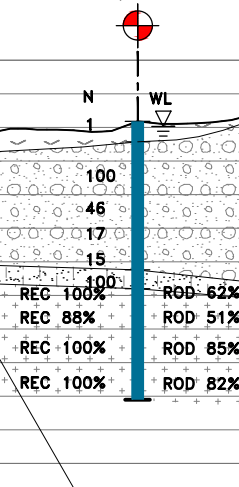
PEAT, Amorphous, Dark Brown, Wet, Very Loose

Silty Sand, Some Gravel, Trace Organic Matter, Cobbles, Dark Brown, Wet, Dense

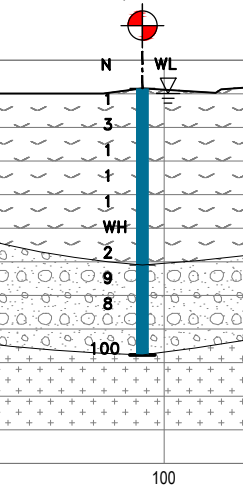
Sand With Gravel to Sand and Gravel, Trace Silt, Trace Clay, Cobbles, Grey, Wet, Compact

Sand With Silt, Trace Gravel, Trace Clay, Grey, Wet, Very Dense

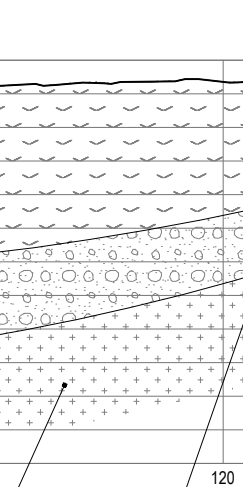
BH-19-1-02  
Sta. 10+463, 17.3 Rt of CL



BH-19-1-03  
Sta. 10+510, 19.3 Rt of CL



BH-19-1-04  
Sta. 10+555, 21.1 Rt of CL



BEDROCK, Greenstone

Gravel to Sandy Gravel, Trace Fines, Cobbles, Brown to Grey, Wet, Compact

PEAT, Amorphous, Wood Fibers, Dark Brown, Wet, Very Loose

PROFILE B-B'  
SCALE

HORIZONTAL 0 2.5 5 10 m

VERTICAL 0 1.25 2.5 5 m

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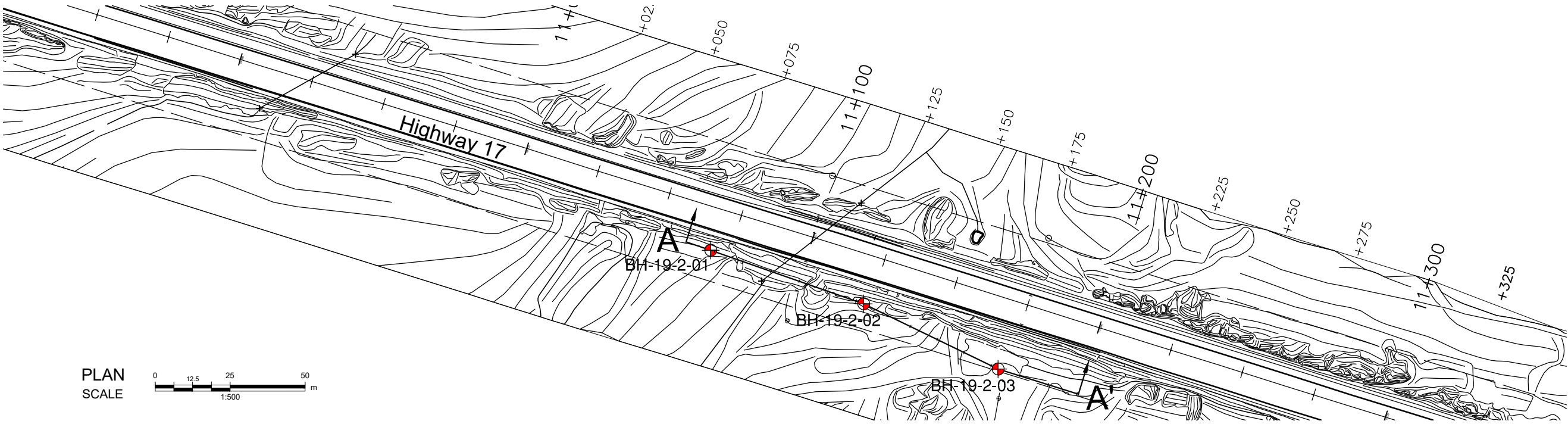
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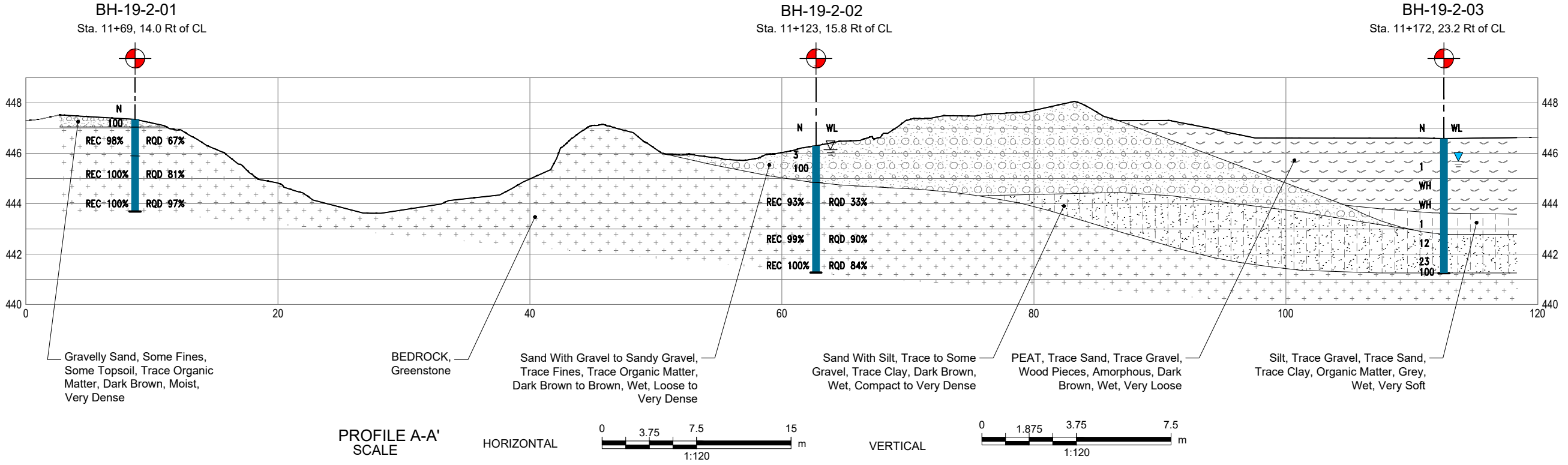
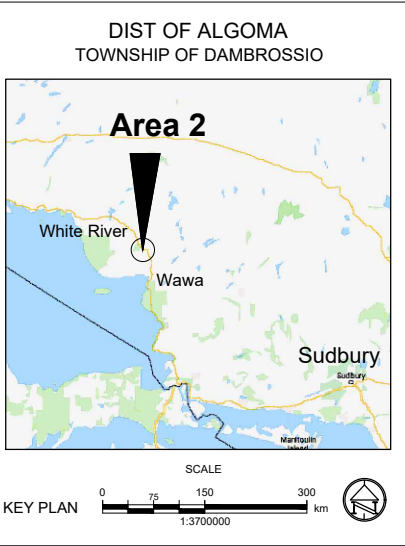
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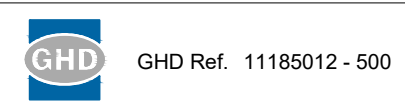
CONT No.: Agreement No.: 5017-E-0043 Work Item No.: 5 G.W.P. No.: 5031-18-00	
Borehole Location Plan and Soil Strata	Sheet



**LEGEND**

- Borehole
- Water Level (WL) Measured
- Water Level (WL) Observed

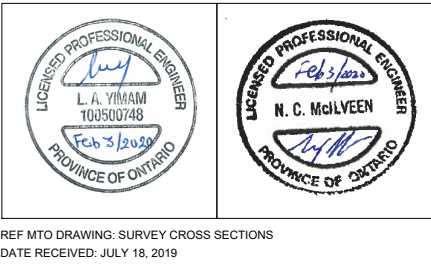
BH No.	Northing (m)	Easting (m)	Elevation (m)
BH-19-2-01	5350884.3	237201.2	447.3
BH-19-2-02	5350866.4	237252.2	446.3
BH-19-2-03	5350844.7	237297.0	446.6



**-Notes-**

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

- NOTES:**
- THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF THE REPORT AND RECORD OF BOREHOLE LOGS.
  - THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
  - DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

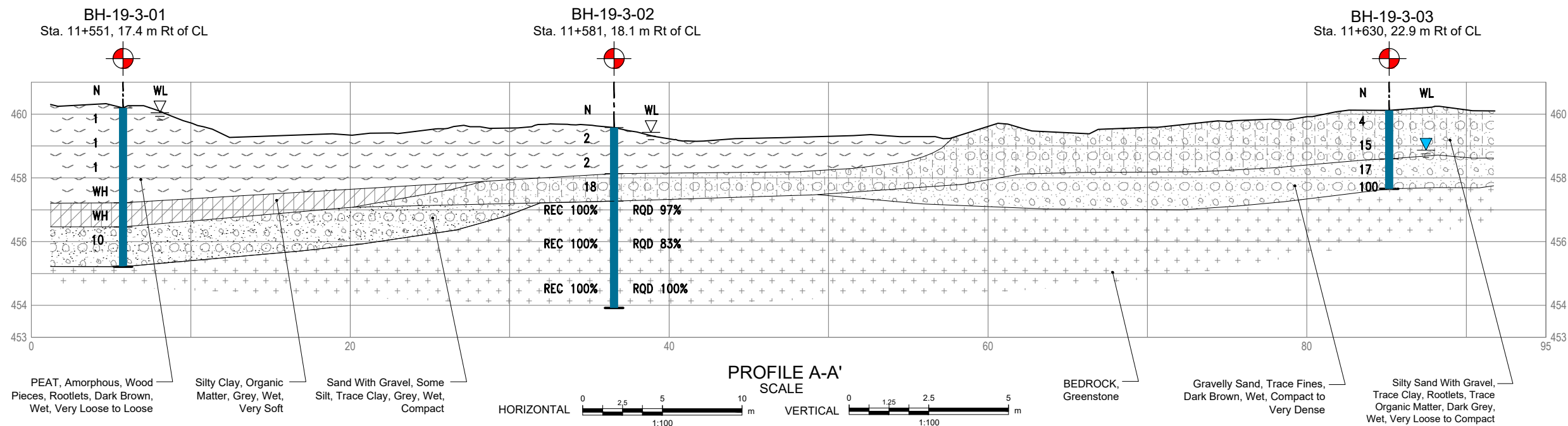
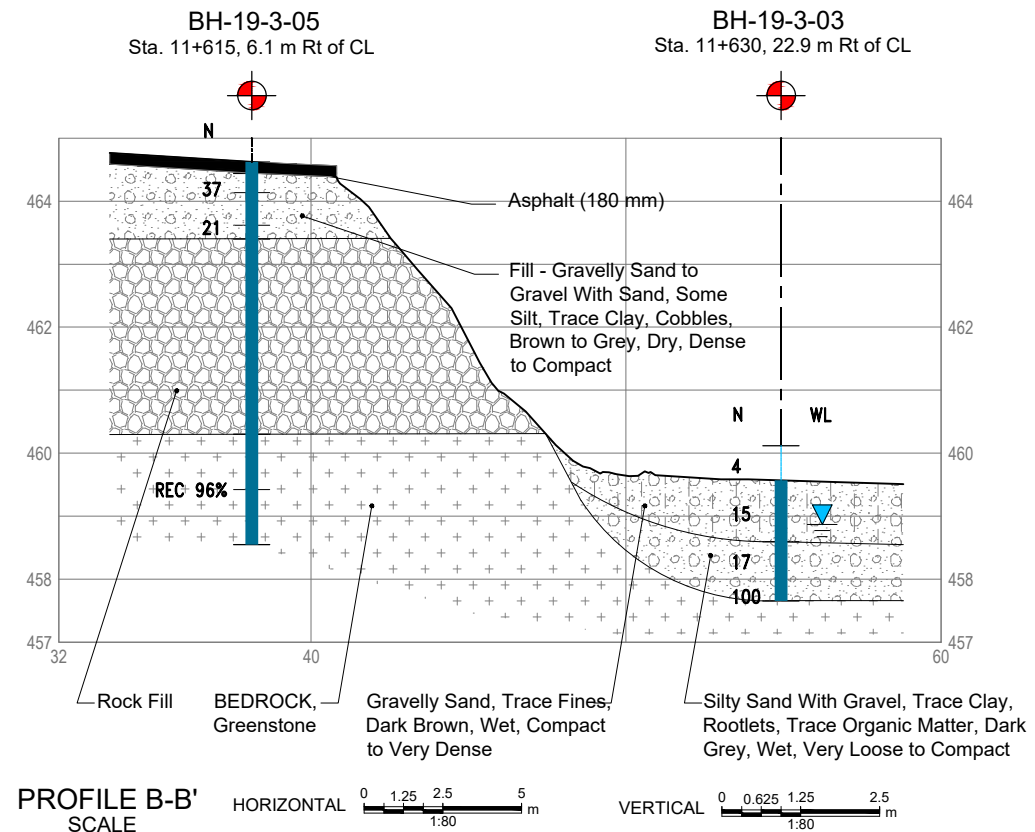
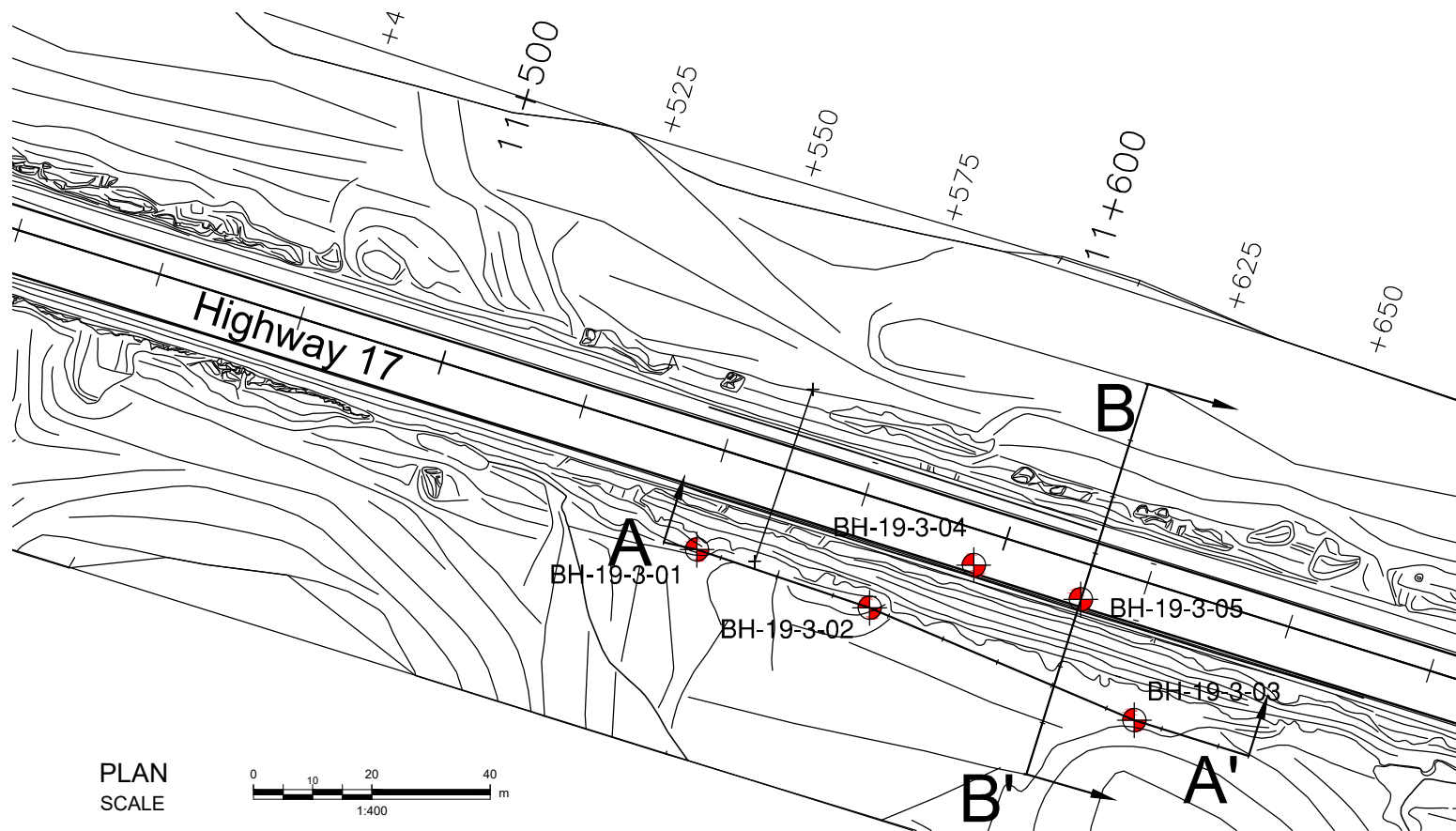


REVISIONS	DATE	BY	DESCRIPTION

GEOCRES No.: 42C-047

SUBM'D:	LY	HWY No.:	17	DATE:	2020.02.03
DRAWN:	AW	DIST:	Algoma	DWG:	3
CHECKED:	LY	SITE:	Area 2		
APPROVED:	NM				





NOTES:

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF THE REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

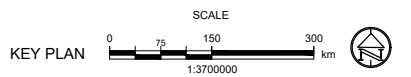
CONT No.:  
Agreement No.: 5017-E-0043  
Work Item No.: 5  
G.W.P. No.: 5031-18-00



Borehole Location Plan  
and Soil Strata

Sheet

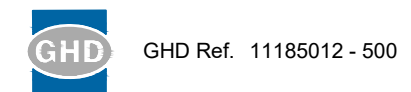
DIST OF ALGOMA  
TOWNSHIP OF DAMBROSSIO



LEGEND

- Borehole
- Water Level (WL) Measured
- Water Level (WL) Observed

BH No.	Northing (m)	Easting (m)	Elevation (m)
BH-19-3-01	5350737.6	237660.3	460.2
BH-19-3-02	5350727.8	237689.4	459.6
BH-19-3-03	5350708.8	237734.2	460.1
BH-19-3-04	5350735.0	237707.0	464.3
BH-19-3-05	5350729.2	237725.2	464.6



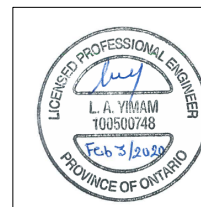
-Notes-

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

REVISIONS	DATE	BY	DESCRIPTION

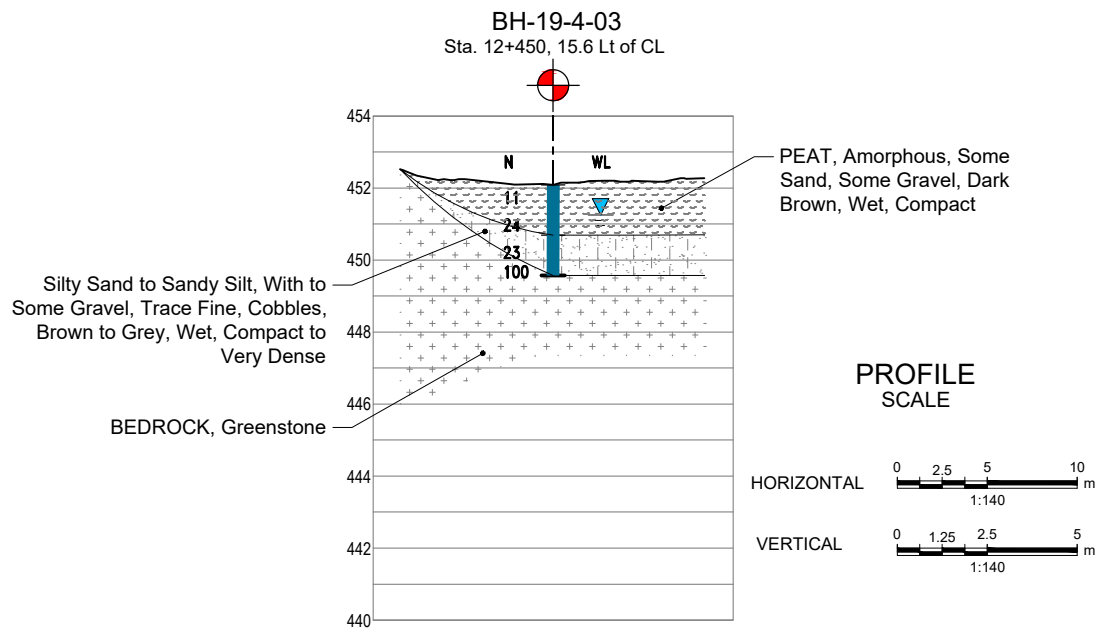
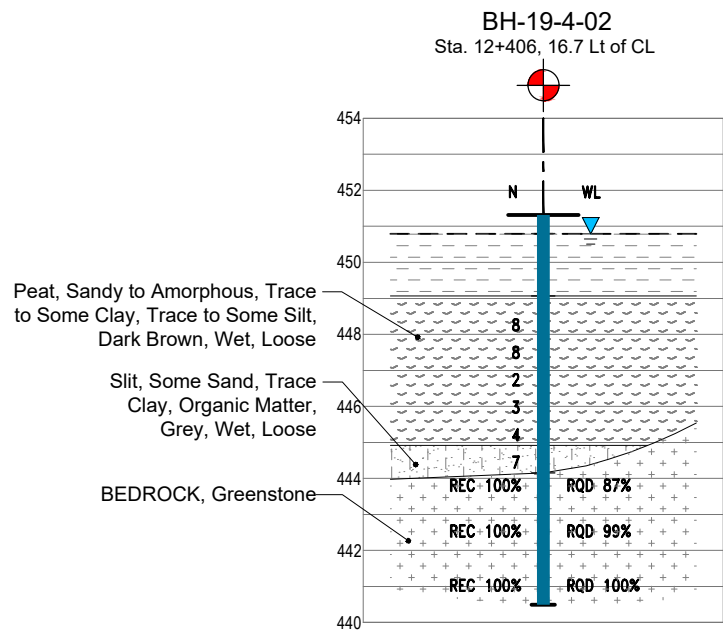
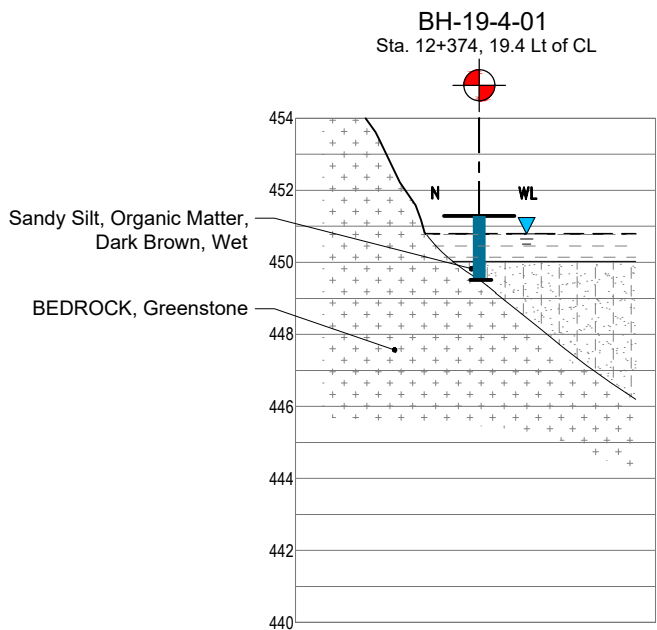
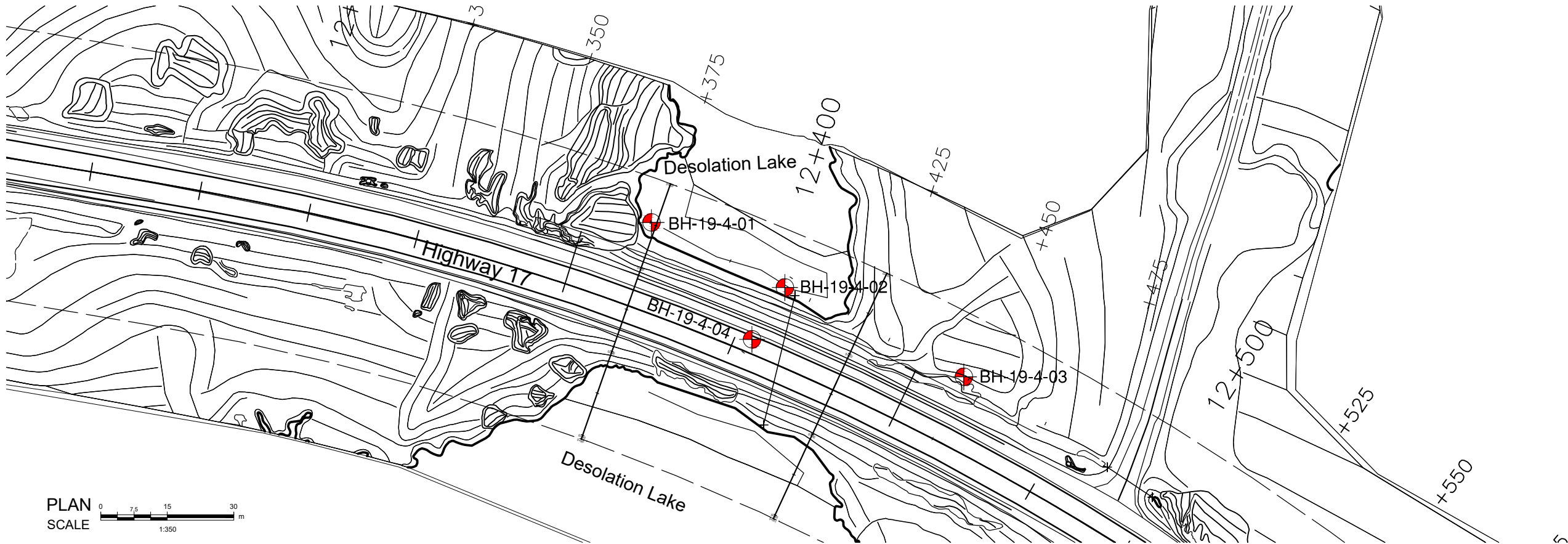
GEORES No.: 42C-047

SUBMD:	LY	HWY No.:	17	DATE:	2020.02.03
DRAWN:	AW	DIST:	Algoma	DWG:	4
CHECKED:	LY	SITE:	Area 3		
APPROVED:	NM				



REF MTO DRAWING: SURVEY CROSS SECTIONS  
DATE RECEIVED: JULY 18, 2019

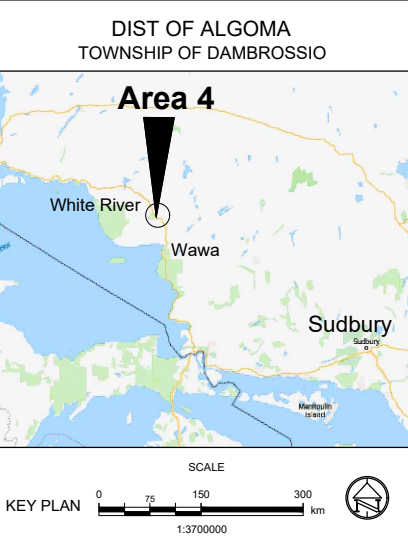




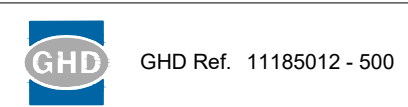
**NOTES:**

1. THIS DRAWING SHOULD BE READ IN CONJUNCTION WITH THE TEXT OF THE REPORT AND RECORD OF BOREHOLE LOGS.
2. THIS DRAWING IS FOR SUBSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.
3. DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN. STATIONS ARE IN KILOMETRES AND METRES.

CONT No.: Agreement No.: 5017-E-0043 Work Item No.: 5 G.W.P. No.: 5031-18-00	
Borehole Location Plan and Soil Strata	Sheet



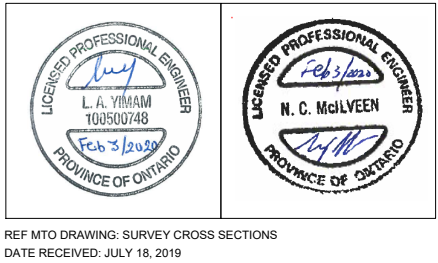
LEGEND			
	Borehole		
	Water Level (WL) Measured		
	Water Level (WL) Observed		
BH No.	Northing (m)	Easting (m)	Elevation (m)
BH-19-4-01	5350576.1	238469.6	450.0
BH-19-4-02	5350561.4	238499.7	449.1
BH-19-4-03	5350541.3	238540.1	452.1
BH-19-4-04	5350549.7	238492.3	455.6



**-Notes-**

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

REVISIONS					
DATE	BY	DESCRIPTION			
GEOCRES No.: 42C-047					
SUBMD:	LY	HWY No.:	17	DATE:	2020.02.03
DRAWN:	AW	DIST:	Algoma	DWG:	5
CHECKED:	LY	SITE:	Area 4		
APPROVED:	NM				



REF MTO DRAWING: SURVEY CROSS SECTIONS  
DATE RECEIVED: JULY 18, 2019



**Notes:**

1. DIMENSIONS ARE IN METERS/OR MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS ARE IN KILOMETRES AND METERS.

CONT No.:  
Agreement No.: 5017-E-0043  
Work Item No.: 5  
G.W.P. No.: 5031-18-00



Borehole Location Plan  
and Soil Strata

Sheet

DIST OF ALGOMA  
TOWNSHIP OF LALIBERT



KEY PLAN  
SCALE  
0 100 200 300  
1:5700000

**LEGEND**



Augerhole

BH No.	Northing (m)	Easting (m)	Elevation (m)
AH-19-7-01	5343192.6	240876.9	424.0
AH-19-7-02	5343177.4	240886.8	421.5
AH-19-7-03	5343167.7	240891.1	420.5
AH-19-7-04	5343157.7	240897.4	421.6
AH-19-7-05	5343145.7	240906.8	420.6



GHD Ref. 11185012 - 500

**-Notes-**

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

REVISIONS			
	DATE	BY	DESCRIPTION
GEOCRE No.: 42C-047			
SUBMD:	LY	HWY No.:	17
DRAWN:	AW	DIST:	Algoma
CHECKED:	LY	SITE:	Area 7
APPROVED:	NM		
DATE:	2020.02.03	DWG:	6



# **Appendix A**

## **Site Photographs**





**Photo 1 – Highway 17 - Area 1 Access Preparation - Looking West**



**Photo 2 – Highway 17 – Area 2 Access Preparation – Looking West**





**Photo 3 – Highway 17 - Area 3 Site Condition - Looking West**



**Photo 4 – Highway 17 – Area 4 Site Conditions - Looking East**





**Photo 5 – Highway 17 – Area 7 Site Conditions - Looking West**



**Photo 6 – Highway 17 - Area 1 – Drilling at BH-19-1-01 - Looking West**





**Photo 7 – Highway 17 - Area 1 – Drilling at BH-19-1-03 - Looking West**



**Photo 8 – Highway 17 - Area 1 – Drilling at BH-19-1-04**





**Photo 9 – Highway 17 - Area 2 – Drilling at BH-19-2-02**



**Photo 10 – Highway 17 - Area 2 – Drilling Setup at BH-19-2-03**





**Photo 11 – Highway 17 - Area 3 – Drilling Setup at BH-19-3-03**



**Photo 12 – Highway 17 - Area 3 – Drilling at BH-19-3-05 – Looking West**





**Photo 13 – Highway 17 - Area 4 – Boat Unloading and Setup – Looking East**



**Photo 14 – Highway 17 - Area 4 – Drilling Setup at BH-19-4-01 – Looking East**





**Photo 15 – Highway 17 - Area 4 – Drilling at BH-19-4-02**



**Photo 16 – Highway 17 - Area 4 – Drilling at BH-19-4-03**





**Photo 17 – Highway 17 - Area 4 – Drilling at BH-19-4-04 – Looking West**



**Photo 18 – Highway 17 - Area 7 – Hand Auger**



## **Appendix B**

### **Borehole Logs**



## Notes on Borehole and Test Pit Reports

### Soil Description:

Each subsurface stratum is described using the following terminology. The relative density of granular soils is determined by the Standard Penetration Index ("N" value), while the consistency of clayey soils is measured by the value of undrained shear strength ( $C_u$ ).

Soil Classification			
Clay (CL)	< 0.002 mm		
Silt (SI)	0.002 to 0.075 mm		
Sand (SA)	0.075 to 4.75 mm	fine	0.075 to 0.425 mm
		medium	0.425 to 2.0 mm
		coarse	2.0 to 4.75 mm
Gravel (GR)	4.75 to 75 mm	fine	4.75 to 19 mm
		coarse	19 to 75 mm
Cobbles	75 to 300 mm		
Boulders	> 300 mm		

Terminology	
"trace"	1-10%
"some"	10-20%
"with"	20-30%
adjective (silty, sandy)	30-40%
"and"	40-50%

Relative Density of Granular Soils	Standard Penetration Index "N" Value (Blows/ft - 300 mm)
Very Loose	0-4
Loose	5-9
Compact	10-29
Dense	30-50
Very Dense	>50

Consistency of Cohesive Soils	Undrained Shear Strength ( $C_u$ ) (kPa)	(P.S.F.)	"N" Value
Very Soft	<12	<250	0-2
Soft	12-25	250-500	3-4
Firm	25-50	500-1000	5-8
Stiff	50-100	1000-2000	9-15
Very Stiff	100-200	2000-4000	16-30
Hard	>200	>4000	>30

Field Moisture Conditions	
Dry	No signs of moisture, dusty and dry to touch
Moist	Damp but no visible water
Wet	Visible free water, soil may be below the groundwater table

Rock Quality Designation	
"RQD" (%) Value	Quality
<25	Very Poor
25-50	Poor
50-75	Fair
75-90	Good
>90	Excellent

### Samples and Symbols:

The type of sample recovered is shown on the log by the abbreviation listed below.

SS: Split Spoon	TW: Shelby Tube	AS: Auger Sample
GS: Grab Sample	WR: Weight of Rod	RC: Rock Core
NQ: Core Size	WH: Weight of Hammer	SSE, GSE, AGE: Environmental Sampling

### Recovery (REC)

The recovery, shown as a percentage, is the ratio of length of the sample obtained to the distance the sampler was driven/pushed into the soil

### RQD

The "Rock Quality Designation" or "RQD" value, expressed as percentage, is the ratio of the total length of all core fragments of 4 inches (10 cm) or more to the total length of the run.

### IN-SITU Tests:

N: Standard Penetration Index	$N_c$ : Dynamic Cone Penetration Index	k: Permeability
VS: In-Situ Vane Shear Test	$C_u$ : Undrained Shear Strength	ABS: Absorption (Packer Test)

### Laboratory Tests:

$I_p$ : Plasticity Index	HA: Hydrometer Analysis	AL: Atterberg Limits	PC: Plasticity Chart
$W_L$ : Liquid Limit	GSA: Grain Size Analysis	w: Water Content	CT: Consolidation Test
$W_p$ : Plastic Limit	SA: Sieve Analysis	$\gamma$ : Unit Weight	UCS: Unconfined Compressive Strength

# RECORD OF BOREHOLE No BH-19-1-01

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Joe Lin  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.05 LATITUDE 48.29472605 LONGITUDE -84.91956688 CHECKED BY Lul Yimam

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)									
								20	40	60	80	100						20	40	60	
435.3	0.0	PEAT, Amorphous, Dark Brown, Wet, Very Loose	1	SS	1										490.9						
434.6	0.7	Silty Sand, Some Gravel, Trace Organic Matter, Cobbles, Dark Brown, Wet, Dense	2	SS	34								○								
433.9	1.4	Sand With Gravel, Trace Silt, Trace Clay, Cobbles, Grey, Wet, Compact	3	SS	23								○			30 57 11 2					
			4	SS	21								○			23 68 (9)					
			5	SS	28								○								
431.6	3.7	End of Borehole  Auger refusal on probable bedrock  ▼ Water Level measured in well / piezometre on 2019.10.02																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH-19-1-02

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Joe Lin  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.11 - 2019.09.12 LATITUDE 48.29462313 LONGITUDE -84.91894737 CHECKED BY Lul Yimam

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			w <sub>p</sub>	w	w <sub>L</sub>		
								○ UNCONFINED      + FIELD VANE	● QUICK TRIAXIAL      × LAB VANE	WATER CONTENT (%)					
436.2 0.0	Peat, Sandy to Amorphous, Dark Brown, Wet, Very Loose		1	SS	1	▽	436							176	
435.6 0.6	Sand and Gravel, Cobbles, Trace to Some Silt, Brown to Grey, Wet, Very Dense to Compact						435								
	-----  Cobbles, Very Dense  -----		2	SS	100+		434								
			3	SS	46		433								
			4	SS	17		432								
			5	SS	15		431								
431.8 4.4	Sand With Silt, Trace Gravel, Trace Clay, Grey, Wet, Very Dense		6	SS	100+		430								9 66 23 2
431.2 5.0	BEDROCK, Greenstone		1	NQ	REC 100%		429								RQD 62%
			2	NQ	REC 88%		430								RQD 51%
			3	NQ	REC 100%		428								RQD 85%
			4	NQ	REC 100%										RQD 82%
427.9 8.3	End of Borehole														
	▽ Water Level measured upon completion of drilling														

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

# RECORD OF BOREHOLE No BH-19-1-03

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Joe Lin  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.12 LATITUDE 48.29449011 LONGITUDE -84.91834494 CHECKED BY Lul Yimam

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w <sub>p</sub>	w	w <sub>L</sub>		GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																			
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437.2 0.0	PEAT, Sandy to Amorphous, Wood Pieces and Fibres, Dark Brown, Wet, Very Loose		1	SS	1		437																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO GDT 17/1/20



# RECORD OF BOREHOLE No BH-19-1-04

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Joe Lin  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.06 - 2019.09.11 LATITUDE 48.29435854 LONGITUDE -84.91776953 CHECKED BY Lul Yimam

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>P</sub> W                      W <sub>L</sub>				GR	SA	SI	CL																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
								○ UNCONFINED                      + FIELD VANE ● QUICK TRIAXIAL                      × LAB VANE	WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
437.7 0.0	PEAT, Amorphous, Wood Fibers, Dark Brown, Wet, Very Loose		1	SS	1		437																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

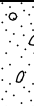
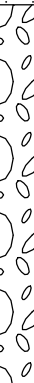

ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

# RECORD OF BOREHOLE No BH-19-1-05

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.24 LATITUDE 48.29465726 LONGITUDE -84.91856528 CHECKED BY Lul Yimam

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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)					
								○ UNCONFINED	+	FIELD VANE													
								● QUICK TRIAXIAL	×	LAB VANE													
441.3								20	40	60	80	100											
0.0	Asphalt (200 mm)																						
441.1																							
0.2	Fill - Sand With Gravel, Trace Silt, Trace Clay, Cobbles, Brown, Dry, Dense		1	SS	37													28 61 10 1					
440.5																							
0.8	Rock Fill																						
438.3																							
2.9	BEDROCK, Greenstone		1	NQ	REC 100%													RQD 73%					
								</															

+ <sup>3</sup>, × <sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


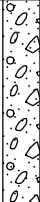

ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

RECORD OF BOREHOLE No BH-19-1-06

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing COMPILED BY Anne Wang  
DATUM Geodetic DATE 2019.09.24 LATITUDE 48.2945342 LONGITUDE -84.91791957 CHECKED BY Lul Yimam

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 (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100									
443.5																	
0.0	Asphalt (230 mm)																
443.3																	
0.2	Fill - Sand and Gravel, Trace Silt, Trace Clay, Rock Fragments, Brown to Grey, Dry to Moist, Dense to Compact		1	SS	34		443									48 48 (4)	
			2	SS	18											36 55 7 2	
442.1																	
1.4	Rock Fill						442										
							441										
440.7																	
2.8	<u>End of Borehole</u>  Casing refusal on Probable bedrock																

# RECORD OF BOREHOLE No BH-19-2-01

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.29 LATITUDE 48.29309826 LONGITUDE -84.91111033 CHECKED BY Lul Yimam

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT  $w_p$	NATURAL MOISTURE CONTENT  $w$	LIQUID LIMIT  $w_L$	UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
447.3							20	40	60	80	100						
0.0	Gravelly Sand, Some Fines, Some Topsoil, Trace Organic Matter, Dark Brown, Moist, Very Dense		1	SS	100+										o		28 61 (11)
447.0	BEDROCK, Greenstone		1	NQ	REC 98%												RQD 67%
0.3			2	NQ	REC 100%												RQD 81%
			3	NQ	REC 100%												RQD 97%
443.7	End of Borehole																
3.7																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH-19-2-02

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.28 LATITUDE 48.29294309 LONGITUDE -84.91042019 CHECKED BY Lul Yimam

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 (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										
								○ UNCONFINED      + FIELD VANE										
								● QUICK TRIAXIAL      × LAB VANE										
						20	40	60	80	100		20	40	60				
446.3	0.0	Sand With Gravel to Sandy Gravel, Trace Fines, Trace Organic Matter, Dark Brown to Brown, Wet, Loose to Very Dense		1	SS	3	▽	446								92.3	26 70 (4)	
				2	SS	100+		445								○	33 55 10 2	
444.8	1.4	BEDROCK, Greenstone		1	NQ	REC 93%		444									RQD 33%	
				2	NQ	REC 99%		443										RQD 90%
				3	NQ	REC 100%		442										
441.3	5.0	End of Borehole																
		▽ Water Level measured upon completion of drilling																

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No BH-19-2-03

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.29 LATITUDE 48.29275248 LONGITUDE -84.90981235 CHECKED BY Lul Yimam

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 ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE										WATER CONTENT (%)
446.6 0.0	PEAT, Trace Sand, Trace Gravel, Wood Pieces, Amorphous, Dark Brown, Wet, Very Loose						446											
			1	SS	1													
			2	SS	WH												617.2	
			3	SS	WH		444									136.5		
443.6 3.0	Silt, Trace Gravel, Trace Sand, Trace Clay, Organic Matter, Grey, Wet, Very Soft		4	SS	1		443									91.2	1 7 89 3	
442.8 3.8	Sand With Silt, Trace to Some Gravel, Trace Clay, Dark Brown, Wet, Compact to Very Dense		5	SS	12												10 61 27 2	
			6	SS	23		442											
441.2 5.3	End of Borehole		7	SS	100+													
	Auger refusal on probable bedrock  Sampling started at 0.75 m because of the presence pieces of undecomposed wood  ▼ Water Level measured in well / piezometre on 2019.10.02																	

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH-19-3-01

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.25 LATITUDE 48.29182823 LONGITUDE -84.90490031 CHECKED BY Lul Yimam

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 (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)				GR	SA	SI	CL
								20	40	60	80	100					20	40	60					
460.2	PEAT, Amorphous, Wood Pieces, Rootlets, Dark Brown, Wet, Very Loose to Loose		1	SS	1		460																	
0.0																								
			2	SS	1		459																	
			3	SS	1		458																	
			4	SS	WH																			
457.2	Silty Clay, Organic Matter, Grey, Wet, Very Soft						457																	
3.0			5	SS	WH																			
456.5	Sand With Gravel, Some Silt, Trace Clay, Grey, Wet, Compact																							
3.7			6	SS	10		456																	
455.2	<u>End of Borehole</u>  Auger refusal on probable bedrock  ▽ Water Level measured upon completion of drilling																							
5.0																								

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH-19-3-02

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.25 LATITUDE 48.2917428 LONGITUDE -84.90450538 CHECKED BY Lul Yimam

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 (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	20					40	60	80				
459.6 0.0	PEAT, Amorphous, Dark Brown, Wet, Very Loose		1	SS	2		459									147.9							
			2	SS	2																191.2		
458.1 1.4	Silty Sand With Gravel, Trace Clay, Organic Matter, Dark Grey, Wet, Compact		3	SS	18			458								○							23
457.3 2.3	BEDROCK, Greenstone		1	NQ	REC 100%		457											RQD 97%					
			2	NQ	REC 100%		456											RQD 83%					
			3	NQ	REC 100%		455											RQD 100%					
453.9 5.7	End of Borehole						454																
	Water Level observed upon completion of drilling																						

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH-19-3-03

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.28 LATITUDE 48.29157693 LONGITUDE -84.90389915 CHECKED BY Lul Yimam

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 (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa													
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE	WATER CONTENT (%)									
								20	40	60	80	100						20	40	60	
460.1	0.0	Silty Sand, With Gravel, Trace Clay, Rootlets, Trace Organic Matter, Dark Grey, Wet, Very Loose to Compact	1	SS	4																
			2	SS	15												25 49 24 2				
458.6	1.5	Gravelly Sand, Trace Fines, Dark Brown, Wet, Compact to Very Dense	3	SS	17																
			4	SS	100+										103.4	36 57 (7)					
457.7	2.5	End of Borehole																			
		Auger refusal on probable bedrock ▼ Water Level measured in well / piezometre on 2019.10.02																			

# RECORD OF BOREHOLE No BH-19-3-04

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.26 LATITUDE 48.29180965 LONGITUDE -84.90426936 CHECKED BY Lul Yimam

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		
464.3 0.0	Asphalt (180 mm)													
464.1 0.2	Fill - Sand and Gravel, Trace Fines, Cobbles, Brown to Grey, Dry to Moist, Dense		1	SS	46		464							
463.5 0.8	Rock Fill						463							
							462							
							461							
460.5 3.8	Sand and Gravel, Trace to Some Silt, Trace Clay, Dark Brown, Wet, Compact		2	SS	16		460							45 43 (12)
			3	SS	21		459							34 49 16 1
458.5 5.8	BEDROCK, Greenstone		1	NQ	REC 100%		458							RQD 90%
			2	NQ	REC 100%		457							RQD 78%
			3	NQ	REC 100%		456							RQD 68%
455.2 9.1	End of Borehole													

ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

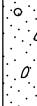




# RECORD OF BOREHOLE No BH-19-3-05

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.28 LATITUDE 48.29175957 LONGITUDE -84.90402415 CHECKED BY Lul Yimam

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										WATER CONTENT (%)		
								20 40 60 80 100										20 40 60		
464.6	Asphalt (180 mm)																			
0.0 464.4																				
0.2	Fill - Gravelly Sand to Gravel With Sand, Some Silt, Trace Clay, Cobbles, Brown to Grey, Dry, Dense to Compact		1	SS	37		464										33 53 11 3			
			2	SS	21												72 24 (4)			
463.4	Rock Fill						463													
1.2							462													
							461													
460.3	BEDROCK, Greenstone		1	NQ	REC 96%		460										RQD 42%			
4.3							459													
458.5	End of Borehole																			
6.1	Possible bedrock encountered at 4.32 m																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE


ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

# RECORD OF BOREHOLE No BH-19-4-01

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Moe Nasir  
 DIST Algoma HWY 17 BOREHOLE TYPE Solid Stem Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.10.03 LATITUDE 48.29046062 LONGITUDE -84.89396816 CHECKED BY Lul Yimam

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									
451.3 0.0	Top of Drilling Platform							20	40	60	80	100					
450.8 0.5	Water Surface					▼	451										
450.0 1.3	Lake Bottom Sandy Silt, Organic Matter, Dark Brown, Wet						450										
449.5 1.8	End of Borehole  Auger refusal on probable bedrock at 1.8 m below the top of drilling platform / boat deck  ▼ Lake Level / Water Surface																

# RECORD OF BOREHOLE No BH-19-4-02

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Moe Nasir  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.10.02 - 2019.10.03 LATITUDE 48.29033197 LONGITUDE -84.89356036 CHECKED BY Lul Yimam

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					w <sub>p</sub>	w	w <sub>L</sub>					
451.3	Top of Drilling Platform							20	40	60	80	100								
0.0																				
450.8	Water Surface																			
0.5																				
449.1	Lake Bottom																			
2.3	Peat, Sandy to Amorphous, Trace to Some Clay, Trace to Some Silt, Dark Brown, Wet, Loose																			
			1	SS	8															
			2	SS	8												155.9			
			3	SS	2												233.9			
			4	SS	3												224.8			
			5	SS	4															
444.9																				
6.4	Silt, Some Sand, Trace Clay, Organic Matter, Grey, Wet, Loose																			
			6	SS	7												89		0 11 84 5	
444.2																				
7.2	BEDROCK, Greenstone																			
			1	NQ	REC 100%														RQD 87%	
			2	NQ	REC 100%														RQD 99%	
			3	NQ	REC 100%														RQD 100%	
440.5																				
10.8	End of Borehole																			
	▼ Lake Level / Water Surface																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

# RECORD OF BOREHOLE No BH-19-4-03

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger COMPILED BY Anne Wang  
DATUM Geodetic DATE 2019.09.30 LATITUDE 48.29015524 LONGITUDE -84.89301315 CHECKED BY Lul Yimam

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									
452.1							20	40	60	80	100						
0.0	PEAT, Amorphous, Some Sand, Some Gravel, Dark Brown, Wet, Compact		1	SS	11		452									164.4	
			2	SS	24		451									107.3	
450.7	Silty Sand to Sandy Silt, With to Some Gravel, Trace Fine, Cobbles, Brown to Grey, Wet, Compact to Very Dense		3	SS	23		450						○				25 39 34 2
			4	SS	100+								○				16 39 43 2
449.6	<u>End of Borehole</u>																
2.5	Auger refusal on probable bedrock  ▼ Water Level measured in well / piezometre																



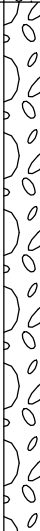
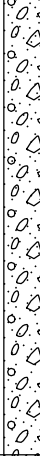


+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No BH-19-4-04

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hollow Stem Auger, and NW Casing + NQ Coring COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.10.01 LATITUDE 48.29022617 LONGITUDE -84.89365822 CHECKED BY Lul Yimam

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 (%)									
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			GR	SA	SI	CL			
								○ UNCONFINED      + FIELD VANE																		
								● QUICK TRIAXIAL      × LAB VANE																		
455.6							20	40	60	80	100															
455.0	Asphalt (200 mm)																									
0.2	Fill - Gravelly Sand, Some Silt, Trace Clay, Cobbles, Brown, Dry, Very Dense		1	SS	72													32	57	10	1					
454.2																										
1.4	Rock Fill		2	SS	100+																					
448.9																										
6.7	Sandy Gravel to Gravel, Cobbles, Trace Organic Matter, Dark Brown, Moist, Compact to Very Dense																									
			3	SS	31														66	30	(4)					
			4	SS	13														99	1	(0)					
			5	SS	100+																					
444.3																										
11.3	Bedrock, Greenstone		1	NQ	REC 60%																					
442.5																										
13.1	End of Borehole																									
	Possible bedrock encountered at 11.3 m (El. 444.3 m)																									
	Auger grinding from the depth of 6.7 m (El. 449 m), and difficult drilling condition because of probable cobbles and boulders (blast rock)																									

ONTARIO MTO (RETAINER) 11185012.500.BH LOGS (FINAL).GPJ ONTARIO MTO.GDT 17/1/20

# RECORD OF BOREHOLE No HA-19-7-01

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.16 LATITUDE 48.22430857 LONGITUDE -84.8604126 CHECKED BY Lul Yimam

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 (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
424.0								20	40	60	80	100								
423.9	TOPSOIL																			
0.1	Sandy Silt, Some Gravel, Trace Clay, Brown, Moist																			
423.7																				
0.3	Sand and Gravel, Trace Silt, Trace Clay, Cobbles, Brown, Moist to Wet																			
423.2																				
0.8	End of Augerhole																			
	Auger refusal on probable bedrock																			





# RECORD OF BOREHOLE No HA-19-7-02

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.16 LATITUDE 48.22417282 LONGITUDE -84.86027641 CHECKED BY Lul Yimam





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									
421.5								20	40	60	80	100					
0.0	PEAT, Amorphous, Wood Fibres, Dark Brown, Wet																
421.1																	
0.4	Sand and Gravel, Trace Fines, Trace Organic Matter, Cobbles, Dark Brown, Moist to Wet																
420.8																	
0.7	End of Augerhole																
	Auger refusal on probable bedrock																
	▽ Water Level observed upon completion of augerhole																

# RECORD OF BOREHOLE No HA-19-7-03

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.17 LATITUDE 48.22408525 LONGITUDE -84.8602172 CHECKED BY Lul Yimam

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 (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									WATER CONTENT (%)			
								20	40	60	80						100	20	40	60
420.5 0.0	PEAT, Amorphous, Wood Fibres, Dark Brown, Moist to Wet, Loose						420													
419.6 0.9	Silt With Sand, Some Gravel, Trace Clay, Brown to Grey, Wet		1	AS			419						o			17 25 54 4				
419.0 1.5	Sand and Gravel, Trace Fines, Cobbles, Brown to Grey, Wet																			
418.6 1.9	End of Augerhole  Auger refusal on probable bedrock  ▽ Water Level observed upon completion of augerhole																			

# RECORD OF BOREHOLE No HA-19-7-04

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.17 LATITUDE 48.22399599 LONGITUDE -84.860131 CHECKED BY Lul Yimam

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 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# RECORD OF BOREHOLE No HA-19-7-05

1 OF 1

METRIC

G.W.P. NO. 5031-18-00 LOCATION Highway 17, Between White River and Wawa ORIGINATED BY Jun Wang  
 DIST Algoma HWY 17 BOREHOLE TYPE Hand Auger COMPILED BY Anne Wang  
 DATUM Geodetic DATE 2019.09.17 LATITUDE 48.22388985 LONGITUDE -84.86000375 CHECKED BY Lul Yimam

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									
								20	40	60	80	100					

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

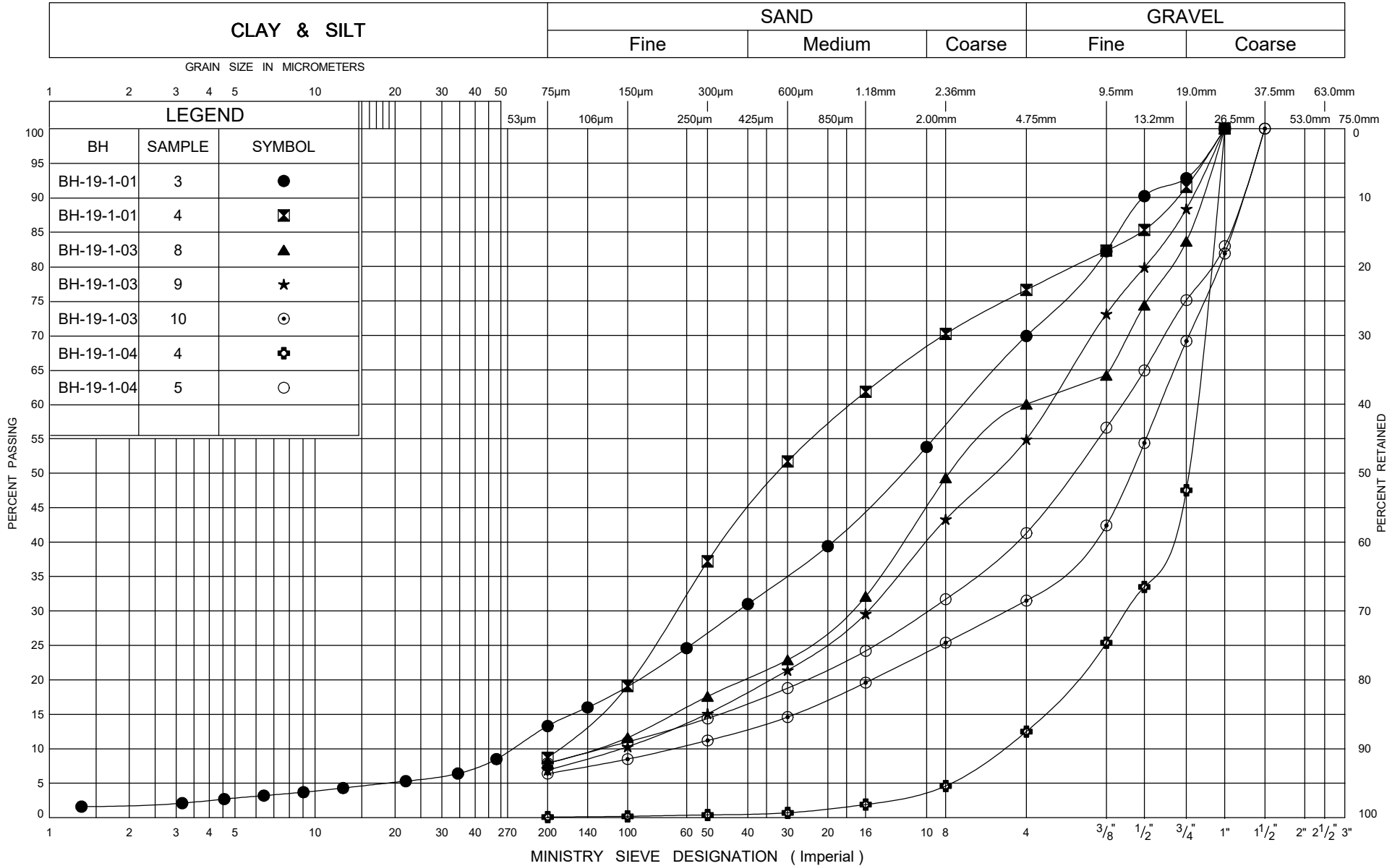


# **Appendix C**

## **Laboratory Test Results of Soil Samples**



# UNIFIED SOIL CLASSIFICATION SYSTEM

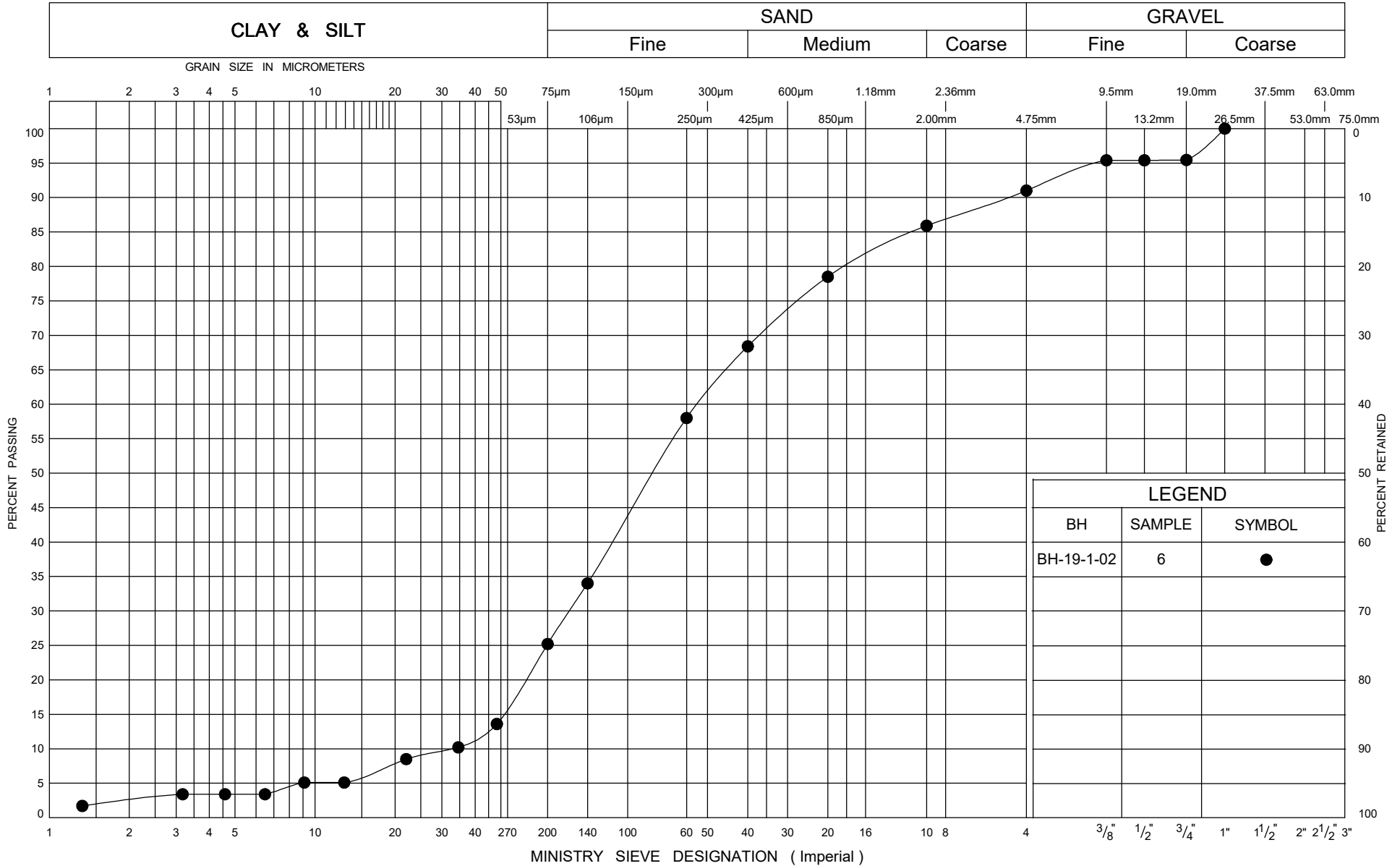


## GRAIN SIZE DISTRIBUTION

Gravelly with Sand / Sand and Gravel / Sandy Gravel, Trace Silt, Trace Clay

FIG No.:	GSA-1-1
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

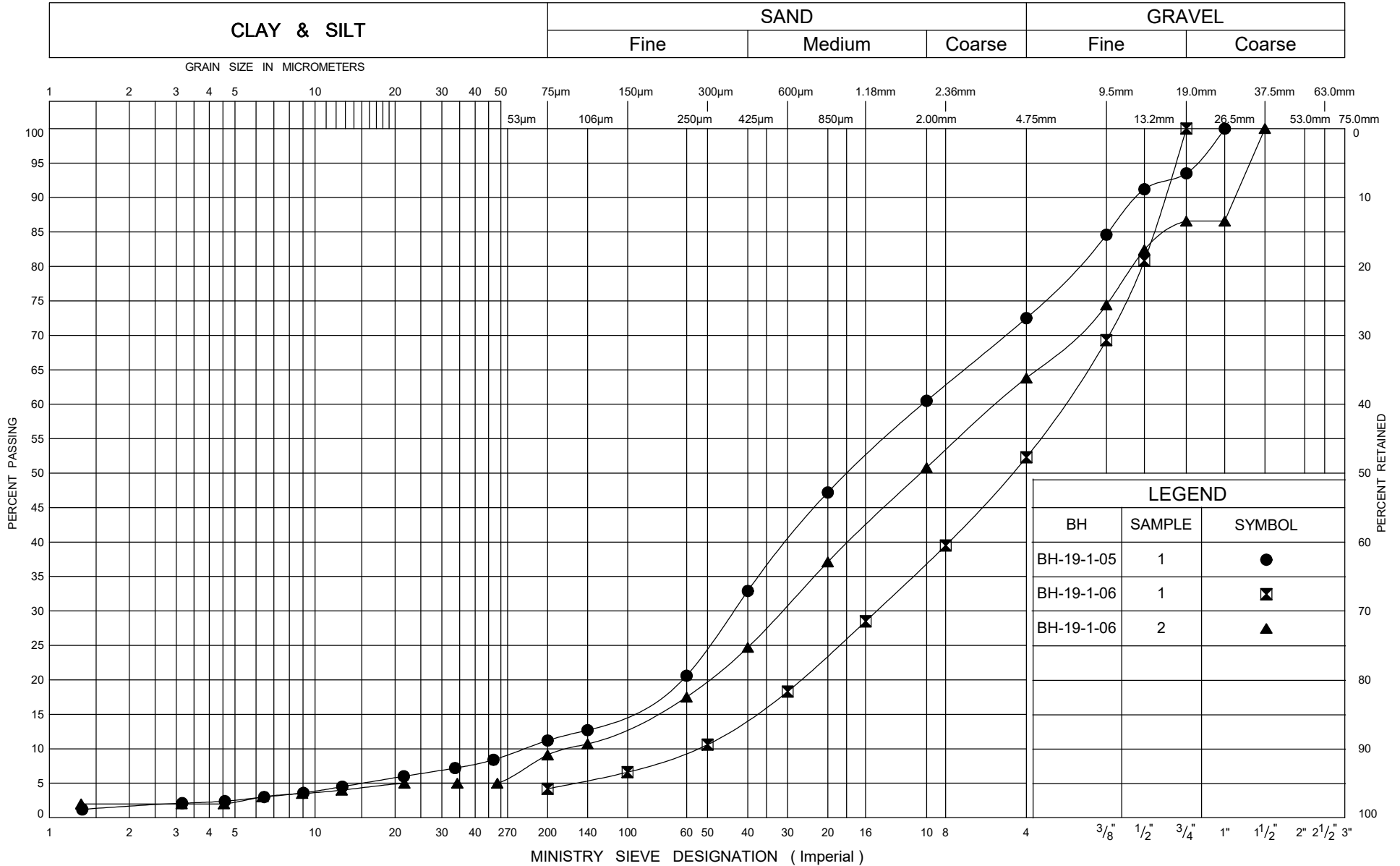
# UNIFIED SOIL CLASSIFICATION SYSTEM



**GRAIN SIZE DISTRIBUTION**  
Sand with Silt, Trace Gravel, Trace Clay

FIG No.:	GSA-1-2
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

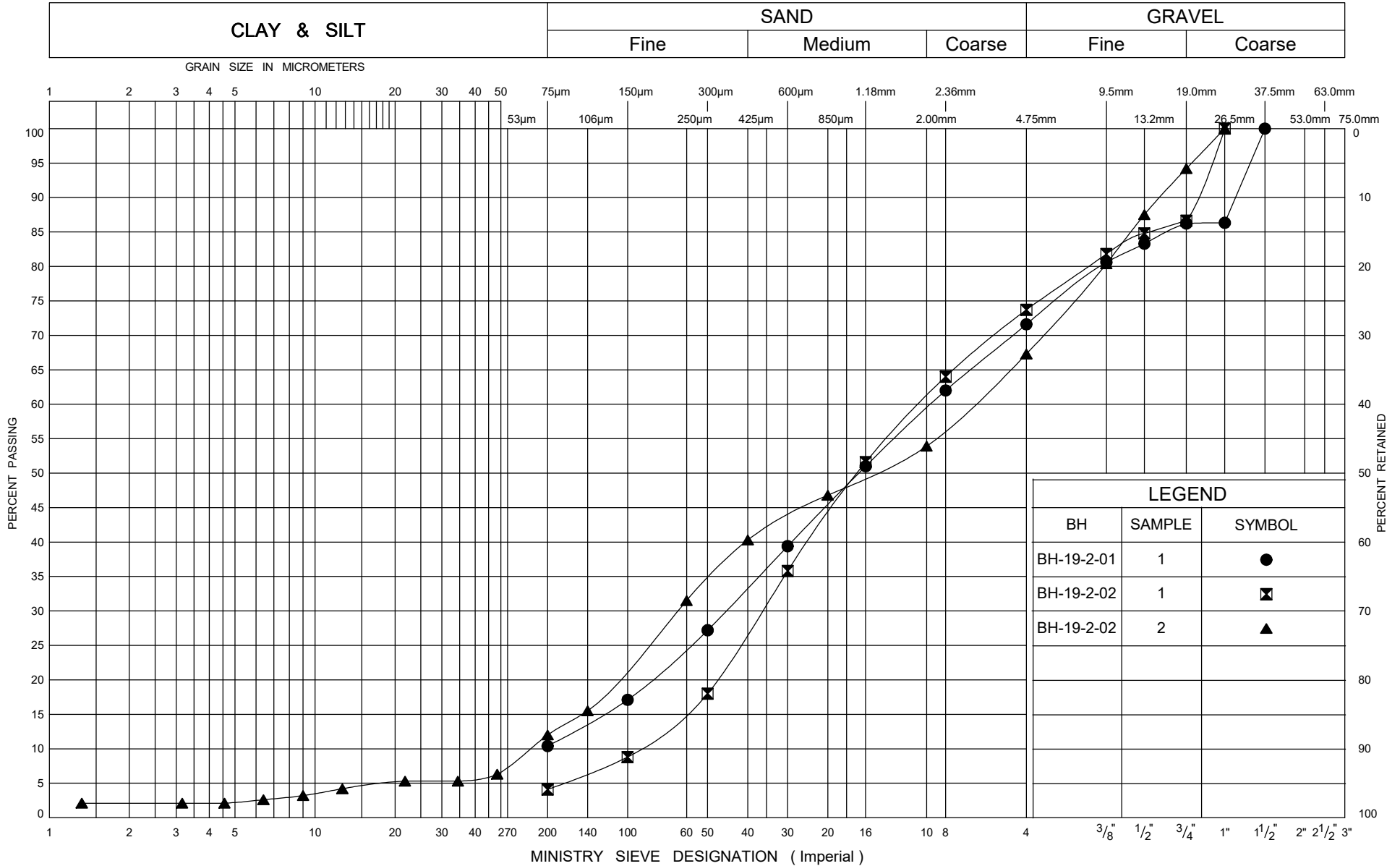


## GRAIN SIZE DISTRIBUTION

Fill - Sand with Gravel to Sand and Gravel, Trace Silt, Trace Clay, Trace Cobbles

FIG No.:	GSA-1-3
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM



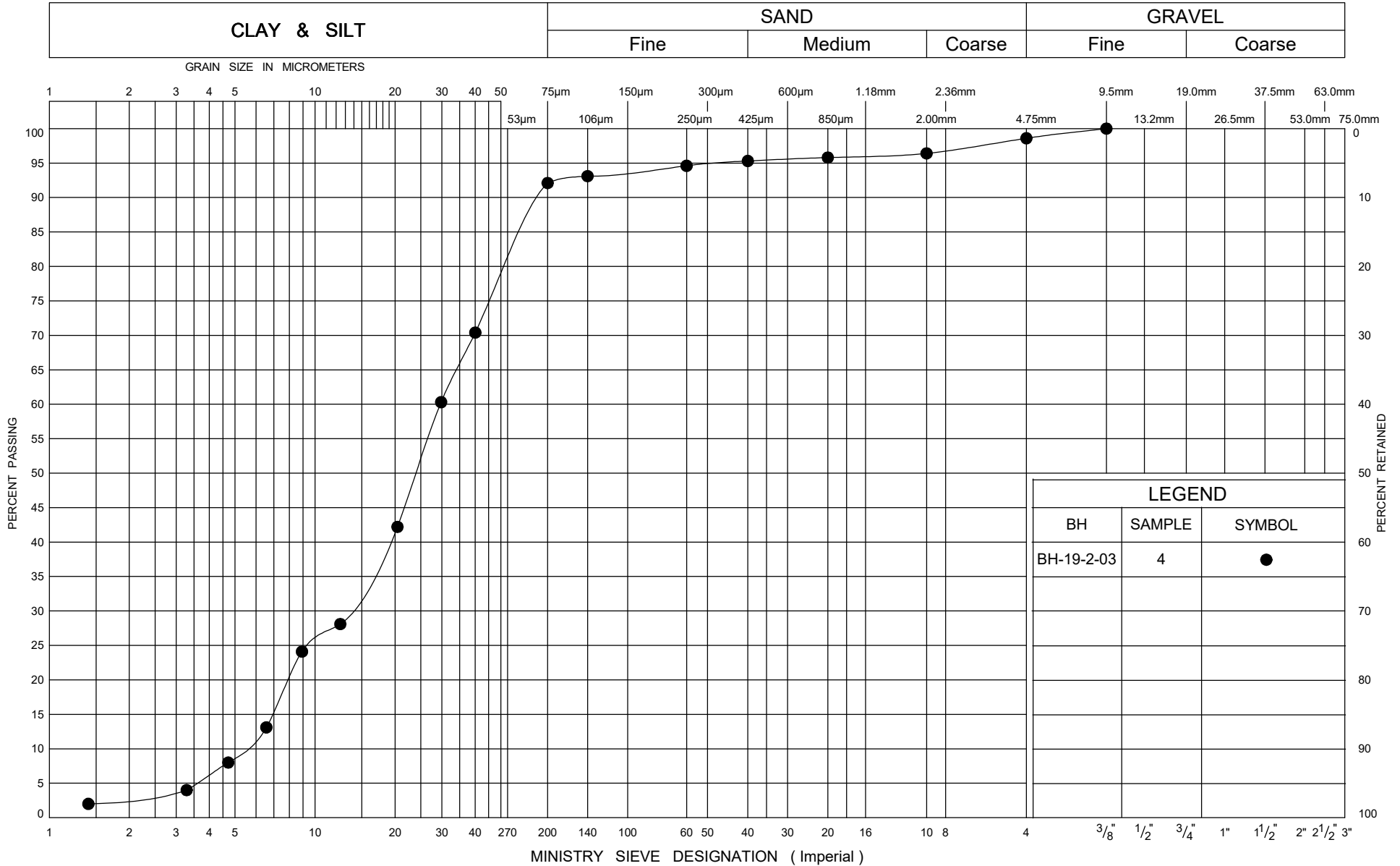
Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

Gravelly Sand / Sand with Gravel, Trace to Some Fines

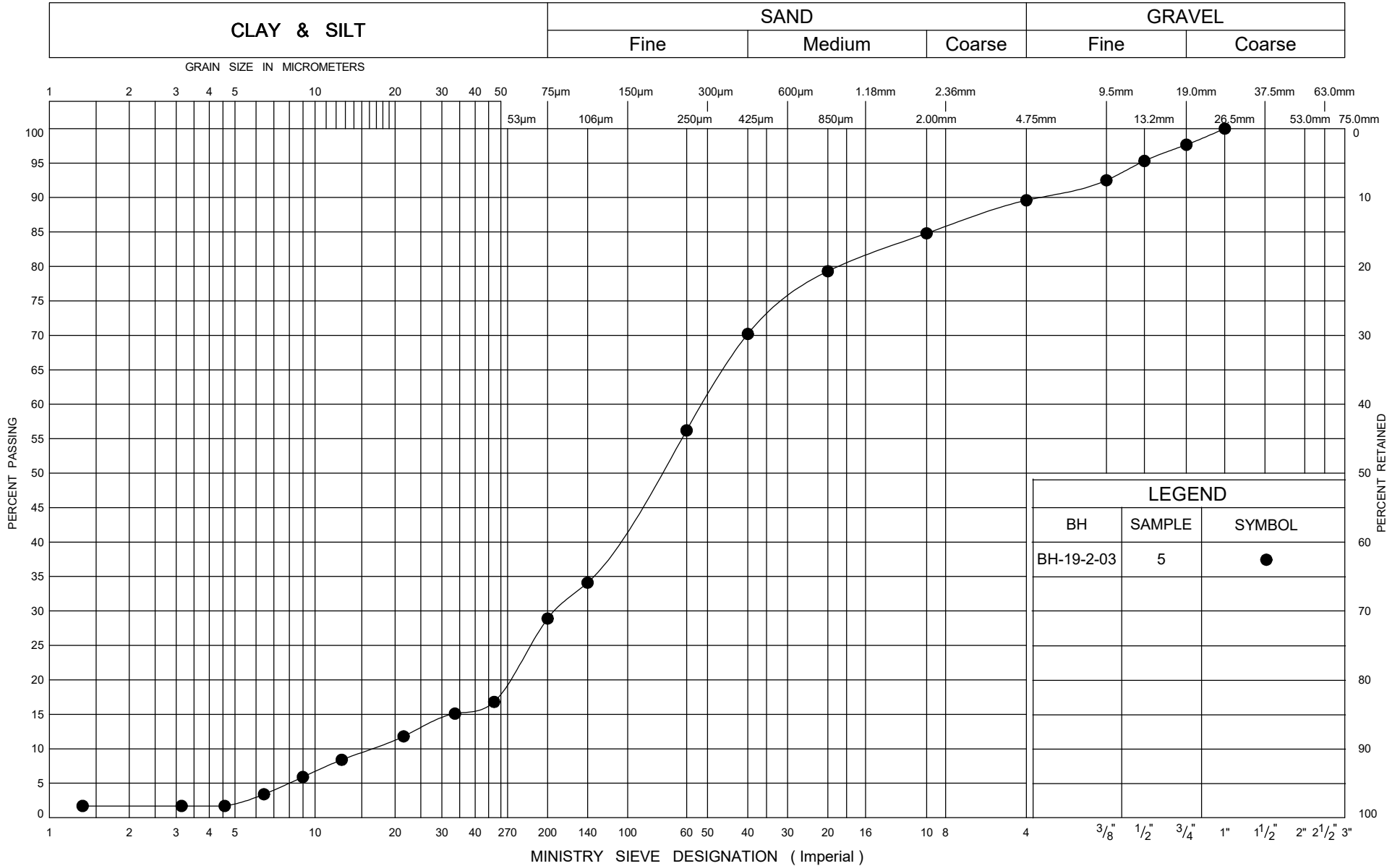
FIG No.:	GSA-2-1
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

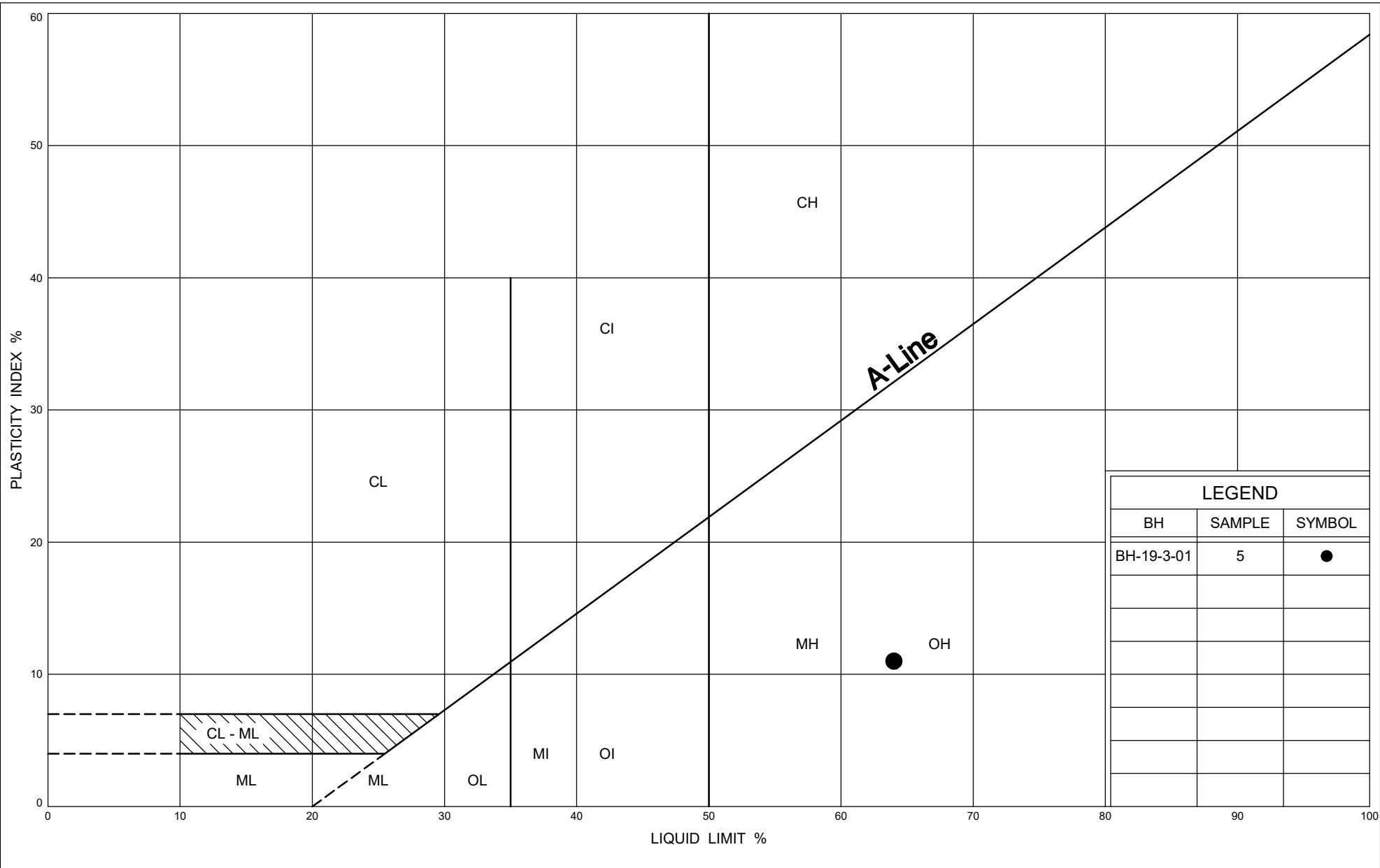
# UNIFIED SOIL CLASSIFICATION SYSTEM





# UNIFIED SOIL CLASSIFICATION SYSTEM

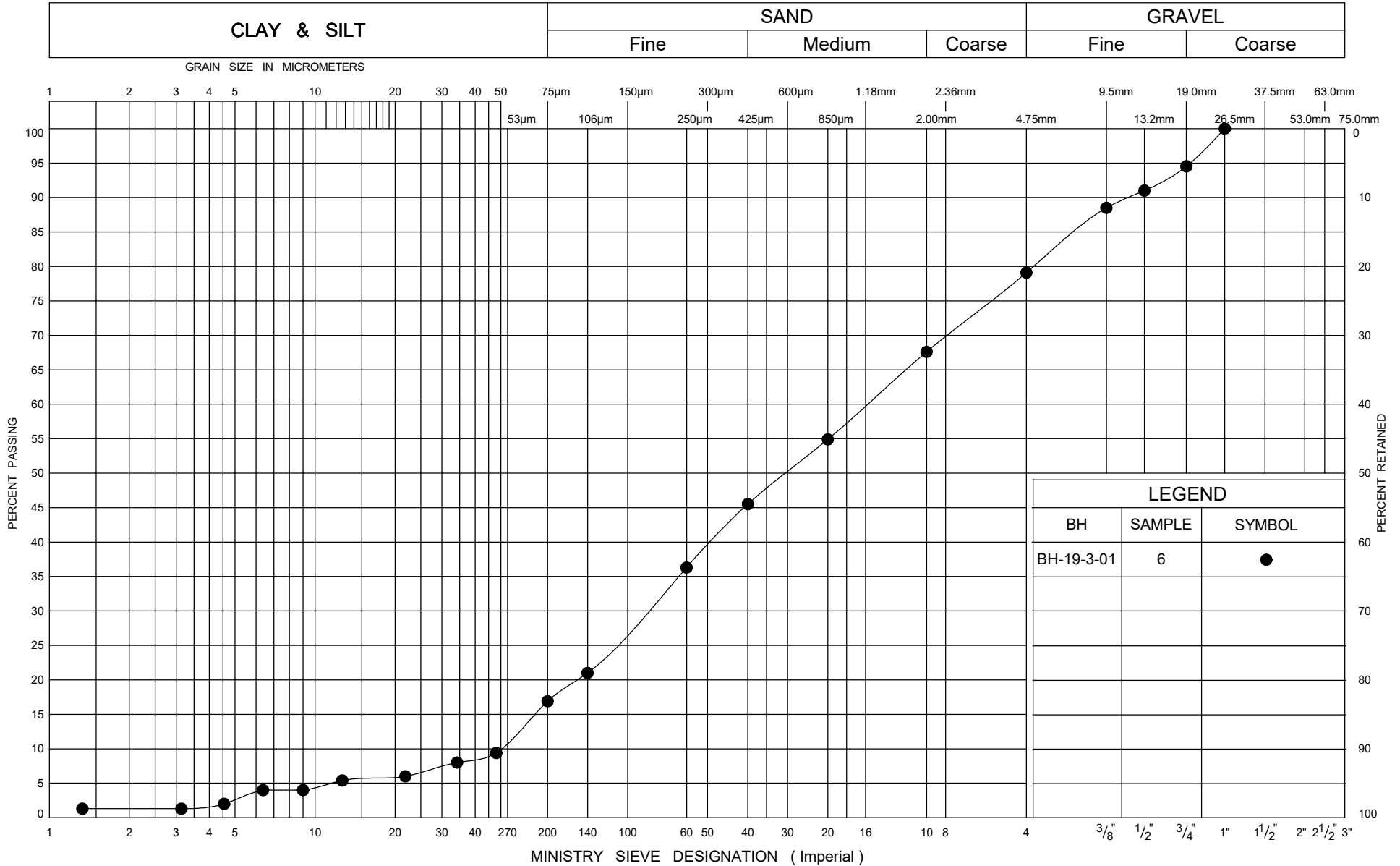




PLASTICITY CHART  
Silty Clay

FIG No.:	PC-3-1
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM



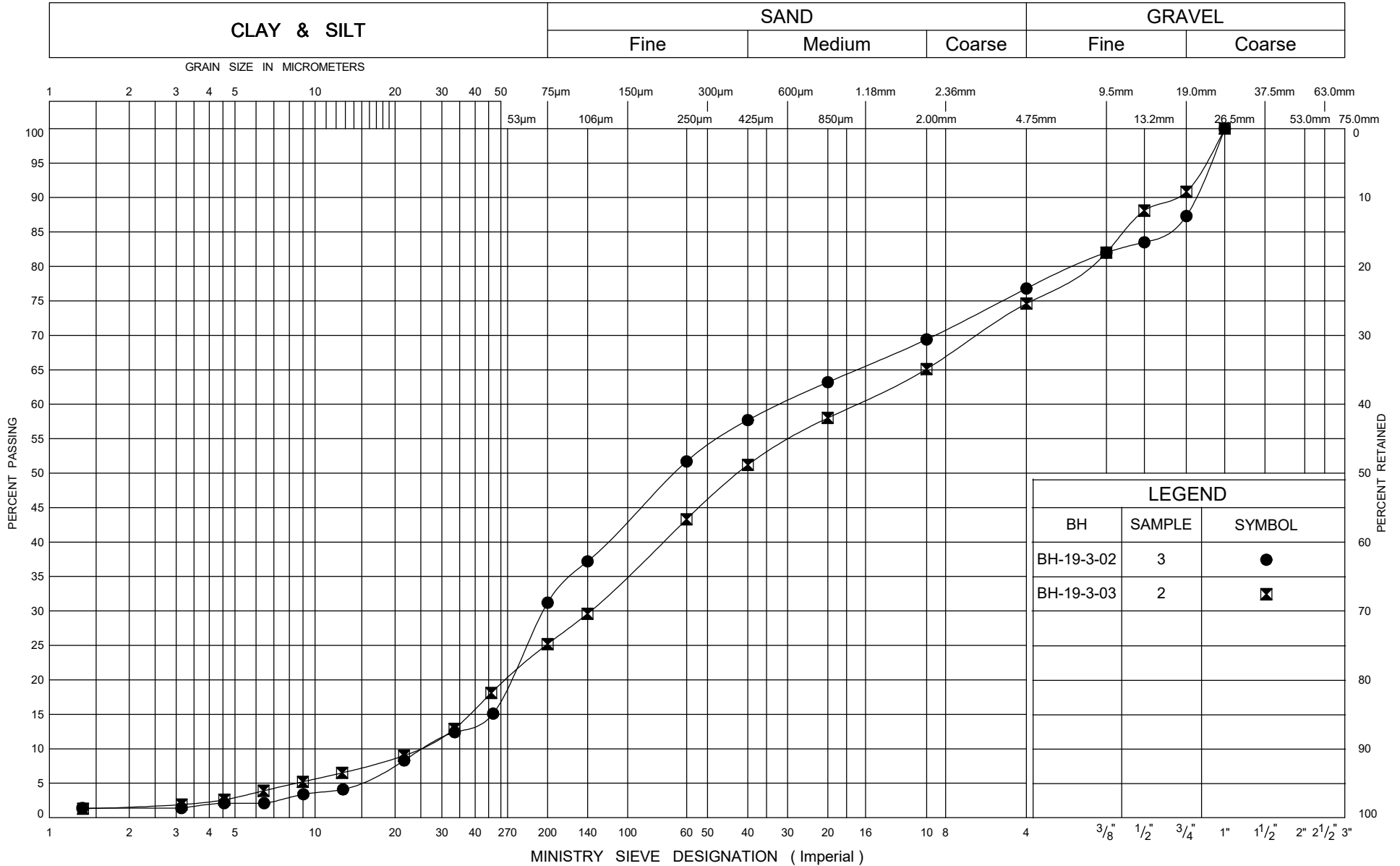
Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

Sand with Gravel, Some Silt, Trace Clay

FIG No.:	GSA-3-1
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

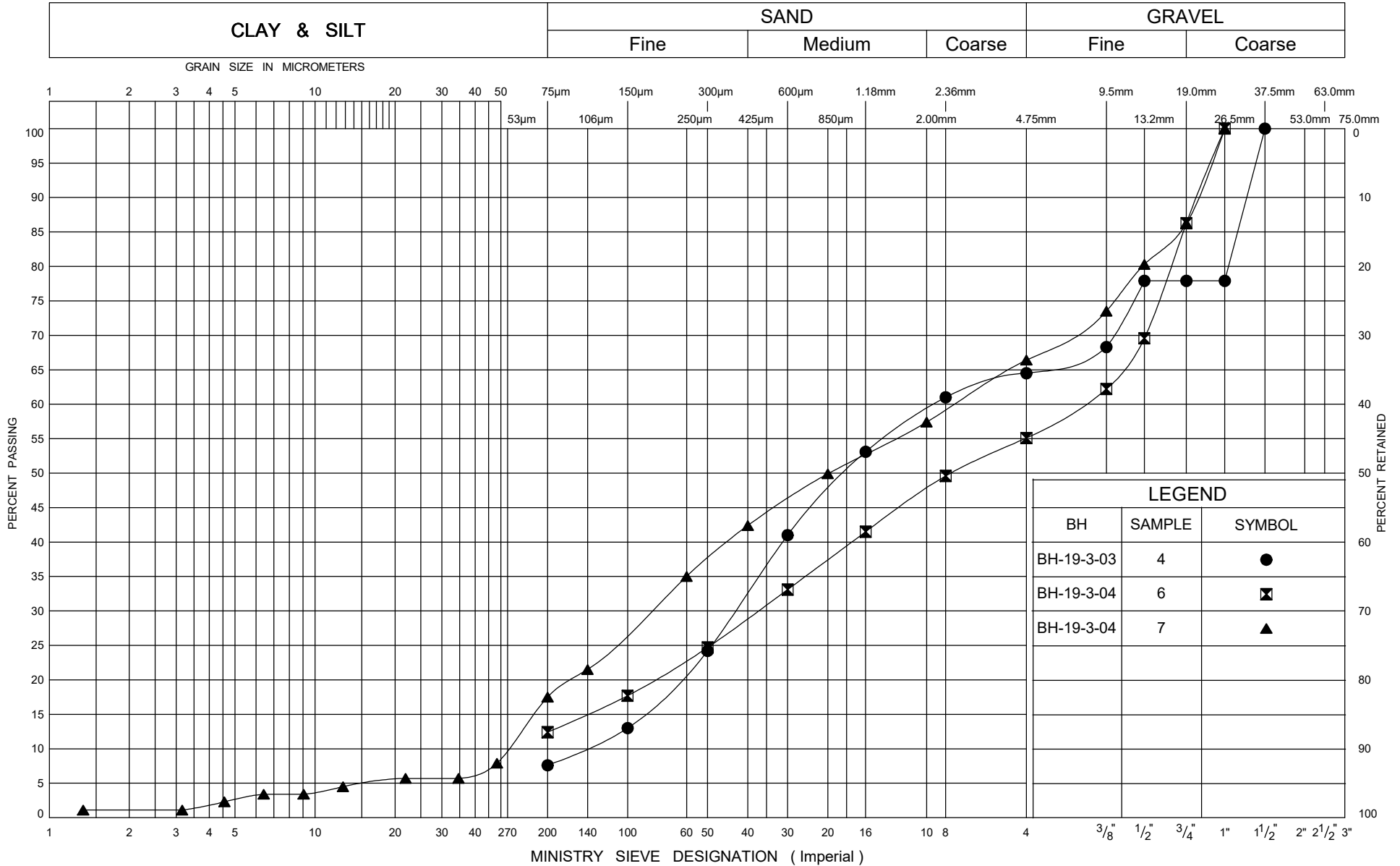


**GRAIN SIZE DISTRIBUTION**  
Silty Sand with Gravel, Trace Clay

FIG No.:	GSA-3-2
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00



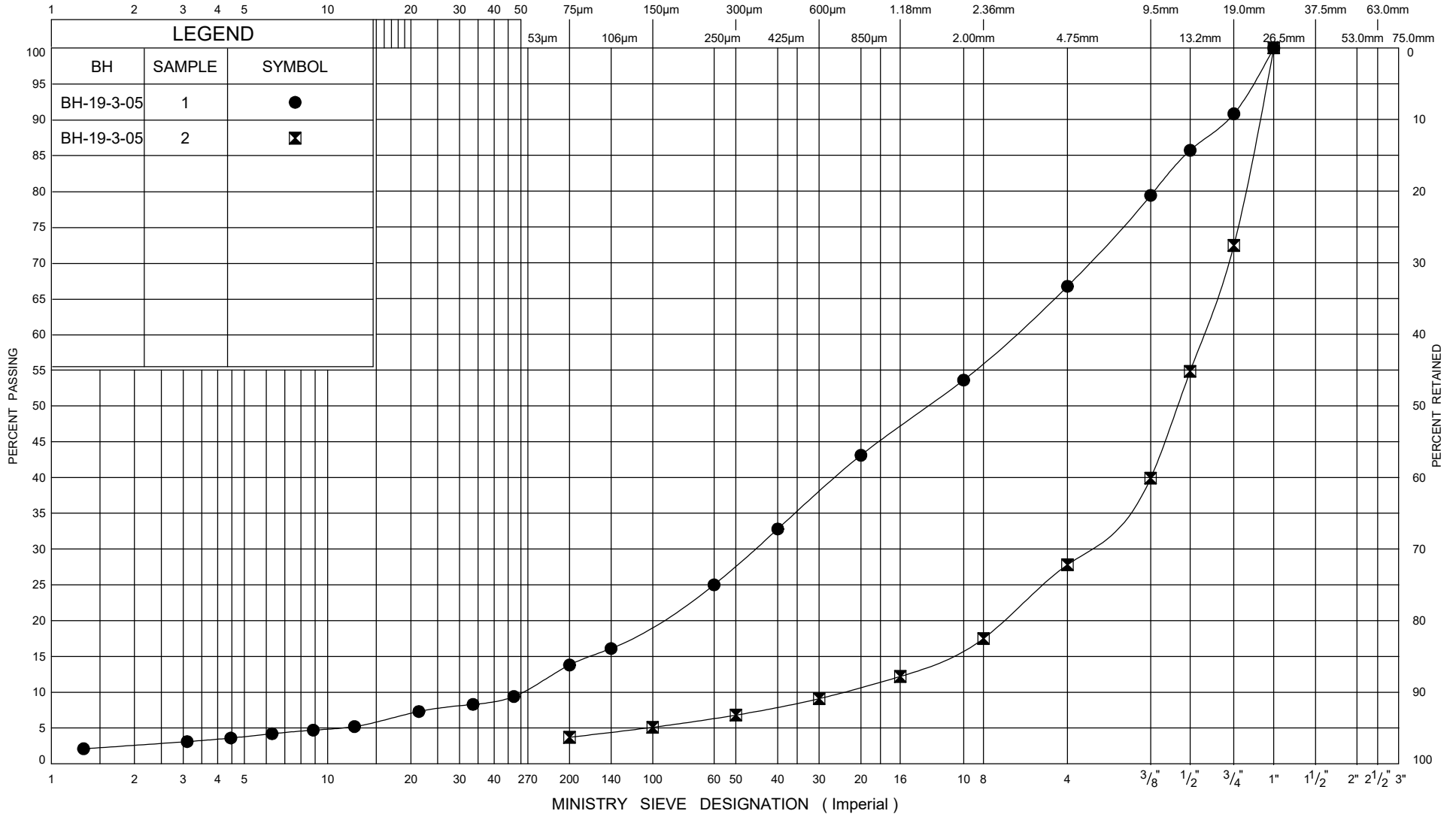
# UNIFIED SOIL CLASSIFICATION SYSTEM



# UNIFIED SOIL CLASSIFICATION SYSTEM

CLAY & SILT	SAND			GRAVEL	
	Fine	Medium	Coarse	Fine	Coarse

GRAIN SIZE IN MICROMETERS

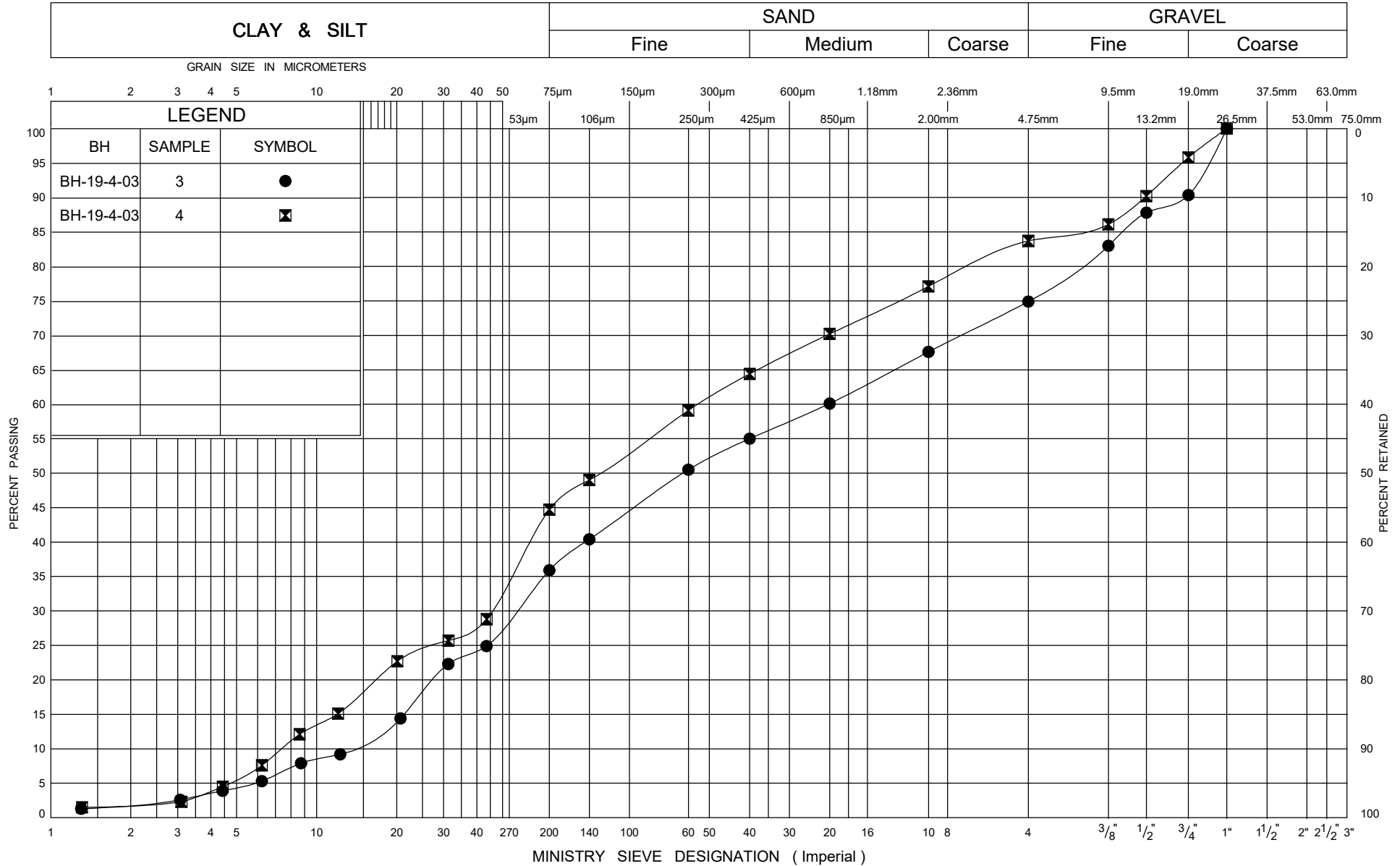


## GRAIN SIZE DISTRIBUTION

Fill - Gravelly Sand to Sandy Gravel, Some Silt, Trace Clay, Trace Cobbles

FIG No.:	GSA-3-4
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM

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## GRAIN SIZE DISTRIBUTION

Silty Sand to Sandy Silt, Trace to Some Gravel, Trace Clay

FIG No.:

GSA-4-1

Agreement No.:
----------------

5017-E-0043

Work Item No.:
----------------

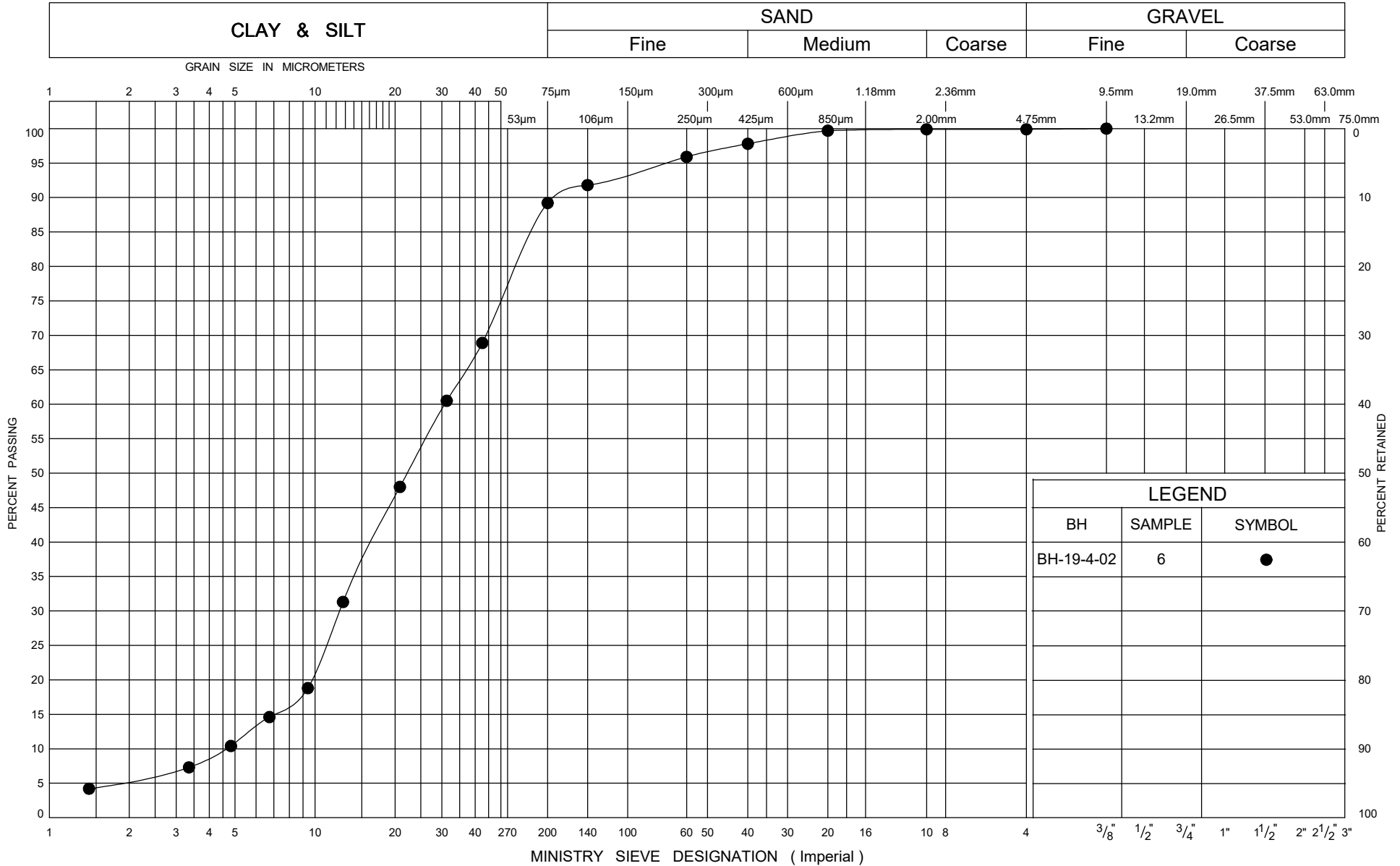
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5

G.W.P. No.:

5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM



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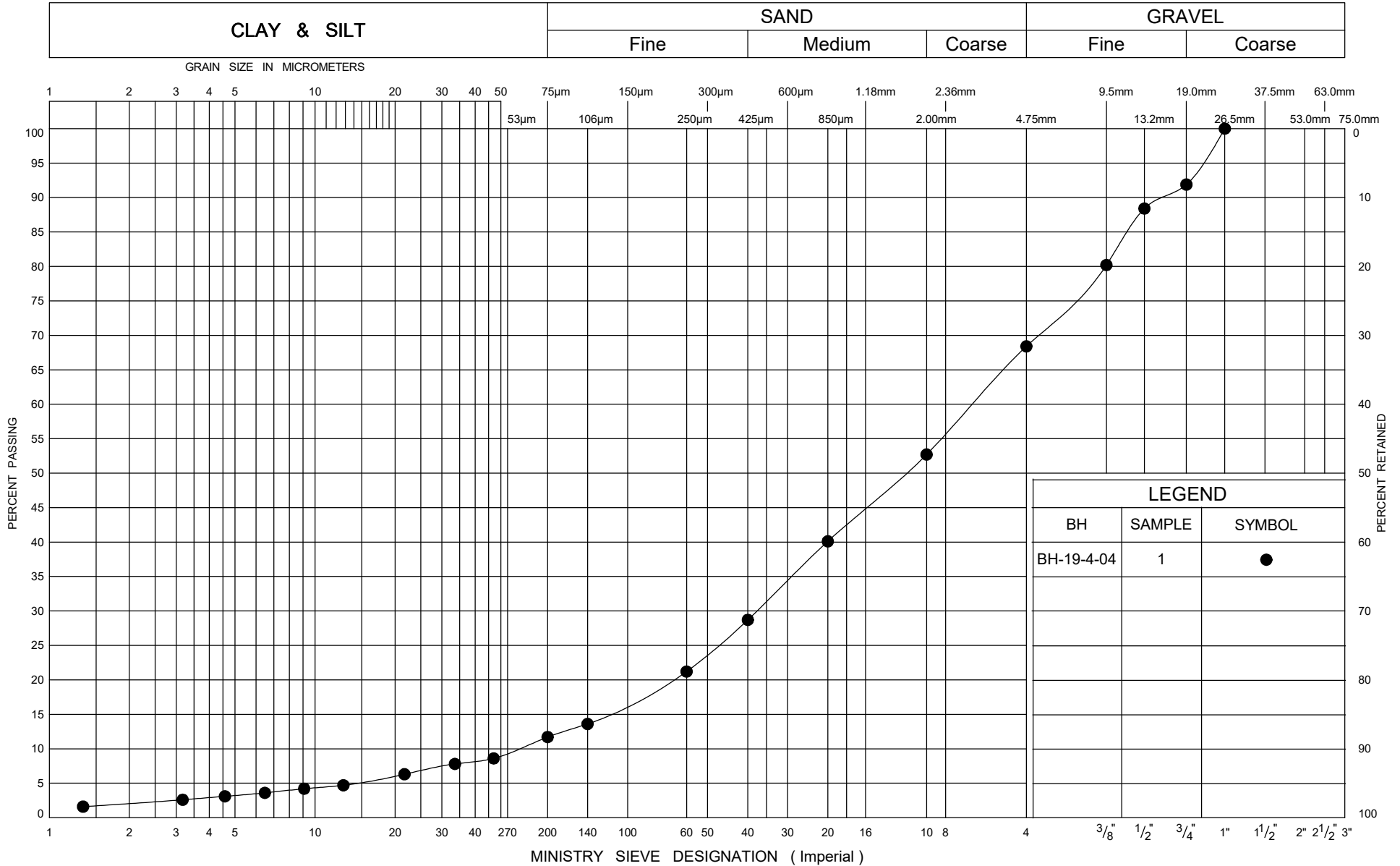
## GRAIN SIZE DISTRIBUTION

Silt, Some Sand, Trace Clay

FIG No.:	GSA-4-2
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00



# UNIFIED SOIL CLASSIFICATION SYSTEM

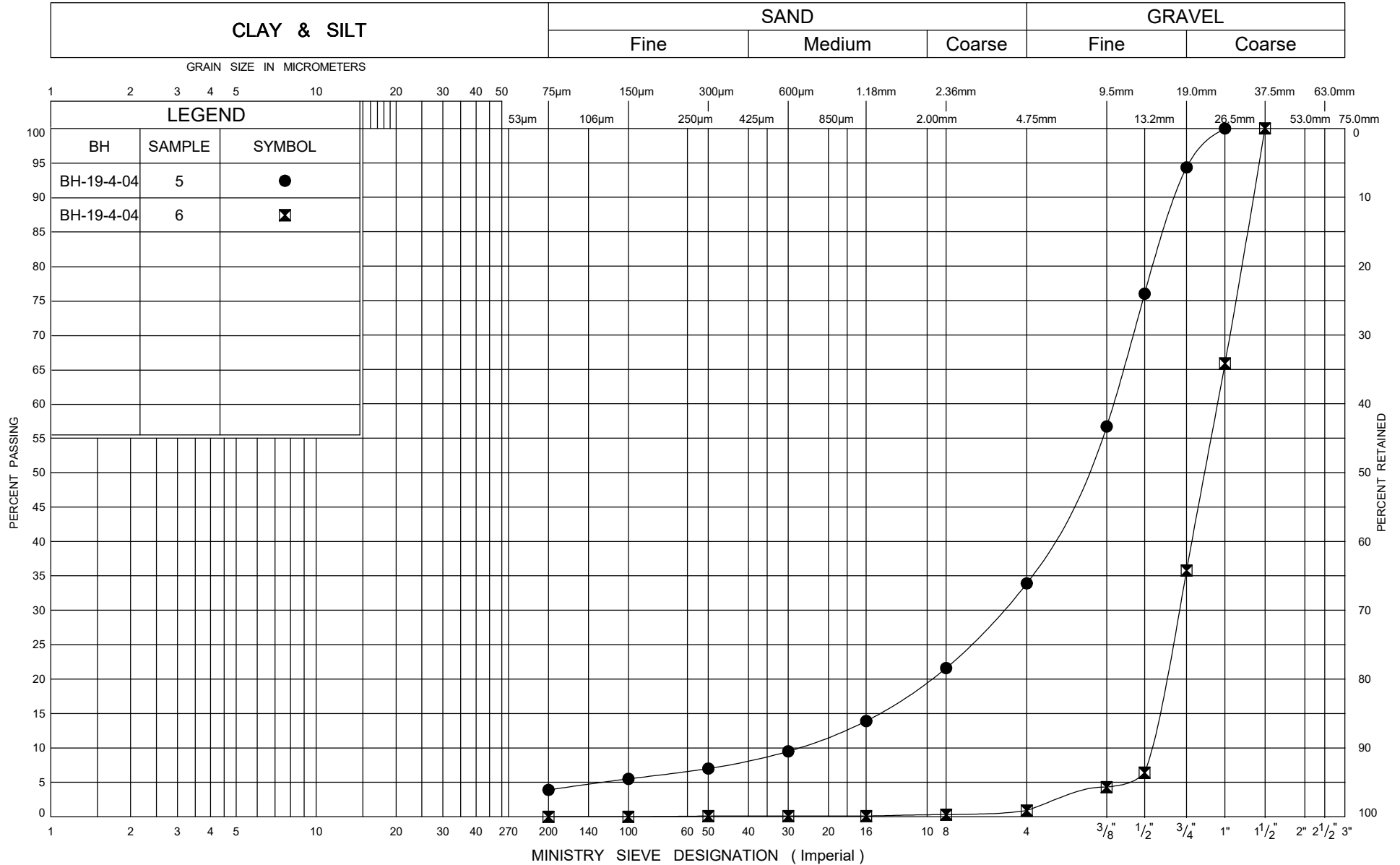


GRAIN SIZE DISTRIBUTION

Fill - Gravelly Sand, Some Silt, Trace Clay, Trace Cobbles

FIG No.:	GSA-4-3
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM



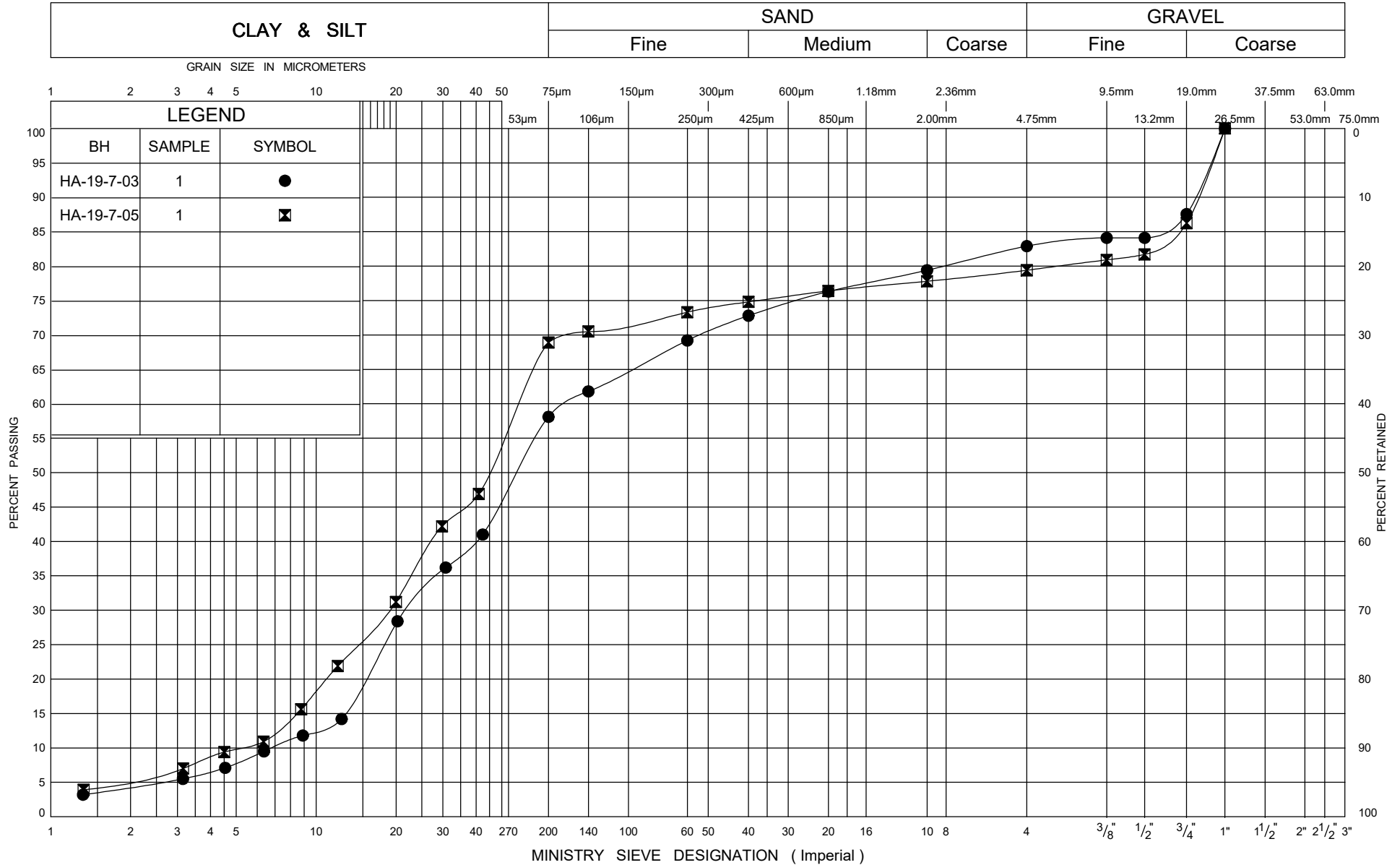
Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

Sandy Gravel to Gravel, Some Cobbles

FIG No.:	GSA-4-4
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00

# UNIFIED SOIL CLASSIFICATION SYSTEM



Ministry of  
Transportation

## GRAIN SIZE DISTRIBUTION

Sandy Silt / Silt with Sand, Trace to Some Gravel, Trace Clay

FIG No.:	GSA-7-1
Agreement No.:	5017-E-0043
Work Item No.:	5
G.W.P. No.:	5031-18-00



## **Appendix D**

# **Rock Core Photographs, Rock Core Description, and Uniaxial Compressive Strength Test Results**



Photo 19 – Highway 17 - Area 1 - BH-19-1-02, R1 = 5.0 m – 5.4 m, R2 = 5.4 m – 6.2 m, R3 = 6.2 m – 7.3 m, and R4 = 7.3 m – 8.3 m



Photo 20 – Highway 17 – Area 1 - BH-19-1-04, R1 = 3.7 m – 4.4 m, R2 = 4.4 m – 4.7 m, R3 = 4.7 m – 6.2 m, and R4 = 6.2 m – 6.8 m



Photo 21 – Highway 17 – Area 1 - BH-19-1-05, R1 = 2.9 m – 4.3 m, and R2 = 4.3 m – 5.9 m





**Table D1 – Area 1 Rock Core Description**

Borehole No.	Core Run	Depth (m)	% REC	% RQD	Description
BH-19-1-02	1	5.0 – 5.4	100	62	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately to highly fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R3 (Medium Strong Rock).  Visual Petrography: Quartz, Plagioclase
	2	5.4 – 6.2	88	51	
	3	6.2 – 7.3	100	85	
	4	7.3 – 8.3	100	82	
BH-19-1-04	1	3.7 – 4.4	100	92	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R4 (Strong Rock).  Visual Petrography: Quartz, Plagioclase
	3	4.4 – 4.7	100	89	
	3	4.7 – 6.2	100	88	
	4	6.2 – 6.8	100	96	
BH-19-1-05	1	2.9 – 4.3	100	73	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately to highly fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R3 (Medium Strong Rock).  Visual Petrography: Quartz, Plagioclase
	2	4.3 – 5.9	100	72	

**Logged by: Joe Lin and Jun Wang**

**Reviewed by: Lul Yimam, PhD, P.Eng.**



Photo 22 – Highway 17 - Area 2 - BH-19-2-01, R1 = 0.3 m – 1.4 m, R2 = 1.4 m – 3.0 m, R3 = 3.0 m – 3.7 m



Photo 23 – Highway 17 – Area 2 - BH-19-2-02, R1 = 1.4 m – 2.9 m, R2 = 2.9 m – 4.4 m, R3 = 4.4 m – 5.0 m



**Table D2 – Area 2 Rock Core Description**

Borehole No.	Core Run	Depth (m)	% REC	% RQD	Description
BH-19-2-01	1	0.3 – 1.4	98	67	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R4 (Strong Rock). Visual Petrography: Quartz, Plagioclase
	2	1.4 – 3.0	100	81	
	3	3.0 – 3.7	100	97	
BH-19-2-02	1	1.4 – 2.9	93	33	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately to highly fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R3 (Medium Strong Rock). Visual Petrography: Quartz, Plagioclase
	2	2.9 – 4.4	99	90	
	3	4.4 – 5.0	100	84	

**Logged by: Jun Wang**

**Reviewed by: Lul Yimam, PhD, P.Eng.**



Photo 24 – Highway 17 - Area 3 - BH-19-3-02, R1 = 2.3 m – 2.8 m, R2 = 2.8 m – 4.5 m, R3 = 4.5 m – 5.7 m



Photo 25 – Highway 17 – Area 3 - BH-19-3-04, R1 = 5.8 m – 6.1 m, R2 = 6.1 m – 7.6 m, R3 = 7.6 m – 9.1 m





**Table D3 – Area 3 Rock Core Description**

Borehole No.	Core Run	Depth (m)	% REC	% RQD	Description
BH-19-3-02	1	2.3 – 2.8	100	97	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R4 (Strong Rock). Visual Petrography: Quartz, Plagioclase
	2	2.8 – 4.5	100	83	
	3	4.5 – 5.7	100	100	
BH-19-3-04	1	5.8 – 6.1	100	90	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately to highly fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R3 (Medium Strong Rock). Visual Petrography: Quartz, Plagioclase
	2	6.1 – 7.6	100	78	
	3	7.6 – 9.1	100	68	

**Logged by: Jun Wang**

**Reviewed by: Lul Yimam, PhD, P.Eng.**





**Photo 25 – Highway 17 – Area 4 - BH-19-4-02, R1 = 7.2 m – 7.8 m, R2 = 7.8 m – 9.8 m, R3 = 9.8 m – 10.8 m**



**Table D4 – Area 4 Rock Core Description**

Borehole No.	Core Run	Depth (m)	% REC	% RQD	Description
BH-19-4-02	1	7.2 – 7.8	100	87	<b>GREENSTONE.</b> Dark green to black in color with white quartz and plagioclase crystals, fine to medium grained, weakly to moderately foliated, slightly weathered and moderately fractured with no fillings, medium to hard (based on geological hammer and knife test). Intact Rock Strength (IRS): R4 (Strong Rock). Visual Petrography: Quartz, Plagioclase
	2	7.8 – 9.8	100	99	
	3	9.8 – 10.8	100	100	

**Logged by: Moe Nasir**

**Reviewed by: Lul Yimam, PhD, P.Eng.**



Uniaxial Compressive Strength of Intact Rock Core Specimens  
(ASTM D7012 - Method C)

CLIENT: Ministry of Transportation LAB No.: WLT 276-1

PROJECT/ SITE: MTO Northeast Region Pavement PROJECT No.: 11185012-500

Borehole No.: BH-19-2-02 Location: Hwy 17, Between White River and Wawa

Depth: 4.42-4.60 m (14'6"-15'1") Date Sampled: 2019.09.28

Lithological Description: Greenstone

Initial Specimen Parameters	
Diameter, cm	4.7
Height, cm	10.0
Height-to-Diameter Ratio	2.1
Volume, cm <sup>3</sup>	174.3
Mass, g	526.8
Bulk Density, kg/m <sup>3</sup>	3023
Moisture Condition	As Received
Moisture Content, %	-----

Maximum Applied Load, kN	346.3
Compressive Strength, MPa	199.3



REMARKS:

PERFORMED BY: M.Mitchell DATE: October 17, 2019

VERIFIED BY: Michael Braverman DATE: October 21, 2019



**Uniaxial Compressive Strength of Intact Rock Core Specimens  
(ASTM D7012 - Method C)**

**CLIENT:** Ministry of Transportation **LAB No.:** WLT 276-2

**PROJECT/ SITE:** MTO Northeast Region Pavement **PROJECT No.:** 11185012-500

**Borehole No.:** BH-19-3-04 **Location:** Hwy 17, Between White River and Wawa

**Depth:** 5.92-6.17 m (19'5"-20'3") **Date Sampled:** 2019.09.26

**Lithological Description:** Greenstone

Initial Specimen Parameters	
Diameter, cm	4.7
Height, cm	9.8
Height-to-Diameter Ratio	2.1
Volume, cm <sup>3</sup>	170.6
Mass, g	487.1
Bulk Density, kg/m <sup>3</sup>	2855
Moisture Condition	As Received
Moisture Content, %	----

Maximum Applied Load, kN	136.4
Compressive Strength, MPa	78.6



**REMARKS:** \_\_\_\_\_  
\_\_\_\_\_

**PERFORMED BY:** M.Mitchell **DATE:** October 17, 2019

**VERIFIED BY:** Michael Braverman **DATE:** October 21, 2019



Uniaxial Compressive Strength of Intact Rock Core Specimens  
(ASTM D7012 - Method C)

CLIENT: Ministry of Transportation LAB No.: WLT 276-3

PROJECT/ SITE: MTO Northeast Region Pavement PROJECT No.: 11185012-500

Borehole No.: BH-19-4-02 Location: Hwy 17, Between White River and Wawa

Depth: 7.62-7.80 m (25'-25'7") Date Sampled: 2019.10.02

Lithological Description: Greenstone

Initial Specimen Parameters	
Diameter, cm	4.7
Height, cm	10.0
Height-to-Diameter Ratio	2.1
Volume, cm <sup>3</sup>	176.9
Mass, g	534.1
Bulk Density, kg/m <sup>3</sup>	3019
Moisture Condition	As Received
Moisture Content, %	-----

Maximum Applied Load, kN	210.9
Compressive Strength, MPa	119.5



BH19 04-02



BH19 04-02

REMARKS:

PERFORMED BY: M.Mitchell DATE: October 17, 2019

VERIFIED BY: Michael Braverman DATE: October 21, 2019





## about GHD

GHD is one of the world's leading professional services companies operating in the global markets of water, energy and resources, environment, property and buildings, and transportation. We provide engineering, environmental, and construction services to private and public sector clients.

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